Walking the land

Examining an ecosystem approach for private estates through the lens of woodland expansion

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Declaration

I, Euan Alistair Drew Bowditch confirm that I composed this thesis, that it has not been accepted in any previous application for a degree, that the work is my own, and all quotations have been distinguished by quotation marks, and the sources of information specifically acknowledged.

Signed: ........................................................................................................ Date: ......................................................

Euan Bowditch
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Abstract

This thesis presents a local interpretation of an ecosystem approach; ‘energyscapes’ constructed through mixed methods, which captures private estate manager perception on land use, woodland expansion and collaboration over four case study areas in the Scottish Highlands. Each case study area of three contiguous estates forms a small landscape cluster, with every estate participating in field interviews, woodland planning and collaborative discussions. Private estates in Scotland cover a significant area of the Highlands and are dominated by traditional sporting interests and recreation that is not always considered compatible with woodland expansion, creating a culture of woodland neglect. Subsequently planting rates are falling and Scottish government woodland expansion targets are not being met, despite large areas of vacant land.

Key areas of estate and woodland resilience are identified by land managers to improve social and structural connectivity using the novel landscape resilience mapping method, which presents land manager perceptions over a spatial scale linked to resilience concepts. The Forest Energy Tool developed in response to the need for economic justification for woodland expansion demonstrates the potential profitability of local woodfuel markets, as well as providing silvicultural treatments for further management aims. Estate resilience involves fostering effective integration between sporting uses, renewable energy and enhanced rural markets, such as value added forestry.

Ecosystem approaches are normally expressed through aspirational policy that is difficult to translate into relevant practice for individual land managers. Energyscapes provides meaning to ecosystem approach policy through CBD principles and operational guidelines, and local practice; including integration of hydro schemes, forest energy and carbon sequestration at estate level and bridging of local and regional scales through six land manager identified landscape partnerships. However, developing leadership, as well as expertise and social capacity in landscape management, is required to mobilise such frameworks. Fundamental to realising these local ecosystem approaches is land manager trust and confidence, which can generate support for emerging land uses alongside tradition, increasing resilience by capturing and utilising the culture embedded within the landscape.
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Chapter 1

Introduction

This thesis explores the practical challenges of implementing ecosystem approaches on private estates in the Highlands of Scotland. Woodland expansion strategies and forest energy potential are used as the focal points from which to study the cross-cutting issues faced by those attempting to integrate multiple land management aims. The research develops, implements and evaluates a series of innovative participatory methods over four case study areas, each of which comprises of three neighbouring estates.

1.1 Rationale for the thesis

An ecosystem approach is an integrated strategy for management of land, water, and living resources that promotes conservation and sustainable use in an equitable way (UNEP, 1992). Ecosystem approaches and practical ecosystem management are core drivers for multiple Scottish Government strategies. Chief among these is the Scottish Land Use Strategy (SG(a), 2011), which links multiple land use sectors with the aim of developing broad and inclusive land management for Scotland. The ‘economics of ecosystems and biodiversity’ report (2010) emphasises that, “Ecosystems don’t depend on economies but economies depend on ecosystems”. Each ecosystem must be considered collectively on multiple scales, such as a forest design plan or hydro scheme (Local), National Parks and river catchments (Regional), Forestry strategy and Climate Change Adaptation framework (National), and North Sea Fishery Plan (International). Therefore, creating landscape-scale management balances priorities, increases effective use of land and produces greater benefits for multiple stakeholders (SG(a), 2011; SG(b), 2011).

Frameworks that encourage stakeholder participation when tackling management issues are increasingly used to address multi-scalar issues (Glass, et al., 2013). These frameworks integrate stakeholders into iterative, long-term courses of action that
empower participants and distribute responsibility (Sayer & Wells, 2004), in a process of top-down approaches to bottom-up actions (Sayer, 2009).

Improving land use and community resilience to threats, climate change and fluctuating rural economies is a core element of ecosystem management (Magis, 2010). Several components are needed to build resilience, including self-organising systems, identity, adaptive cycles, thresholds, transformation and linking multiple scales (Gunderson, 2000; Folke, et al., 2010; Walker & Salt, 2012). Resilience acknowledges the importance of the linkages between economic, biophysical and social domains. Recognition of these factors, together with uncertainty of long-term planning and short-term aims informs resilience of land management (Haines-Young & Potschin, 2010; Skerrat, 2011). According to Walker and Salt (2012) the transition from resilience thinking to practice is achieved in three stages; system description, analysis of system dynamics and application.

This thesis attempts to link the theory and practice of resilience in a specific land management setting (Highland private estates and woodland expansion), using specific area examples and focal points that identify pathways for adaptive management responses. Subsequently informing applied management options that support a regionally specific ecosystem approach. In order to explore these issues the thesis aims to establish/describe:

1. Land use drivers from the perspective of individual estate land managers and how these influence decision-making and perception of estate resilience
2. The potential for woodland capacity through the identification of specific planting sites and suitability analysis on private sporting estates
3. The potential profitability, suitability and feasibility of short rotation forestry (SRF) for Highland estate managers
4. The use of carbon sequestration as a management tool to support woodland expansion and ecosystem approaches
5. The potential for collaborative activities and actions for private Highland estates;
6. The influence land manager perceptions on land use and woodland expansion upon practical landscape-scale management options
This thesis makes a unique contribution to the study of spatially driven interviews techniques and the application of practical woodland planning and decision-making tools that could aid the identification of suitable woodland expansion areas. It also develops insights into potential aspects of an ecosystem approach based upon individual and collective estate land manager perspectives. The use of individual land managers to evaluate and describe the landscape makes this methodological approach transferable to multiple forms of land management boundaries and ownership structures, as landscape scale is captured through perceptions of an individual associated with specific locations, areas and practices.

1.2 Research approach
The methodological approach is developed within the context of a framework (Chapters 2, 3 and 4) that uses multi-scalar consultation methods to explore the role of individuals and collectives in constructing regionally relevant practices (Prager, et al., 2012). There is growing evidence that multi-method approaches can uncover important local knowledge and practices, which can result in the development of more robust policies and practices than any single approach can achieve in isolation (Hubacek, et al., 2009; Nkonya, et al., 2011). The methods in this study use individual and collective discursive techniques alongside mapping tools to interpret the cultural significance of land use drivers on a landscape-scale (Cumming, 2011; Jones & Evans, 2012). Understanding the history, current condition and future considerations of land management can bridge connections to alternative approaches (Nkonya, et al., 2011). Such approaches offer potential to inform the continual refinement of land management practices, which achieve multiple objectives and address emerging challenges, such as climate change and fluctuating markets.

Greater development of land manager participation as a central component of sustainable land management practices improves communication and understanding (Reed, 2008). Thus face-to-face interaction such as interviews, focus groups and workshops can provide
a joint reflective and deliberative forum to tackle complicated issues that affect the broader landscape (Evans & Jones, 2011). However, a fine balance between useful and detrimental participant interaction is required, as these methods can propagate consultation fatigue, disinterest and low confidence in the process, which can undermine its effectiveness (Scott, 2011).

Increasingly, a shift from conventional participatory methods to more creative approaches that are capable of responding to the multiple demands and tackling complex issues is occurring (Wilmsen, et al., 2012; Liu & Opdam, 2014). Innovative approaches can provide land managers with the opportunity to solve problems in an engaging, reflective, deliberative and collaborative manner (Davies & White, 2012). This thesis links single estates and estate clusters through individual land manager perceptions of estate resilience and woodland practice, which uses unique landscape resilience mapping technique and Forest Energy Tool to inform short rotation forestry and carbon sequestration value from woodland planting in the Highlands. As a result potential avenues for improved woodland management practices and landscape scale integrated land use approaches are developed. Demonstrating the value of iterative engagement and spatial mapping of individual land manager perceptions.

1.3 Research context
Many Scottish private estates are dominated by sporting management aims (especially deer and grouse shooting), which can conflict with woodland planting and management objectives (Wightman, et al., 2002; MacMillan, et al., 2010; Haydn, et al., 2015). As privately owned estates account for a significant proportion of land in the Highlands, they form an influential group of decision-makers, both individually and collectively (Wightman, et al., 2002; Warren, 2009). Despite the crucial role of private sporting estates in the management of the Highland landscape, few studies have been carried out with this important group of land managers, which are often portrayed as ineffectively supporting the rural economy, public goods and progressive management approaches (MacMillan, et al., 2010; Glass, et al., 2013; Lawrence & Dandy, 2014).
Deer browsing at high densities and resultant overgrazing suppress natural regeneration of woodland and disrupts successional stand recruitment over the landscape (Hunt, 2003; Hobbs, 2009). Woodland and sporting interests are therefore predisposed to a degree of conflict, as planted woodland requires deer fences, which are considered expensive and an obstacle for facilitating sporting management in combination with other land uses (Haydn, et al., 2015). The forestry industry has declined in the last fifty years on many private sporting estates in the Highlands, resulting in reductions to the workforce, significance to the rural economy and the amount of active management (Oosthoek, 2013). Consequently forestry has remained undervalued and underdeveloped on many private estates, which has resulted in woodlands of low value and poor health (Macmillan, 2001; Hobbs, 2009; Haydn, et al., 2015).

Native woodland are estimated to have covered between 50-60% of Scotland 2000-3000 years ago (Smout, 2005). At the beginning of the 20\textsuperscript{th} century woodland covered 5% of Scotland’s land due to continued pressure in the preceding period from logging, sheep farming and hunting, due to the preference for open moors and Glens (Robbins & Fraser, 2003; Smout, 2003; Smout, 2006). The Scottish government has a target to expand woodland cover from an existing level of 17\% to 25\% by 2050 (WEAG, 2012). However, planting rates continually fall short of annual targets (10,000-15,000 ha/year) (SG, 2006; Wilson, 2011). Innovative management approaches are therefore required to increase the appeal and application of woodland expansion. The Woodland Expansion Advisory Group (WEAG) was established in 2008 to facilitate this aim and propose recommendations.

As woodland generates a range of benefits further expansion is strongly supported by public interest and international policy (Quine, et al., 2010). Scottish woodlands contribute to overall landscape importance through biodiversity, conservation, amenity and recreational values, as well as ecosystem services such as soil protection, flood mitigation and carbon sequestration (SG, 2006). Productive forestry is re-emerging as a vital concern of the rural economy, and intelligent silvicultural management will be necessary to meet future timber demands (Wilson, 2014). Woodfuel production or forest
energy has an important role to play in meeting domestic renewable energy aims, especially in remote and rural areas, such as the Highlands (WEAG, 2012). Forest energy could provide a market for low grade timber, support traditional management practices and reduce carbon emissions (Tullus, et al., 2013). However, the core challenge in the Scottish Highlands is integrating this broad set of interests into a landscape dominated by traditional sporting management.

1.4 Structure of thesis
As illustrated in Figure 1.1 this thesis is divided into four main sections. **Section 1, Chapters 1, 2, 3 and 4**, provides the context for the research drawing upon an extensive range of literature.
Chapter 1 introduces the research topic, gives a rationale for the area of study and presents the scope of the research. Chapter 2 develops the conceptual framework by tracing the development and relevance of ecosystem approaches and multifunctional management from international, national to regional scales. This also includes a critical review of the components that constitute an ecosystem approach, the relevance of similar management approaches and their application in the wider landscape. Chapter 3 focuses on land use management in the Scottish Highlands and provides a contextual framework. This chapter critically reviews the interactions between the history of land use, current
challenges and future uses that may play a vital role in forming integrated land use approaches. *Chapter 4* equips the reader with an understanding of participatory methods and the application of mapping within this process. This provides theoretical and contextual background for the methodology.

**Section 2 (Chapters 5 and 6)** demonstrates the methodological approach, which focuses around woodland expansion on private estates and forest energy production. *Chapter 5* describes how the multi-methodscale participatory approach was developed to connect land manager perspectives with landscape scale management. *Chapter 6* describes the case study areas and participating estates.

**Section 3 (Chapters 7, 8 and 9)** presents the results of the multi-methodscale participatory approach applied over the case study areas, including field interviews, woodland planning, Forest Energy tool outcomes and collaborative discussions. *Chapter 7* establishes the main land use drivers from the perspective of land managers and places them within the context of resilience and adaptive management. Regional character of the case study areas is examined through dominant traits. The final part applies the landscape resilience concept to the case study areas, which analyses the areas and practices of the estates through a spatial resilience perspective. *Chapter 8* presents the dominant drivers and obstacles for woodland management, the areas of planting, the potential value of forest energy and displays woodland landscape corridors over the case study areas. This provides a practical assessment of woodland expansion capacity through an applied approach linked to land manager narratives and management challenges. *Chapter 9* develops the case for integration of carbon sequestration and collaborative activities into estate planning and management. This presents the value of carbon sequestered from potential woodland planting on estates, land manager perspectives on the ecosystem services concept and the results of the collaborative discussions, which resulted in the development of landscape partnerships to benefit estate practices. Each results chapter produces mapped outcomes, which presents a cumulative picture of the spatial-cultural geography of the case study areas.
Section 4 (Chapters 10 and 11) presents a detailed discussion of the results, critically analyses estate resilience and re-interprets estate woodland management based upon land manager perspectives and FET outcomes. Chapter 10 presents the Energyscapes concept, which was developed as a result of the processes and outcomes of Section 3. This explores the components of implementing an ecosystem approach in relation to practical management benefits for private estate operations and landscape scale challenges. Chapter 10 finishes with a critique of the methodological approach. Chapter 11 includes overall conclusions of the thesis and suggestions for further work and lays out a set of recommendations for developing integrated land use strategies and ecosystem approaches.
Chapter 2

Ecosystem approaches and ecosystem services in land use management

2.1 Origins of the ecosystem concept
Awareness of linked ecosystems can be traced back thousands of years to when Plato recognised the link between deforestation in Attica, soil erosion and the desiccation of natural springs (Mooney & Ehrlich, 1997; McNeely, 2010). The term ‘ecosystem’ was used first by Tansley in (1935), with his stature as a scientist, in part, facilitating the establishment of the concept in modern ecology (Golley, 1993). Lindeman’s (1942) paper, on a small lake system, postulated the ‘ecosystem’, “As the system composed of physical-chemical-biological processes active within space and time of any magnitude, that is, the biotic plus its abiotic community”. Odum & Odum (1953) identified the importance of energy dynamics and flows in ecological systems, which led to recognition of the critical role that ecosystems play in energy management; providing a common ground for integrating economic and ecosystem sciences (Hau & Bakshi, 2004). The significant scale of the dustbowls of the first half of the 20th century (Fraser, 2013) highlighted the consequences of damaged ecosystems negatively influencing a wider system of interactions. Aldo Leopold (1949) further recognised the impossibility of substituting naturally developed ecosystems and services with intensively managed systems. This has led to the development of core principles, objectives and applied approaches by natural resource projects in recent history.

2.2 The development of ecosystem concept (1960-80’s)
In 1962 Bormann and Likens (1979) began the Hubbard Brooke catchment experiments. These examined whole watersheds in the northern hardwood forest of New Hampshire. The experiments operated at a landscape scale and emphasised ecosystem functioning in managing nutrient, sediment and water budgets. Research such as Hubbard Brooke’s
provided the early foundations for implementing applied ecosystem management approaches. Caldwell (1970) suggested that the ecosystem concept could be the basis of public land policy in the USA. Despite progress made by the environmental movement, and the development of wider environmental legislation in the 1970’s in the USA, the ecosystem approach was not fully integrated into the policies of the time. The political landscape of the period lacked the capacity to put the ecosystem concept at the centre of policies that were already undergoing major change (Hill-Mackenzie, 1996).

The Great Lakes Basin has an inherent need for an integrated approach to management and effective cooperation between agencies. The Water Board and the Science Advisory Board, an operational arm of the International Joint Commission adopted an ‘Ecosystem Approach’ to tackle resource degradation and restore the ecological integrity of the Great Lakes Basin Ecosystem (US Congress, 1986). It was the first instance where the ‘Ecosystem Approach’ (EA) had been explicitly applied and used, not only as a guiding principle, but as an operational framework under which multiple interacting elements were planned, integrated and managed.

The potential of the ecosystem concept to successfully protect and restore ecological integrity at large-scales, was further highlighted by a 12-year study of Grizzly bear (*Ursus arctos*) populations in Yellowstone National Park (NOROCK, 2013). This research demonstrated that larger ecosystems were required to support smaller areas of primary habitat, and that populations of Grizzlies could not be supported by activity confined to the National Park area; a larger-scale ‘Ecosystem Management’ (EM) approach was required to ensure their long-term conservation (Craighead, 1979).

This seminal study, along with the Great Lakes study, created a vibrant platform upon which scientists assembled, exploring defined regions where ecosystem-based concepts could be applied. The Great Lakes and the Yellowstone National Park projects demonstrated that core objectives could impact different ecosystems in similar ways, which linked areas and systems that might normally be considered separate (Smith & Maltby, 2003).
Developing in parallel with the ecosystem approach to resource management was the concept of ecosystem function (Schulze & Mooney, 2012). This focused on productive capacity; centred primarily upon the cycling of carbon, water and nutrients between the biota, the soil and the atmosphere (Golley, 1993; Mooney & Ehrlich, 1997). Seminal work, such as Rachel Carson’s ‘Silent Spring’ (1962), brought attention to the urgency of preserving ecosystem function, the fragility of ecological systems, and the short-term, as well as long-term, ramifications of human activity (Ehrlich, 1968). Linked to the growing recognition of ecosystem function was the concept of ‘Ecosystem Services’ (ESS), which emerged from scientific and environmental efforts to understand the connections between ecological damage and human well-being. In 1970, a report entitled ‘Study of Critical Environmental Problems’, explicitly mentioned delivering services to humanity, citing a range of ‘environmental services’, which would go into decline if ‘ecosystem function’ was to deteriorate (SCEP, 1970). These services included:

- Pest control
- Insect pollination
- Fisheries
- Climate regulation
- Soil retention
- Flood control
- Soil formation
- Cycling of matter
- Composition of the atmosphere

Later, Holdren and Ehrlich (1974) articulated the ecosystem services concept in terms of ‘public-service of the global environment’ under which they added: Maintenance of soil fertility and maintenance of a genetic library. The concept evolved around this established suite of services in the latter part of the 70’s, characterised by terms such as ‘public services of the global ecosystem’ (Ehrlich, et al., 1977), ‘nature’s services’ (Westman, 1977), and finally the term which is now widely accepted in modern
environmental management and policy, ‘ecosystem services’ (Ehrlich & Ehrlich, 1981; Daily, 1997; Farber, et al., 2006; Karereiva, et al., 2010).

2.3 Modern shape and significance of the ecosystem concept
Since the 1980’s ecosystem-related concepts have been increasingly used in literature and policy. Through much of the 20th century, ecosystem concepts remained metaphors, which explored their structure and impact, often maintaining that they were machine-like systems that aspired to a singular state, containing distinct components to be sustained at an optimal equilibrium (Gunderson, 2000; Holling, 1973). The logic being that once their function had been fully explored and understood, policy-making could take over to design efficient methods through which ecosystems could be maintained and controlled in an optimal state, often to ensure maximum resource productivity (Cortner & Moote, 1999). For example, in forestry, singular optimal state was for many years the main focus of sustained yield management regimes. This practice aimed at extracting the greatest volume of timber without degrading the productive stock, keeping the forest at a constant level of management, climax, extraction and succession (Helms, 1998). In the 21st century, ecosystems have taken on a different meaning. No longer are they seen as complicated machines but rather as complex, evolving systems in a state of constant flux and change; much like a living organism (Levin, 1998; Norberg & Cumming, 2008).

This systems perspective leaves behind the notion of the singular optimal state and acknowledges constant change and transformation within ecosystems, whether gradual or rapid (Holling & Gunderson, 2002; Repetto, 2006). In practice, this encourages a shift in management objectives away from rigid constructs and narrow focus, towards approaches based on guidance, which support changes to the ecological balance along desired pathways (Biggs, et al., 2010). Within the scope of a complex systems perspective, there is a requirement for constant evaluation - feedback loops that refine adaptive management are emphasised throughout the developing ecosystem paradigm (Chapin, et al., 2009).
Direct experience of applying these concepts in specific landscapes, such as Yellowstone, gradually allowed a number of principles and themes to emerge. A central theme was the importance of placing humans, their needs, impacts and drivers at the core of ecosystem concepts. This acknowledged that implementation of ecosystem-based management approaches are unachievable without understanding of the influential, if not dominant, role of humans (Agee & Johnson, 1988).

Decline of biodiversity and loss of ecological integrity often remains an abstract notion on a global scale, disconnected from local issues (Hanski, 2005). Ecosystem-based approaches can bridge the gap between distant ecological losses occurring at multiple scales. Adaptive management and ecosystem-based approaches working together can operate through landscape connections, which are absent in most environmental policy mechanisms (MA, 2005).

Despite the momentum captured by the ecosystem approach and particularly ESS, the implementation and adoption of these concepts by many countries and agencies represents a formidable challenge in terms of policy development and applied management (Hill-Mackenzie, 1996; Dekker, et al., 2007). Particular challenges which need to be resolved, include addressing institutional effectiveness and aligning the functionality of social systems and institutions with that of the non-human components of ecosystems (Fleeger & Becker, 2008; Carmon-Torres, et al., 2011; Garrelts & Filtner, 2011; Gäth, et al., 2010). Ecosystem based approaches have many interpretations and meanings, hindering implementation through policy (Waylen, et al., 2014).

2.4 Connections with the Convention of Biological Diversity (CBD)
The main convention providing guidance for the EA is the Convention on Biological Diversity (UNEP, 1992). In 1995 at the second meeting of the parties in Jakarta, the EA was adopted as the primary framework under the convention. Even as a central concept of the Convention, EA proved difficult to define in a simple and communicable manner (Fee, et al., 2009). At the 5th COP, 12 principles and 5 points of operational guidance (The Malawi Principles) were endorsed (Tables 2.1 and 2.2) and it was stated that for the EA to
be effective, all principles should be considered and given appropriate weight in accordance with local conditions (SCBD, 2004).

**Table 2.1 – 12 Principles & 5 Operational Guidelines of the Ecosystem Approach (UNEP, 2000)**

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<tbody>
<tr>
<td>1</td>
<td>The objectives of management of land, water and living resources are a matter of societal choice.</td>
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<tr>
<td>2</td>
<td>Management should be decentralised to the lowest appropriate level.</td>
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<td>3</td>
<td>Ecosystem managers should consider the effects (actual or potential) of their activities on adjacent and other ecosystems.</td>
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<td>4</td>
<td>Recognising potential gains from management, there is usually a need to understand and manage the ecosystem in an economic context. Reduce those market distortions that adversely affect biological diversity; Align incentives to promote biodiversity conservation and sustainable use; Internalise costs and benefits in the given ecosystem to the extent feasible.</td>
</tr>
<tr>
<td>5</td>
<td>Conservation of ecosystem structure and functioning, in order to maintain ecosystem services, should be a priority target of the ecosystem approach.</td>
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<td>6</td>
<td>Ecosystems must be managed within the limits of their functioning.</td>
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<td>7</td>
<td>The ecosystem approach should be undertaken at the appropriate spatial and temporal scales.</td>
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<tr>
<td>8</td>
<td>Recognising the varying temporal scales and lag-effects that characterise ecosystem processes, objectives for ecosystem management should be set for the long-term.</td>
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<tr>
<td>9</td>
<td>Management must recognise that change is inevitable.</td>
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<tr>
<td>10</td>
<td>The ecosystem approach should seek the appropriate balance between, and integration of, conservation and use of biological diversity.</td>
</tr>
<tr>
<td>11</td>
<td>The ecosystem approach should consider all forms of relevant information, including scientific, indigenous and local knowledge, innovations and practices.</td>
</tr>
<tr>
<td>12</td>
<td>The ecosystem approach should involve all relevant sectors of society and scientific disciplines.</td>
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**Table 2.2 – 5 Operational Guidelines of the Ecosystem Approach (UNEP, 2000)**

<p>| | |</p>
<table>
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<tbody>
<tr>
<td>1</td>
<td>Focus on the functional relationships and process within ecosystems</td>
</tr>
<tr>
<td>2</td>
<td>Enhance benefit-sharing</td>
</tr>
<tr>
<td>3</td>
<td>Use adaptive management practices</td>
</tr>
<tr>
<td>4</td>
<td>Carry out management actions at the scale appropriate for the issue being addressed, with decentralisation to the lowest level, as appropriate</td>
</tr>
<tr>
<td>5</td>
<td>Ensure intersectoral cooperation</td>
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</table>
This thesis uses several of the Malawi Principles (2, 3, 4, 6 and 7) and Operation Guidelines (3 and 4) to inform the conceptual and methodological framework. Focusing upon land manager perceptions through these principles will link aspects of ecosystem based approaches to specific landscape challenges. The CBD Conference of the Party (COP) and working groups are continually developing the EA concept through case studies, which track and synthesise practical ‘on the ground’ efforts to utilise EA. For example in Lao the EA was used to connect local livelihoods with Non Timber Forest Products, which promoted, through participatory methods, economic development and benefit sharing (UNEP, 2012). However, for wider impact and adoption at local levels, the EA needs to be connected from multiple scales (Smith & Maltby, 2003).

2.5 Interpretations of the ecosystem based approaches

In the last 40 years there has been a surge of terms describing ecosystem based approaches, which have become commonplace in both policy documents and wider sector-related literature. Such approaches include ecosystem approach, ecosystem management, integrated management, multifunctionality, sustainable development and ecosystem services. Due to the complexity of ecosystem approach principles and the difficulty of implementation various interpretations and different meanings have been applied, resulting in confusion (Adams, 2009; Dick, et al., 2011; Waylen, et al., 2014). Doubt has also been cast at the Rio +20 meeting on the effectiveness of high-level international policy on governance and management (Tollefson & Gilbert, 2012). Raum and Potter (2015) view these concepts as paradigm shifts that question current ideas and standards, disrupting the continuity of public policy. These shifts often overlap and incorporate previous practices and ideas rather than making a single approach redundant as a new one is adopted. Most ecosystem approaches emphasise the focus upon natural processes and systems rather than single species or objectives management (Grumbine, 1994). Increasingly other interpretations highlight the importance of a society centred perspective and knowledge creation between managers, scientists and the public (Szaro, et al., 1998; Sterling, et al., 2010). Furthermore the EA can be viewed as an instrument to deliver sustainable development, including adaptive management, supported by an
organisational set-up that encourages long-term trust and maintenance of balanced interests (Richter, et al., 2015).

Wide scope and ambitiousness is a persistent issue of translating the CBD Malawi Principles into practice (Fleeger & Becker, 2008). Involvement of stakeholders continues to be challenging as potential conflicts and complex interactions can interfere with current land manager aims (Reed, 2008; Blackstock, et al., 2012). This trend correlates with the increasing integration of socio-ecological systems into complex ecosystem based approaches, recognising humans as interdependent systems that affect resilience and trade-offs between ecological and social well-being (Chapin, et al., 2009; Richter, et al., 2015). Demonstrating a clear need to link and accounted for land manager perceptions in a meaningful way, which respond to the main goals of ecosystem based approaches. Guidance documents have been produced to hone the use of the Principles, however many example projects highlight the lack of connection to the majority of the principles and continued efforts to drive them forward seem to be unsuccessful (CBD WRGI, 2005). There is successional quality in many of the ecosystem based concepts and in wider environmental management that uses different approaches to feed into others, which are then abandoned in pursuit of more accessible approaches, such as CBD EA lending to an ecosystem services approach (Waylen, et al., 2014; Raum & Potter, 2015).

The CBD EA was translated into British law through the 2000 Countryside Rights of Way Act, which obligated government departments to implement the functions of the EA in accordance to the CBD (HMSO, 2000). In 2006 the Natural Environment and Rural Communities Act extended the incorporation of CBD EA aims to UK public bodies (HMSO, 2006), including the Forestry Commission Scotland who are responsible for approximately 33% of Scotland’s woodlands (FC, 2015). This figure highlights the quantity of woodland in private ownership in Scotland (Warren, 2009), which may have no ties to any of the Principles unless public bodies explicitly include them in their deployment of EA strategies. Collier (2015) emphasises the opportunity for ecosystem approaches to be formed at regional levels in response to specialist issues that are important to local managers and communities. In effect developing locally specific EA’s from land manager scale perceptions of the landscape and required management
approaches. This thesis, as stated in Chapter 1 aims to examine the landscape scale from individual and collective land manager perceptions. DEFRA published an Ecosystem Approach Action Plan with an Ecosystems Valuation Guide aiming to encourage a shift towards an EA, which would be reflected at all levels in environmental public bodies (FC, Natural England, Environmental Agency) strategies and plans (DEFRA, 2007a; DEFRA, 2007b).

Ecosystem services approach (ESA) has been interchanged with the EA in recent history due to the difficulty in distinguishing between meanings, aims and implementation. The shift towards an ESA was instigated by the Millennium Ecosystem Assessment in 2005 (MEA, 2005), which also encouraged the UK National Ecosystem Assessment in 2009 (UK NEA, 2011). The final report included a chapter on woodlands, which attempted to value timber, fuel production, deer stalking/venison and carbon sequestration (Valatin & Starling, 2010). The NEA aimed to assist the development of an “evidence base” needed for the implementation of an ecosystem approach in the UK (FC, 2011). This identifies ecosystem services as a valuation centred mechanism that provides economic platforms for products and services that maintain a functioning ecosystem a constituent part of understanding an EA. Quine et al., (2013) fear that the over emphasis on the monetarisation of ecosystem services may introduce another era of forest management that pursues single objectives, as services such as carbon sequestration that are easy to value may come to dominate land manager concerns. Currently the EA has not been supported by any specific forest policy measures, instruments or tools. The first reference of the CBD’s EA can be found in the revised UK Forestry Standards in 2011 (FC, 2011). Despite workshops and conferences to examine the concepts incorporation into forest policy and practice no new legislation, specific policy or guidance document has been produced (Mason & Mencuccini, 2014). Raum and Potter (2015) argue that multifunctional and sustainable forestry have been so deeply entrenched in modern forestry that there is little room for another paradigm, such as EA to motivate change. However, the advent of ecosystem services suggests that agencies such as the Forestry Commission must find ways to integrate an EA or what may turn out to be an ESA and clearly define what this means to both policy-makers and practitioners.
2.5.1 Clarifying the current understanding of ecosystem approaches

In the following section different ecosystem-related management concepts are further explored. Concepts are broken down into common workable goals, identifying how they may function together and where they may differ. Table 2.3 brings together common attributes used in a wide range of ecosystem-related literature and draws out an explanation and function for each attribute.

Table 2.3 – Definitions of common attributes in Ecosystem-related concepts (synthesised from a comprehensive literature review (Hill-Mackenzie, 1996; Grumbine, 2002; Sabine, et al., 2004; Carmon-Torres, et al., 2011; Daily, 1997; Farber, et al., 2006; MA, 2005; de Groot, et al., 2010))

<table>
<thead>
<tr>
<th>Common Attributes of Ecosystem-related Concepts</th>
<th>Definitions</th>
<th>CBD EA</th>
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<tbody>
<tr>
<td>Physical/Environmental</td>
<td>Protects natural integrity of the system through alleviation of physical stresses, restoration of healthy structure. Understanding that change and transformation are natural processes.</td>
<td>P: 3, 4, 5, 6, 10 OG: 1</td>
</tr>
<tr>
<td>Ecological Integrity</td>
<td>All life functions interdependent and survival is dependent upon ecological integrity-threshold limits and tolerances, which respond to external influences.</td>
<td>P: 3, 4, 5, 6, 8, 10 OG: 1</td>
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<tr>
<td>Self-sustaining System</td>
<td>Boundaries are defined by the spatial distribution and function of the resource rather than political units or jurisdiction. Recognising the complex ecological relationships as more appropriate boundaries or units.</td>
<td>P: 2, 3, 5, 6, 7 OG: 1 &amp; 4</td>
</tr>
<tr>
<td>Holistic/Interconnectedness</td>
<td>Planning, management and accountability of all elements should be planned for simultaneously within the same framework: Natural resources and human and technological</td>
<td>P: 1-12 OG: 1-5</td>
</tr>
<tr>
<td>Management</td>
<td>development are given balanced consideration to aid their mutual, beneficial and (sustainable) growth.</td>
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<td><strong>Adaptive management</strong></td>
<td>Takes the perspective that management is not a static, rigid process but one that is constantly evolving and learning. Practices and management strategies are provisional in nature and are involved in a continuous experiment in which flexibility and adaptation to uncertainty are key.</td>
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<tr>
<td><strong>Cooperation (interagency)</strong></td>
<td>Governmental agencies, Institutes, Universities, private organisations and managers must learn to work together across ecological boundaries that are shared while shaping new legal and management parameters.</td>
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<tr>
<td><strong>Data collection/Monitoring</strong></td>
<td>On-going research is needed (Climatic conditions, habitat dynamics, species distribution, supply and demand, cultural perspectives etc.) to inform better management. Creating feedback of valuable information from landscape experiments and tracing the process as well as the results of successes and failures in management.</td>
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<tr>
<td><strong>Education/Outreach</strong></td>
<td>Comprehensive networks of advice with ease of access to educational material. Awareness created on pertinent issues and opportunities (grants, initiatives, programmes, emerging markets etc). Outreach needs to be expressed in national policy but operationalized on the ground. For individual managers engagement and interaction are fundamental.</td>
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<td><strong>Organisational Change</strong></td>
<td>Requires changes in the composition and structure of how agencies and organisations operate. This may involve forming constructs for joint</td>
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<td>P: 3, 4, 8, 9, 10, OG: 3</td>
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<tr>
<td>P: 3, 9, 10, 11, 12 OG: 2, 3, 5</td>
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<td>P: 4, 6, 8, 9, 11, 12 OG: 1, 3, 5</td>
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<td>P: 1, 5, 9, 11, 12 OG: 2, 3, 5</td>
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<tr>
<td>P: 1, 2, 4, 11, 12 OG: 2, 5</td>
<td></td>
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<tr>
<td>Cultural</td>
<td>management, shifting of power dynamics and changing professional norms.</td>
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<tr>
<td>Humans as Core Elements</td>
<td>Humans cannot be separated out from the environment, they drive change, influence the processes and progression of the landscape and are in turn affected by change.</td>
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<tr>
<td>Values/Attitudes</td>
<td>Despite the importance of scientific knowledge, the main drivers for change are the values, attitudes and cultural relationships of humans and their communities.</td>
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<tr>
<td>Collaboration</td>
<td>Collective action has greater potential influence than an individual. Collaboration will bind managers, not only in relation to aims and goals, but in pushing forward mandates to collectively use resources, inputs and outputs, and combine management. Physically rather than theoretically integrating into one another’s land practices.</td>
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Table 2.3 shows identified aspects of ecosystem approaches from a collection of authors and the specific CBD EA principles to which they can be associated. According to some EA is the over-arching framework for implementing ecosystem and integrated management (Smith & Maltby, 2003), mobilising strategic action at larger scales (Regional) into active management at sub-regional scale (López, et al., 2009). Whereas Hiedanpää et al., (2011) suggest the main purpose of EA is to provide a flexible framework under which adaptive management can operate. Each of these authors emphasise the top-down strategic role of EA, which tends to distort the focus by placing the development responsibility in the hands of the policy makers, which diminishes the potential importance of individual land managers in developing and defining relevant EAs. Thus bottom-up approaches may provide valuable guidance and specific management lessons that would be overlooked by larger scale policy and planning (Fraser, et al., 2006). Table 2.3 demonstrates the broad application of the CBD’s twelve principles and five operational guidelines in comparison.
with a synthesis of ecosystem based approaches. All twelve principles and five operational guidelines could be linked with each of the categories in Table 2.3 but only more explicit links have been focused upon. This demonstrates the need for more specificity to local contexts and greater interpretation of ecosystem based approaches from local regions and managers (Curtin, 2014; Collier, 2015).

Scale is a major aspect of ecosystem approaches, which is expected to cover international to local issues, as well as short-term to long-term consequences and planning. However, this breadth of scale causes uncertainty in the implementation over multiple scales, undermining the connections to manager actions and practice. Some examples, such as the science and management partnership for National Forests in the USA adapt to climate change by collaboratively deploying policy and practice over various forests and adjusting responses over time (Littel, et al., 2012). Scale effects the majority of the EA attributes in Table 2.3 highlighting the importance of scale interaction and inclusion requiring development of coherent landscape scale planning, which connects species, habitats and the maintenance and structure functional ecosystems (Ferroni, et al., 2015).

2.6 Resilience as a component of ecosystem approaches

Resilience is the capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks (Holling, 1973; Walker, et al., 2004). Now a popular policy goal resilience has become difficult concept for managers to implement or even understand from a practical perspective (Newton, 2016). Nevertheless the concept is integral to ecosystem services rhetoric and continued interpretation of the CBD commitments (Thompson, et al., 2009), which has been transposed into a number of Scottish Government environmental policy documents (SG, 2011). Resilience and ecosystem approaches share the challenge of interpreting and bringing meaning to similar concepts with the aim to give land managers some understanding of how these higher level objectives influence practice. Aichi Biodiversity Target 15 of the CBD commits signatories by 2020 so that, “ecosystem resilience and the contribution of biodiversity to carbon stocks has been enhanced through conservation and restoration” (CBD COP 10 Decision X/2). The
Intergovernmental Panel on Climate Change (IPCC) views adaptation as a means to “build resilience” in response to climate change (IPCC, 2014). Current UK environmental policy aims to create, “a more resilient natural environment for the benefit of wildlife and ourselves” (Government, 2011). In Scotland resilience is being viewed through the adaptation to climate change and biodiversity to create resilient ecosystems that can continue to supply ecosystem services, which support the economy and developing communities (SG, 2009).

The shift of resilience from ecological origins to the political arena and its influence on environmental change is under scrutiny (McEnvoy, et al., 2013). This is illustrated by the increasingly flexible and wider interpretations of resilience emerging, which involves socio-economic and ecological systems being applied to ecosystem approaches (Brand & Jax, 2007; Olsson, et al., 2015). Such shifts are suggested to be undermining the conceptual value and application of resilience due to the expanding scope of meaning through policy (Brand & Jax, 2007).

There has been increasing attention on bolstering the resilience of ecosystems, which strongly links the concept within the ambit of ecosystem approaches (Batt, et al., 2013). Emphasising the need to ensure the persistence of essential ecosystems in the face of new conditions, aiming to maximise adaptive responses to a changed environment is becoming a priority action. The enthusiasm for adopting resilience into policy documents belies the complexity of the term, resulting in accessible meaning but little guidance on operational definitions including levels of system resilience, to what pressures and how success can be measured in implementing such goals (Cavers & Cortrell, 2015).

Walker et al (2004) defines resilience as, “the capacity of a system to absorb disturbance and reorganise while undergoing change, essentially retaining the same function, structure, identity and feedbacks”. The resilience concept was developed to understand the capacity of ecosystems to persist in their original state, while being subjected to varying disturbances and perturbations (Holling, 1973; Gunderson, 2000). However, the ability to absorb shocks while retaining the same ecosystem structure and function (Walker, et
al., 2002) is insufficient to tackle rapid changes, depleting resource bases and unpredictable factors such as climate change. Several extensions of resilience theory have been developed. These operate in conjunction with robust ecosystems, which shift in structure and function, transitioning from one dominant regime to another (Scheffer, 2009). Transformability’ or ‘transformational change’ is the adaptation of ecosystems to changes in structure and function, finding new states, which differ to previous ones (Folke, et al., 2010).

Resilience is increasingly articulated within a Social-ecological Systems (SES) framework, with interacting factors directly influencing change, persistence and transformation in ecosystems. These factors are often the fundamental drivers for regime shifts and adaptation (Folke, et al., 2010). Social-ecological systems examine the feedbacks within and between the social and ecological fields that occur at multiple-scales. Resilience identifies adaptive management as a key component to facilitating practical initiatives and projects at smaller scales. Thus adaptive management can guide systems through periods of transformations and new states (Folke, et al., 2010). This approach encourages cross-sector learning, which enables examples and models for these transformative projects to emerge, generating new perspectives in land use management. Learning to avoid the undesirable outcomes that may compromise known thresholds (Müller, et al., 2010) are important priorities in using lessons to guide flexible management approaches.

Transformational change is unlikely to be detectable at catchment or landscape scales, as the number of interacting components mean it is difficult to identify specific areas of change. At smaller scales, sequential or cumulative effects can lead to feedback that inform and benefit the larger scales (landscape/catchment) through combined learning processes. This can be facilitated by bridging organisations that possess the capacity to operate between the smaller and larger scales (Olsson, et al., 2004; Krager, et al., 2012). Such organisations can be government agencies like the Forestry Commission, that advises land managers and maintains landscape objectives for multiple stakeholders, or NGO’s that help community groups develop their management capacity. Chapin (2010) suggests that transformability operates through three phases:
i) Preparing for change, especially in SES’s.

ii) Using obstacles and barriers as opportunities for change and;

iii) Reinforcing resilience within the new SES regime.

Resilience continues to extend its scope and impact as ecosystem approaches gain more traction through practical application. Maintaining ecological integrity at the same time as adaptive management and transformation influence an ecosystem’s response to changing SES’s will develop the application and impact of resilience (Schultz, et al., 2015). Resilience identifies opportunities for change and facilitates shifts between ecosystem states. Transformability uses resilience at multiple scales integrating knowledge, practical management and the SES lessons (Walker & Salt, 2012).

Current thinking on woodland resilience in Britain focusses on adaptation to climate change, as well as species and genetic diversity that enhances evolutionary resilience. Such thinking highlights the key relationship between diversity and resilience through the need and role of redundancy in a system. Mostly positive relationships are drawn between high diversity and stability (Laliberte, et al., 2010), however this depends on the context and the effect of SES’s and socio-economic considerations (Wellnitz & LeRoy Poff, 2001). Clarifying the type of resilience that land manager or policy-maker is targeting is critical in the approach to operationalising and measuring the success of actions. For example ecosystem resilience, species resilience, which may look at the structural diversity or the intra specific genetic diversity and the processes that regulate them (Cavers & Cortrell, 2015). This could be the case for particular ecosystem services such as watershed protection, carbon sequestration, timber production or recreation.

In Scotland’s Economic Strategy (SG, 2015) resilience is mentioned nine times in the document representing a clear aim for both the national and regional economies. One of the paths to resilience is ‘Natural capital, resource efficiency and low carbon economy’, which is centred upon actions to aid Scotland’s 80% reduction of Greenhouse gases by 2050 (SG, 2010). This involves renewable energy generation, development of primary industries such as forestry, agriculture and fisheries, targeted infrastructure development
and sustainable communities to reinvigorate remote and rural areas (SG, 2015). All are considered key to Scotland’s economic resilience and demonstrates the important link to socio-ecological resilience, the criteria used to define and measure this goal, and the determination of valuable actions to resilience building. The complexity of resilience has been increasingly emphasised in recent years (Messier, et al., 2013; Pacheco-Vega, 2013), which has led to greater focus on different elements, such as spatial resilience and resilience based upon collaborative structures over large landscapes (Cumming, 2011; Curtin, 2014). In response to this complexity knowledge brokering organisations have emerged, as third party interpreters and facilitators of resilience, directing both meaning and actions for useful implementation. For example in Scotland ‘Sniffer’ deliver knowledge based solutions to resilient and sustainable Scotland. They focus their efforts around five themes, which includes ecological networks and practical partnerships that aim to use Scotland’s natural capital and developing new strengths within these themes (Sniffer, 2016).

- Resilience to Climate change
- Sustainable places
- Resilient catchments
- Health and well-being
- Environmental regulation

Development of organisations that solely focus on exploring practical solutions for resilience demonstrates a clear need for greater guidance and application of resilience for both land managers, policy-makers and general public. Therefore using research to link terminology and meaning of resilience to accessible and practical action is a key in addressing these gaps.

### 2.6.1 Adaptive management (AM)

Adaptive management is an instrument for implementing ecosystem approaches (Schultz, et al., 2015). Widely used in natural resource management (Walters & Holling, 1990) as an iterative decision-making process, which informs management objectives by
monitoring and re-evaluating outcomes (Savory & Butterford, 1999; Sabine, et al., 2004). This increases knowledge and learning processes while decreasing uncertainty, which makes adaptive management a critical element of a land management strategies and plans (Williams, et al., 2009). Allowing adequate time for adaptive management processes to develop over time is vital, as the scope to incorporate valuable lessons into management considerations is greatly enhanced (Walters, 2007). Additionally, function will be increased, therefore translating benefits to higher scales to improve adaptive governance (Gunderson & Light, 2006), which engages socio-political elements, to influence management through policy. This linkage between practice and policy will encourage incremental improvements over time and create beneficial relationships for landscape scale management. However, linking the needs and challenges of individual land managers to higher scales, which form mutually beneficial solutions are difficult operationalise.

Allen & Gunderson (2011) argue that adaptive management has been over-stretched and inappropriately applied. It is often only deployed as a last resort to preserve the status quo, as opposed to feeding adaptive processes into a system before change or transformation becomes unachievable. Allen & Gunderson (2011) infer that adaptive management is a quick-fix method to overcome intractable social problems. These authors propose that adaptive management is most effective where great uncertainty exists, allowing for multiple approaches to achieve broad mutual benefits and workable solutions. Whereas Lawrence and Marzano (2014) learned that private forest owners viewed uncertainty of the future as a reason to avoid adaptive management. Additionally, lack of confidence in markets and climate change predictions result in varied responses from private and public sectors, therefore greater engagement is required to develop appropriate strategies, which connect attitudes to management behaviour (Lawrence & Marzano, 2014). This requires a method to capture perceptions, attitudes and values of managers and translate them into a useable and connected management unit to identify relationships, gaps or anomalies between perception and action.
Accepting uncertainty is necessary for successful adaptive management, as well as incorporating alternatives that emerge alongside 'best practice', to mitigate over-investment in a single action (Keith, et al., 2011). Multiple factors such as stakeholder risk aversion, inappropriate statistical approaches, poor monitoring of management actions and lack of foresight can hinder effective adaptive management (Duncan & Wintle, 2008). However, if adaptive management goals are applied too broadly and without clear goals, this can result in little change or momentum. Therefore, developing powerful tools from practical experience is key in moving from exploratory strategies to effective implementation (GAMWG, 2000).

2.6.2 Collaborative Adaptive Management (CAM)
Collaboration strengthens resilience and adaptive management aims with collaborative planning (Williams, et al., 2009; Innes & Booher, 2010). However, this approach has proven difficult to implement and has fallen short of expectations (Wiersema, 2008; Ruhl & Fischman, 2010). CAM projects are often designed without clear over-arching goals or measureable objectives to guide management processes. Also inadequate provision for shared learning and development of protocols to manage scientific uncertainty can reduce effectiveness. Whereas tools and incentives, which facilitate participation and foster collaboration can improve project management (Susskind, et al., 2012) and also long-term planning procedures.

The Glen Canyon Dam adaptive management programme experienced little success, despite data supporting the finding that modified water releases increased the habitat and population of the endangered Humpback chub (Anderson, 2009). Ineffective use of data and inadequate management that failed to implement long-term water releases undermined the project, highlighting the vital role of communication and flexibility to incorporate important findings within modified project timeframes (Melis, 2011).

Substantive goals are elusive in collaborative projects, as flexibility and adaptation can mask measurable long-term outcomes, especially in government initiatives, which are based upon empirical targets (Wiersema, 2008). Doremus et al., (2011) highlights the
faltering efforts of the Comprehensive Everglades Restoration Plan, which experienced little progress, despite considerable federal funding, as too much flexibility within the project design inhibited the realisation of the programme’s main objectives.

Creating an effective environment for social learning is one of the main challenges for collaborative projects (Reed, 2008). Following a review of 105 ecosystem management projects, Yaffe (2002) concluded that dedicated participation of stakeholders was the single most important factor. Distrust between stakeholders and working groups, along with unilateral decision-making and disenfranchised participants are common issues that work against ecosystem approaches (Camacho, 2008). Therefore building a strong basis for trust between stakeholders, project aims and transparent decision-making would begin to address some common deficiencies of ecosystem approaches. Successful frameworks are developed through monitoring and experience (Camacho, 2008), as lack of funding, organisational development or technical capacity has failed working groups in the past (Susskind, et al., 2012) For example, the development of the Northwest Forest Plan in the USA balanced logging and wildlife conservation interests, despite repeated controversy and legal challenges, by using ‘Adaptive Management’ zones, with provision for continual adjustment of the management regime (Ruhl & Fischman, 2010). Giving ecosystem approaches a strong practical link to a driving concept such as adaptive management would seem to increase the legitimacy of assessments that are relevant to issues emerging on a landscape-scale (Potschin & Haines-Young, 2013).

2.7 Current significance and policy frameworks of the ecosystem-based approaches

2.7.1 Global scale
The CBD and Millennium Ecosystem Assessment (MEA) lead the international stage in developing common policy frameworks for the EA and ESS. Fee et al., (2009) highlights that implementation of EA has been limited to international and national administrative levels. This prevents application of practical management due to poor information
exchange and insufficient cooperation, thus obstructing implementation of EA. Fee et al., (2009) go on to suggest that targeted roadmaps, detailing development from National policy through all levels of governance would provide much needed guidance (Fee, et al., 2009). Such roadmaps could be developed on a regional or local level, which focus on delivering local interpretations of an EA that are relevant to individual land managers (Collier, 2015).

Incorporating conservation values into multiple sectors as an economic entity would increase their acceptance and give EA a stronger identity (Smith & Maltby, 2003; Haines-Young & Potschin, 2008). Therefore, it is vital that managers identify as core drivers of the EA process, which may involve stakeholder participation and incentives (Fee, et al., 2009). These actions would develop an EA that includes connections between ecosystems in a landscape, moving beyond protected areas and single species conservation (Hannah, et al., 2002). However, EA needs greater penetration at lower levels of governance to influence practical land management (Hiedanpää, et al., 2011). Integrating EA with Climate Change strategies may provide opportunities to introduce it as a central aim for managers and decision-makers (Carmon-Torres, et al., 2011).

The MEA assessed the consequences of ecosystem change for human well-being and the scientific basis for conservation and sustainable use of those ecosystems (MA, 2005). This assessment has fostered communication and understanding between policy-makers, scientists and the business community (de Groot, et al., 2010). However, practical application through land use planning and decision-making have been challenging (Daily, et al., 2009; Naidoo, et al., 2008). One way this thesis addresses this problem is to design a methodology that incorporates land use planning (woodland) alongside regionally specific decision-making support tool (Chapter 6).

The MEA identifies knowledge gaps and uncertainties at local and national scales, noting insufficient information on full economic costs and benefits of alternative ecosystem uses (MA, 2005). The decision-making support tool mentioned above aims to provide economic costs and net revenue on woodland used for forest energy. The main purpose
of the MEA was to develop improved decision-making for EM and human well-being, while building a combined platform for science and policy (Larigauderie & Mooney, 2010; Mooney & Mace, 2009). Currently the MEA framework encourages further development and research by governments and institutions to implement ESS and EA at multiple scales.

2.7.2 UK & Scottish

Almost every environmental planning framework in the UK is adopting EA as an avenue to deliver holistic management, tracing a common route from the CBD principles, through the EU WFD to national policy frameworks. Currently the EA has been included as a core framework for Marine and Coastal Strategies (Laffoley, et al., 2004), UK Forestry Standards (FC, 2011) and by the Department for Environment and Rural Affairs (DEFRA, 2011). DEFRA (2011) describes EA as a framework that encourages broad decision-making for valuing the ESS to ensure society can maintain a healthy and resilient natural environment. As such the EA that has been adopted by national government could be considered an ecosystem services approach, which has become an increasing focus in ecological economics and in wider environmental management discourse (MEA, 2005; UK NEA, 2011; TEEB, 2010). Considerations of spatial scale interactions, ranges of constraints, and people that drive integration of ESS valuation are pivotal. This emphasised further by the UK Houses of Parliament commitment to supporting EA through national advisory publications (Wentworth, 2011). Additionally, the UK Bioenergy Strategy incorporates EA and ESS through reduction of greenhouse emissions, diversification of land use and stimulation of rural development (DECC, 2012).

In 2011 the UK released its first National Ecosystem Assessment (UK NEA) report. Driven by the MEA (2005), it provides a comprehensive picture of ecosystem services trends and response strategies. The report is being developed for a wide range of stakeholders and varying spatial scales, focusing on several key areas:

1) Development of economic analysis to better understand the value of ESS
2) Exploration of cultural ESS and how their value can be integrated alongside economic valuation.
3) Exploring ecosystem changes and how they will influence landscapes and societal responses.

4) Development and enhancement of tools and other materials to engage a range of key stakeholders and organisations, providing best practice (UK NEA, 2012).

One of the main outcomes of the UK NEA is the embedding of EA and ESS aims as fundamental techniques for strengthening decision-making at all scales, from landowners and local government to national administrations (UK NEA, 2010).

Scottish Policy is also incorporating EA and ESS into relevant frameworks. The Forestry (2006), Agriculture (2006), Land Use (2011), Biodiversity (SG, 2004) Strategies, Central Scotland Green Network (2012), and Marine Plan for Scotland (SMP, 2011) all incorporated ecosystem approaches and management. The Scottish Land Use Strategy (SG, 2011) brings together forestry, agriculture and biodiversity, setting out three core objectives, which focus strategy into thirteen proposals (See Figure 2.4) (SLUS, 2012). In (HC, 2012) the Highland Council Rural Affairs and Climate Change Strategy Group adopted Scotland’s land use action plan. Within this report the Council’s role in encouraging partnerships and delivery of the strategy, and the principles are central in land use planning and policy development.
Recent Scottish policy documents present bioenergy, rural energy development and forest energy as cornerstones of land use strategies. The UK NEA (2010) draws attention to the increasing importance of this sector because the UK relies heavily on biomass imports, highlighting the potential growth in production and use. Diversification of agriculture land, estates and forests in Scotland is encouraged by the NEA (UK NEA, 2012), as it may help with regional development. The Highlands has extensive renewable resources, including hydro, wind and bioenergy. Creating a domestic sustainable renewable energy supply based upon regional industry and contributing to Scotland’s Climate Change targets are top priorities for the Highland Council. Potential

**Figure 2.1** – Scottish Land Use Strategy core objectives and proposals (Boxed and highlighted areas indicated particular relevance to this research)
developments of renewables is directed through Strategic Environmental Assessment (SEA) whereby the cumulative renewable projects (current, underdevelopment and future) are assessed on a regional level to understand their overall impact on the Highland region (HC, 2006).

Land use is a cross cutting theme in the Scottish Climate Change Adaptation Framework (SG, 2009). Promoting spatial planning, integrative and adaptive measures as well as collaboration. Action plans support the development of an EA by identifying multiple benefits from land use and investing in further research to develop practice through guidelines for decision-making. Furthermore, the Scottish government is eager to see EA applied as a core methodological approach for case study research (SLUS, 2012), such as this thesis that uses individual land manager insights and planning preferences to inform a regional interpretation of EA. Spatial planning and integrative policies is evident in Highland region strategies (Energy and Woodland) that use mapping policies and exercises to inform regional planning of renewable energies and hotspots for woodland expansion that does not impede upon prime agricultural and grassland (HC, 2006). However, these maps are relatively coarse grain, applicable to the Highland region and may not be relevant to individual land managers. A finer grain approach that focusses specifically on individual land boundaries connected over a larger region of boundaries could inform the bridge between individual decision-making and management to that of landscape scale (Muñoz-Rojas, et al., 2015).

National strategies are key to fulfilling the potential of practical integrated approaches to land management (SG, 2006; SG, 2006; SG, 2011). Farm generation of renewable energy to reduce climate change impact, in conjunction with farm forestry, represents the converging goals of Scottish land use strategies (SLUS, 2012). Farm forestry (also known as farm woodlands and forest energy) has the potential to become a leading example of the EA in practice. Land managers could use EA guidelines and planning tools to create climate change friendly land management, which would account for ESS’s at multiple scales. Such approaches would contribute to woodland expansion targets to plant 10,000
ha of new woodland per year. This, integrated with other land uses, offers the potential to support rural economic growth (FCS, 2009).

2.8 Ecosystem approaches in practice

This section explores ecosystem approaches that currently exist, demonstrating the successes and directions of ecosystem approaches in practice. Best and sustainable management practice is difficult without knowledge of land capability, which can clearly identify critical constraints and opportunities. Brown et al., (2012) presented valuable insights into the impacts of current and future climate change on land use potential through landscape mapping scenarios. Although specifically designed for agricultural land the data compiled can be used for multiple sectors, professions and policy-makers (Brown, et al., 2008). The strategic nature of the information makes it ideally suited to landscape level planning and emphasises land capability importance in anticipating adaptation to future climate change trends. In addition, the study identified soil moisture as a significant attribute for predicting land use options and incorporating this information into future models, should make planning and management more robust (Brown, et al., 2008).

Aspinall and Milne (2009) examined relationships between ESS and land systems in the north-east of Scotland. These were based upon water catchments, allowing the research to address scalar dynamics, which are vital for interpreting ESS for policy at multiple levels. Furthermore, the study area represented an extensive range of mixed land uses, ecosystem services and habitats, representative of the environmental diversity found in the region (Aberdeenshire). To complement the environmental context the nested areas encompassed several administrative areas, which gave the study a socio-political context. The outcomes from this type of study can provide better understanding of the ecology and interactions of ESS in the region. In effect, this study built a model to predict future land use changes and their influence on ESS, by using methodologies that emphasise strategic spatial management.
The Scotland River Basin Management Plan takes a source-to-sea approach, integrating land and water management for effective protection and improvement of the water environment (SRBMP, 2009). This plan embraces EA, as impacts upon one part of the river are shown to affect other parts of the basin, thus demonstrating that all aspects of land use activities and their interaction with catchment waters, as well as human populations, have to be considered in the planning process (SRBMP, 2009).

Biosphere Reserves are recognised as globally significant environments, which promote and demonstrate a balanced relationship between people and nature (UNESCO, 2012). They are regional areas that value and promote sustainable development, biological and cultural diversity, conservation and economic growth. The Biosphere Reserve is a rare example of an EA being implemented on a large scale, through trans-regional landscapes where conservation and development work alongside one another (UNESCO, 2010). Cooperation, education and research connect local communities, environmental groups and economic interests into collective action for the benefit of the Biosphere.

Galloway and Ayrshire is the first of the new style Biosphere Reserves in Scotland and only one of three in the UK. It is divided into three complementary management zones: core, buffer and transition (See Figure 2.5) (UNESCO, 2010). The reserve is defined through the ecological boundaries based around upland areas which centre on the Merrick Kells, a water catchment that provides water for south-west Scotland and feeds a number of rivers, lochs and water bodies before it reaches the sea (GABR, 2012). This reserve provides an area of commonality and interaction for multiple ecosystems, which in turn is managed for the landscape as a unique cultural and environmental identity. Specific strategic aims and action plans will be developed in partnership with stakeholders and local organisations to address and support the core purpose of ‘testing and demonstrating sustainable development on a regional scale’.
Collaborative deer management is another example of an ecosystem based approach in Scotland designed to respond to the challenges of integrated, adaptive and ecosystem management. Deer Management Group’s (DMG) occur across the Highlands using an integrated management platform that links established groups to address changing environmental practices (Davies & White, 2012). The Cairngorms Speyside Deer Management Group is one such example that uses a GIS based platform and internet presence to help inform the collaborative approach (CSDMG, 2015). Participatory natural resource management processes such as deer management groups, are increasingly used to address the complex and conflicting values placed upon environmental resources (Mckenzie, et al., 2010). Stakeholder engagement is taking on an important role in balancing the traditional top-down processes with bottom-up approaches that promote a more sustainable, equitable and comprehensive management model (Berkes, 2010). Although stakeholders have influence over management (Prell, et al., 2009) a collaborative process can potentially dilute the equitable distribution of benefits and costs (Lockwood, 2010).

Deer are a landscape resource, which cannot be managed by a single manager or landholding (Mitchell, et al., 1986). The impacts of their management, control and behaviour on one landholding can affect others. Deer populations in Scotland have
increased significantly in recent decades, causing greater conflict with woodland cover and regeneration (Côté, et al., 2004). Management of private land for social and biodiversity objectives that result in community benefits can have significant implications for deer populations, as certain population levels are more suited to specific land management aims. Although a significant proportion of landowners retain comparatively high deer populations for sporting purpose, many also require lower deer numbers to limit browsing as woodland creation and management is becoming a priority (Fiorini, et al., 2011). These factors, combined with the impetus for integrated management demonstrates the need for collaborative approaches, which encompass property boundaries and landscapes.

Davies and White (2012) used a mixed methods approach of semi-structured interviews, questionnaires, and participant observation from three interconnected initiatives to represent a landscape framework. Even with an established organisation like a DMG, the task of balancing divergent objectives remains difficult, despite wide acceptance and respect within the group. Collaboration was viewed as a cautious and delicate process, because benefits and costs, especially public goods, could be unevenly distributed (Davies & White, 2012). Deer are a fluid resource. They move across the landscape, influencing ESS and cultural values, while adapting to external pressures such as landscape, climate and human population change. Deer require a landscape scale management approach.

Other resources have focussed landscape scale action and increasingly take the form of partnerships. For example the Peatland Partnership includes, Scottish Natural Heritage, Forestry Commission, RSPB, Highland Council, Plantlife International and Environmental Research Institute (Peatland Partnership, 2016). These core organisations along with interested parties carries out and helps fund the aims of the partnership, as detailed in a joint management strategy, which looks at the balanced management of peatland restoration, carbon stocks, deer resources, forests, bird habitats and renewable energy development. Such initiatives develop from important regional characteristics, which aids the formation of strategies and management priorities. Strong links with Climate Change strategies and spatially defined carbon catchment areas has developed a solid
platform for securing funding and ranking high in national priorities (Dinsmore, 2014). Another landscape partnership related to carbon sequestration that has emerged in recent years is the Forestry Commission Carbon Code, which encourages voluntary partnerships between woodland managers (creating carbon stocks) and buyers (those wanting to buy carbon) (FC, 2015). While only a few projects have taken advantage of such schemes, the forest owners highlight the extra financial contribution to woodland creation as a large motivator (FC, 2016). Additionally, such schemes that recognise less tangible inputs provide a substantial link to Climate Change management actions, connecting local forests to larger landscapes of concern (Everard, et al., 2014; Sheppard, 2015).

Energyscapes is a new concept that uses the complex spatial and temporal combination of supply, demand and infrastructure for energy within a landscape (Figure 2.5), and will play a key role in shaping interpretations of ecosystem approaches in this thesis. This provides as basis for considering the positive and negative interactions of ecosystem services within a particular area (Howard, et al., 2013). The growing discourse and concern of domestic energy supply and renewable energy investment places this energy based approach for assessing ecosystem services at the forefront of current resilience and environmental planning thinking (Rist, et al., 2014; Hodbod & Adger, 2014). Importantly, this assessment adopts a multi-disciplinary approach including detailed landscape knowledge, energy options and different stakeholder perspectives, all of which feature prominently in definitions of ecosystem approaches (UNEP, 1992; DEFRA, 2007).

![Figure 2.3](environnmental/ecosystem/energy/energyscapes.png) – Energyscapes spatially planned through land use types and predicted energy demand
In Scotland, two other constructs represent significant potential for EA application: estates and National Parks. Large rural landholdings (known as estates) are often referred to as examples of integrated management, which incorporate a mix of land uses, and often deliver community benefits (Warren, 2009). EA is a strategic framework for Scotland’s National Parks, which provide an ideal regional landscape setting with boundaries and working partnerships (CNPA, 2012). Both of these land use management units operate over specific areas and are well-placed to adopted energyscapes concepts, carbon sequestration mechanisms and collaborative partnerships that tailor management to local conditions.

2.9 Summary
Despite adoption by the CBD and subsequent organisations at different scales (DEFRA), the ecosystem approach is still undeveloped as a management concept, mainly due to confusion over definitions and application. People are embedded at the centre of the concept, along with adaptive and collaborative management, processes that feedback into flexible management systems. The role of resilience is becoming increasingly important and identifying meaningful application of resilience for both socio-ecological and socio-economic systems may help land managers understand policy and other concepts such as ecosystem services. Strong links to spatial areas over several land management units is a common attribute of projects that are deploying ecosystem approaches on the ground, and within these areas partnerships play a formative role in landscape scale management.

Carbon sequestration schemes integrated into management plans as core objectives may encourage greater entry into recognising aspects of ecosystem approaches. However, including individual land managers’ perspectives and management requirements within their region is a significant gap in ecosystem approaches, as often development is hindered at higher scales. Therefore exploring the application of ecosystem approaches from a bottom-up approach that relies on the input of individuals and finer grain information from both socio-ecological and economic perspective could establish a more
promising platform for ecosystem approach application. For this to occur innovative and multi-disciplinary approaches, such as Energyscapes, which incorporates spatial planning, land use options and stakeholder perspectives might prove important in future ecosystem approach developments. Bridging organisations could play an important role by providing access to emerging market mechanisms and supplying management plans, through which traditional management can operate alongside ecosystem orientated goals.
Chapter 3

Land Use in the Highlands

3.1 Introduction
This chapter covers land use history in the Highlands and links current land use drivers to woodland planting opportunities and other integrated land uses that could support woodland planning. It will also inform land manager attitudes towards woodland in the Highlands through historical perspectives, as well as current and traditional land pressures that influence estate manager decision-making. Use of woodland for forest energy markets will be evaluated within the context of the Highlands, focussing upon its suitability and range within the region. The combination of historic and current land use management in the Highlands can indicate the potential for landscape-scale collaboration for private land managers.

The Highlands evoke powerful imagery ranging from mountains and hills to large lochs and Caledonian pine forests. In the past the Caledonian forests were widespread and provided a more enclosed habitat suitable for predators such as wolves and bears. It was commonly believed that Scotland was once covered in an uninterrupted wildwood that extended over the majority of the north (Smout, 2002). However, this view has been challenged recently, suggesting that cyclical transitions of patchy and fragmented forest were more common (Smout, 2000; Muir, 2005; Tipping, 1991). Before human development over-utilised the resource, it is thought that woodland covered 50-60% of the country around 5000 years ago (Smout, 1993; Turnock, 1995; Tipping, 1991). Through a combination of socio-political pressures, the native forests of Scotland, especially the pinewoods, have undergone exploitation and reduction for many centuries as agriculture and sporting use became prominent (Hobbs, 2009).
3.1.1 Socio-Political Influences

At the end of the Jacobite Rebellion the Highlands underwent a period of transformation (Devine, 1994). As the Highland Clans were systematically dismantled, the traditional social fabric and land use changed (Lenman, 2004). This period of dramatic change (1750-1800) in land use and population distribution is known as the ‘Highland Clearances’. A combination of factors led to the eviction and emigration of thousands of Highland residents (Richards, 2002). The transfer of hereditary lands to Clan chiefs with no familiar ties compromised the security of agricultural small holdings, which led to the expansion of more profitable intensive land uses. In the early 1800’s potatoes were introduced and cattle husbandry was replaced by extensive sheep grazing, which was less compatible with small-scale farming. The removal of farming communities during the clearances was made possible by the lack of land tenure rights (Wightman, 2013). Unable to survive in coastal areas people emigrated to other parts of the world, including the USA, Canada and the Caribbean (McIntosh, et al., 1994). Populations were dramatically reduced due to changes in labour requirements, as only a single sheep farmer was necessary to manage thousands of sheep (Love, 2001). This population upheaval was heightened by the potato famine, which drove thousands from the land to seek other opportunities.

A new shift in land use and population dynamics was to affect Scotland after the Napoleonic war in 1815 (Hobbs, 2009). As demand for lamb and wool declined and infrastructure improved in the Highlands large parcels of land were bought by wealthy landowners for recreation, known as ‘Balmoralisation’ led by the British royal family and the status associated with shooting (Warren & McKee, 2011). Hunting (Red deer), shooting (Red grouse) and fishing became key land use objectives on many Highland estates and extensive management of red deer and other game species has continued throughout the intervening period (Hobbs, 2009). Farming communities were not the only land use to suffer; in the Cairngorms for example, forests in Abernethy were cleared for a deer reserve, with the 104 forest workers replaced by seven employees (Smout, 2006). By 1912 around 203 Highland estates existed (Innes, 1983), which amounted to 1.5 million hectares under sporting estate control (Smith, 1993). Higgins (2000) suggests
that there are some 334 sporting estates in the Highlands and Islands, which represents over 43% of all privately owned land (approximately 2.1 million ha, see *Figure 3.1*).

![Figure 3.1 – Distribution and extent of Sporting Estates in the Highlands & Islands (*Higgins, et al., 2000*).](image)

### 3.1.2 Woodlands in the Highland landscape

The Highlands is often viewed as a landscape of open hillsides and heather moorlands. At the beginning of the Holocene (12,000 years ago) juniper (*Juniperus*) was abundant. birch (*Betula*) and hazel (*Corylus*) woodland succeeded juniper, while oak (*Quercus*) and elm (*Ulmus*) occupied lowland areas, the Western Highlands and favourable Straths (*Huntley, et al., 1997*). Alder (*Alnus*) was a late arrival in the Highlands but has since spread throughout the region (*Birks, 1989; Bennet, 1990*). By 6000 BP Scots pine (*Pinus sylvestris*) had spread to become the principal forest species in the Highlands (*Gear, 1989*), oak continued to dominate the forest canopy in the West (*Birks, 1977*), and Birch/Hazel woodlands persisted in the north and south (*Huntley, 1981*). Extensive forest cover remained in many lowland areas of the Highlands until relatively recently, as much of the land was unsuitable for cultivation (*Huntley, 1981; Tipping, 1991*).
greatest extent of Scottish woodland occurred around 5000 years ago when Scots pine advanced from the heart of the Highlands and colonised drier peat bogs in the north. Hazel and oak dominated woodlands colonised the west and east coast of the Highland region (Oosthoek, 2013). A climate induced deforestation took place around 500 years ago turning the climate cooler and wetter, waterlogging woodland and leaving Scotland without a mature tree structure (Moir, et al., 2010). Along with agriculture this had been thought to have shaped the open blanket bog environment but recently these habitats are thought to have been already established by the time farming arrived in the Scottish uplands (Tipping, 2008).

Tipping suggests that in eastern Highlands low-intensity grazing sustained over long periods of time led to serious woodland decline long before the Romans arrived (Tipping, 1991). In the Bronze established pastoral systems with more persistent tree clearance occurred and from 500 BC agricultural intensification coincided with a period of increased woodland clearance across Scotland, including the Highlands (Smout, 2003). By the end of the first millennium most of the wildwood had disappeared from Scotland, except for some remote parts of the Highlands, and woodland was below to 20% cover (Kirby, et al., 1995). In 1300 timber supplies for buildings and structural purposes (oak) were already exhausted, as timber was often taken from protected reserves and the introduction of hedgerow and montane species were being increasingly used (Crone & Watson, 2003). Even in the 1500’s the importance of a sustainable timber supply was recognised and in 1503 the Scottish Parliament claimed that “Scottish woodlands were utterly destroyed”, and subsequently passed two Acts to ban felling and burning or woodland, and secondly instructing landowners to plant an Arce (0.4 hectares) of new woodland where there was no large woodland or forest (Brown, et al., 2005). The importance of woodland to national security and the economy continued but protectionist laws failed to make an impact on the contraction of Scottish and Highland woodlands. Many of the issues lay in the traditional use of woodland resources by communities and the local Lairds lack of ability to enforce aspirational protection laws (Brown, et al., 2005). For century’s aspirational woodland planting and protection targets have been difficult to
enforce and the gap from aspirations to action lay between local users and the Lairds, making woodland a centre of conflict over the landscape for half millennium.

The introduction of domesticated grazing herbivores in the late 1700’s was the principal cause of deforestation in the Highlands (Holl & Smith, 2007), with further reductions caused by climatic changes that lowered the treeline, removed forests from more exposed areas and increased the extent of blanket mires (Huntley, et al., 1997). From the 19th century onwards forest cover declined due to extensive sheep grazing, which also suppressed natural regeneration (Hanley, et al., 2008). Over a third of Scotland’s mature forests were logged for shipbuilding and fuel during the two World Wars (Dunlop, 2002). Forest cover and natural regeneration were inhibited further as a result of burning of the heathlands to increase Red grouse habitat for sporting objectives (Hobbs & Gimingham, 1987) increased red deer populations and browsing pressures (Cote, et al., 2004).

3.1.3 Drivers for afforestation and modern forestry

Afforestation in the 18th and 19th centuries saw the introduction of exotic conifer species: Norway spruce (Picea abies), European larch (Larix europea), European silver fir (Abies alba), North America Douglas fir (Psuedotsuga mensizii), Sitka spruce (Picea stitchensis) and lodgepole pine (Pinus contorta). In 1919 the Forestry Commission (FC) was established to create a strategic reserve and a rigid commercial approach led to the establishment of large monocultures of exotic conifers throughout large parts of the Highlands (Slee & Wall, 2006). These planted areas aimed to maximise timber production but failed to consider landscape design objectives or long term sustainability. Planting schemes continued after 1945 but increasing competition with food security objectives marginalised woodlands further north and at higher altitudes, resulting in reduced productivity and woodland diversity (Mather, 1993).

Forest cover in Scotland increased from 4.5% (7% in the Highlands) at the beginning of the 20th century (Mather, 1993) to 16% at the turn of the 21st century, with non-native conifers making up the bulk of new plantings (FC, 2012). Private forestry became prominent in Scotland as large landowners and companies took advantage of tax-saving...
benefits of forest investment (Warren, 2009). Plantation forestry replaced smaller-scale regionally compatible woodlands, which reduced woodland biodiversity in many areas (MacKay, 1995). These new plantings had little impact upon the rural economy until new farm forestry measures, introduced in the late 1980’s, provided annual payments and planting grants (Mather, 2004).

The afforestation efforts of the 1960-80’s resulted in a rapid approach forest expansion that negatively impacted the ecological integrity of many regions. The negative impact of plantations was highlighted by the controversy of the Flow Country. Caithness and Sutherland possess the richest repository of peatlands, bogs and pool systems in the northern hemisphere (Pearce, 1994; Warren, 2000). In the late 1970’s and early 1980’s the Flow Country was targeted by private forestry due to several factors. These included large areas of open land being sold at low prices, improved ploughing technology and the introduction of fast growing coniferous species with potentially high yields (Sitka spruce and lodgepole pine) (Warren, 2000). The region was set to lose 67,000 ha of peatland to plantations but was halted by the collective action of conservationists and media attention (Stround, et al., 1987). Ultimately the controversy encouraged conservation, biodiversity and community-orientated aims in forest planning (Warren, 2000). In time this led to indicative forest strategies and adoption of multifunctional forest management (Warren, 2009). However, some unhealthy and unproductive stands from those private forestry initiatives remain in the region and continue to impact forestry’s image in the area.

3.1.4 Land manager attitudes to woodland expansion

As demonstrated in section 3.1.1 sporting estate owners represent an influential group of land managers. Any policy’s success, such as the woodland expansion heavily relies upon corporation and engagement with estate owners due to the vast amounts of the Highlands that they manage. Lawrence and Edwards (2013) highlight that estate owners manage for historic landscape values and represent the largest area of unused land in Scotland and therefore the greatest potential for woodland creation. However, cultural barriers for traditional owners in realising the potential of their land is difficult to change, as planting of woodland, especially productive woodland has been a low priority (Lawrence
& Edwards, 2013). Most owners have to consider economic success before they can act upon other land use priorities (Miller, et al., 2009), and for many estate owners deer stalking, grouse shooting and fishing (sporting pursuits) constitute the majority of the estate’s economic stability, which support large proportions of the estate’s land (MacMillan, et al., 2010). Main themes of land owner attitudes cover production, diversification, responsibility, ecology and community with main aims to reduce input costs, take advantage of niche markets and improve the quality of land for future generations and local communities (Miller, et al., 2009).

In essence the majority of land owners view themselves as environmental stewards. This stewardship often extends to traditional priorities, and local landscape narratives that inform dominant management practices where commitment to sporting activities precludes investment in forestry inputs that contributes low economic returns to the estate and traditional management practices (Miller, et al., 2009; Macmillan, et al., 2010; Lawrence & Edwards, 2013). This thesis focuses upon attitudes toward woodland expansion and management on sporting estates that have typically held an antipathy toward woodland in favour of sporting use with the aim to uncover potential avenues for integration of tradition and woodland use. Morgan-Davies et al., (2015) that such concerns as Climate Change and carbon management has shifted the balance from delight for the few to use for the many, which may give greater preference to woodland expansion, as woodlands provide multiple services that cannot be explicitly monetised. Glass et al., (2013) developed a sustainability assessment toolkit for upland Scottish estates, which identified five sustainable estate principles: Adapting Management; Broadening Options; Ecosystem Thinking; Linking into the Social Fabric; and Thinking Beyond the Estate. This interpretation for sustainable estate management recognised the further need for changes in manager behaviour, if such principles were to be translated into practice (Glass, et al., 2013). Additionally collaborative attitudes that enhance accountability and connectivity across landscapes was viewed as important to further embed environmental and social responsibility into sustainable estate management, which supports the need to better understand and integrate social-ecological perspective into landscape scale management to develop collaborative relationships and stronger science-practice interfaces (Fischer, et al., 2015). Therefore in order to gain a better
understanding of collaborative thinking and connectivity of land use practices individual managers perspectives on useful and feasible landscape actions need to be recognised and integrated into a transboundary construct. This thesis attempts to assess land use practice connections through planning and analysis over multiple scales (Chapter 5.2-7).

3.2 Land use drivers
As governments seek to make better use of their resources and develop policies that aid implementation of multiple land use objectives, increasing importance has been placed on understanding the influences driving land use decision-making. This section will review five core drivers of land use in Scotland and more specifically the Highlands.

3.2.1 Environmental
Responses to Climate Change and well-being of human populations are recognised as key components of multifunctional land use (MA, 2005). Increasing adaptability and ecological resilience will support these aims across planning and policy. Climate change is likely to significantly affect the range of land use options in Scotland, including expansion of agriculture, increased range and yield for trees species, as well as heightened vulnerability to disease (Brown, et al., 2008). This could create increased competition for land or provide opportunities for integration (Slee, et al., 2014; Cavers, 2015). Under the Climate Change Scotland Act (2009) the government has committed to a 42% reduction of greenhouse emissions by 2020 and 80% reduction by 2080. The Act sets out strategies for mitigation and adaptation to climate change through Scotland’s commitment to a low carbon economy. Agriculture is Scotland’s second largest contributor to greenhouse emissions (20%) behind the energy sector (37%), however agriculture and forestry are significant GHG sinks (Sutherland, et al., 2011). Increasing renewable energies, greening of agriculture practices, and woodland expansion offers the government viable strategies for reducing GHG’s.

In the last 20 years sustainable forest management has risen to prominence (Mason, 2007), and has been further embedded in global and local environmental planning due to
its role in delivering ecosystem services. Scotland’s national policies (SCCAF, 2009; SG, 2006; SG(a), 2011) identify woodland expansion and best practice as crucial to implementing climate change actions. Forest management is moving away from exotic conifer plantations towards an emphasis on native species mixtures (Gimingham, 2002) to diversify forest structure (Humphrey, 2005) and improve integration (Humphrey, et al., 2006) with agriculture and deer management (Swales, 2009). However identifying locations for expansion as well as increased integration is difficult. The Woodland Expansion Advisory Group is attempting to address this issue with country-wide consultations (WEAG, 2012). New woodland needs to balance all considerations, such as flood risk reduction (Nesbit & Broadmeadow, 2003), biodiversity, energy crops and contribution to the local rural economy (FCS, 2009).

Woodland expansion aims to increase woodland cover to 25% by 2050 with planting targets of 10,000 ha/year and increasing the provision of woodfuel. The Scottish Rural Development Programme provides land managers with support, advice and grants to implement such schemes and projects that will aid the Scottish Government to meet their targets (SRDP, 2015). Land managers are regarded as critical to efforts of practical and effective responses to climate change (Haines-Young & Potschin, 2008; Matthews, et al., 2008; Reed, et al., 2009).

Agriculture has undergone dramatic changes in recent history. Farmers are reconsidering the practical and financial viability of livestock due to changes under the Common Agriculture Policy (CAP), which decoupled the Single Farm Payments (SFP) and introduced more diversified and environmentally sensitive regulations (EU, 2013). The new round of the CAP (2014-2020) aims to support small and start-up farms, as well as increasing support for livestock on rough grazing land. Rural development, supported by the Scottish Rural Development program (SRDP), plays a central role in encouraging landscape-scale collaboration, innovative practices, knowledge transfer and rural infrastructure (SRDP, 2015). The restructured CAP reflects the visions set out in Scotland’s most recent land use strategy, which emphasises the importance of cross-sector, cross regional and locally focussed integrated land use (SG(a), 2011).
Water resources and soils are important to land use in Scotland and the Highlands. As cross-cutting and fundamental resources to land use they provide a base for common frameworks and integrative policies to manage multiple land use functions (Miller, et al., 2009). For example, the peatlands in the Flow Country are critical to the regions biodiversity and carbon stores (Warren, 2000), which require careful land use planning. Water management maintains flooding control, drinking water, habitats and irrigation for land based industries (SMP, 2011), offering landscape-scale management opportunities. Management structures can form around catchments, such as the Spey Catchment Initiative in the Cairngorms National Park (SCI, 2015) and the Galloway and Southern Ayrshire Biosphere Reserve (GSAB, 2015). These areas recognise the importance of land use balance and the capacity of the catchment to support multiple objectives, which will have interactive and reciprocal effect on land use practices for the region.

Land use is dependent upon climatic conditions, temperature variations, rainfall, seasonality and atmospheric composition (Reed, et al., 2009). Climatic change (including atmospheric composition, rainfall, acidification levels, soil erosion and temperature) can create new conditions and responses that affect species distribution, formation of habitats, regional weather patterns, and the capacity of land management practices to support human communities (Evans, et al., 2004; Monteith, 2007; Brown, et al., 2008).

3.2.2 Demographic
Scotland’s population is approximately 5.3 million with the Highlands and Islands home to 233,000 people (5% of the national population) with an area of 39,050 km², which is just under 50% of Scotland’s entire land mass (NRS(a), 2015). The Highlands and Islands has one of the lowest population densities in Europe of 8 people per km², compared to the EU average of 116 per km², the UK average of 242.4 per km² and the Scottish average of 64.8 per km² (NRS(b), 2015). Remote communities exist in the Sutherland and Caithness (2 people/km²), as well as on ninety inhabited islands, which hold 23% of the Highland population (NRS(c), 2015). Inverness and the surrounding Moray Firth localities
comprise 20% of the regional population; however the majority of people (61%) live in settlements with less than 5000 people (NRS(c), 2015).

By 2031 Scotland’s population is estimated to rise by 5% to 5.9 million. The Highlands and Islands are projected to increase their population by between 5 and 15%, concentrated around the Inverness and Moray Firth region. Remote rural areas also showed a significant rise in the proportion of the population aged over 60 (SE, 2005), emphasising the increasing imbalance of working age population. These factors will have a direct bearing on availability of skill base, development and services, possibly influencing attitudes towards rural sectors, such as forestry and their support of the rural economy (Miller, et al., 2009). Another significant driver of change is the balance and composition of rural communities, including ratio of second homes and their use, in and out mitigation of different age groups and professionals and increased commuting distances for work.

3.2.3 Economic
Economic factors have a significant influence over land use change and decision-making, affecting the composition and management of the landscape (FCS, 2009). Market fluctuations drive land use, reacting to costs of production and demand. For example timber prices in Scotland rose in 2007, as the strength of the Euro against the pound increased the cost of importing timber, and encouraged processors to buy domestically produced timber (Cameron, 2011). Food security and energy account for a large proportion of economic activity in Scotland (Swales, 2009), which cause reactions in other markets, such as forestry (i.e. cost of fuel for transport/decreasing value of wheat and livestock) (McKay, 2006; Sherrington, et al., 2008).

Recent trends, such as foot and mouth, currency strength, global commodity lows and reliance on productive farm subsidies have contributed to the decline of agriculture. However, recent food shortages increased the price of wheat to a record high in 2009, in spite of the sharply rising cost of fuel and fertilisers used during production of the crop (Feliciano, et al., 2013). Traditional farming practices have been reinvigorated as food
security concerns have increased; consequently agriculture commodity prices are predicted to rise in the foreseeable future (OCED-FAO, 2009; Schwarz, et al., 2009). The continual fluctuations in farm prices and changing subsidy climate have highlighted the fragility of the farm business model in the Highlands, which rely on targeted grants (SRDP, 2015). Tourism and recreation is an important contributor to the rural economy generating £9.3 billion in 2013 (Table 3.1). It is Scotland’s second largest employer behind energy and low carbon technologies (SE, 2015). In response to uncertainty, many farms are diversifying their activities to include recreation and tourism, as well as food and drink elements (Table 3.1). The industries that show most growth and continue to be Scotland’s largest contributor to the economy are the energy and low carbon technology sectors (26% of national GVA) (SE, 2015). In the Highlands Agriculture, forestry and hunting accounts for 4.6% of the sector GVA contribution, whereas over Scotland this figure drops to 1.8%. Hotels, restaurants (6.7%), health and social work (9.6%), as well as transport and communications (9.1%) are significantly higher in the Highlands than the rest of Scotland (SG, 2008).

Table 3.1 – Economic contribution of Scottish industries (SG, 2013; PACEC, 2014; SE, 2015)

<table>
<thead>
<tr>
<th>Industry</th>
<th>Gross Value Added (GVA)</th>
<th>Percentage of National GVA</th>
<th>Employment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy and low carbon technologies</td>
<td>£23.1 Billion</td>
<td>26%</td>
<td>254,000</td>
</tr>
<tr>
<td>Tourism</td>
<td>£9.3 Billion</td>
<td>11%</td>
<td>181,500</td>
</tr>
<tr>
<td>Forestry and timber technologies</td>
<td>£1 Billion</td>
<td>1.1%</td>
<td>50,000</td>
</tr>
<tr>
<td>Chemical sciences</td>
<td>-</td>
<td>-</td>
<td>70,000</td>
</tr>
<tr>
<td>Construction</td>
<td>£8.7 Billion</td>
<td>10%</td>
<td>170,000</td>
</tr>
<tr>
<td>Creative industries</td>
<td>£2.8 Billion</td>
<td>3.2%</td>
<td>65,200</td>
</tr>
<tr>
<td>Aerospace, defence and marine</td>
<td>£1.8 Billion</td>
<td>2%</td>
<td>38,500</td>
</tr>
<tr>
<td>Financial and business services</td>
<td>£13.9 Billion</td>
<td>16%</td>
<td>215,000</td>
</tr>
<tr>
<td>Technology and engineering</td>
<td>£11.2 Billion</td>
<td>13%</td>
<td>155,000</td>
</tr>
<tr>
<td>Food and drink</td>
<td>£4.8 Billion</td>
<td>5.4%</td>
<td>118,000</td>
</tr>
<tr>
<td>Life sciences</td>
<td>£1.6 Billion</td>
<td>1.8%</td>
<td>30,000+</td>
</tr>
<tr>
<td>Textiles</td>
<td>£835 Million</td>
<td>0.9%</td>
<td>8,400</td>
</tr>
</tbody>
</table>
Most of the Highland is classed as Less Favoured Area (LFA), which is mostly used for grazing. Only a few areas are suitable for cereal crops, however, further price increases may bring greater attention to the potential of LFA’s and set-aside land for cropping (SG, 2013). This may place greater pressure on environmental and social objectives, as higher energy prices will impact livestock systems due to higher management costs, affecting the profitability of crop production systems and supply chains (ADAS, 2007). In contrast, higher costs may increase reliance upon social and environmental orientated subsidies, as agricultural management has been increasingly subject to shifting conditions and a fragile economy (Schwarz, et al., 2009). Miller, et al., (2009) emphasise the role of diversification in countering constant uncertainty for land managers, reducing risk of loss and low returns. As shown in Table 3.2 the Highland regions are heavily reliant on Service activities but the difference between the Agriculture, hunting and forestry GVA is significant with Lochaber region and Caithness region having increased GVA’s in comparison to Inverness (2.6%), the Highland (4.6%) region and Scotland (1.8%) (SAC, 2008). Orkney and Shetland possess even higher percentages of GVA centred on the primary resource industries (12 and 11.5%), demonstrating the decentralised, remote and rural reliance upon these sectors (SAC, 2008).

Table 3.2 - GVA within Highland regions (SAC, 2008)

<table>
<thead>
<tr>
<th></th>
<th>Agriculture, hunting and forestry Total</th>
<th>Industry, including energy and construction</th>
<th>Service activities</th>
<th>GVA (£ million)</th>
<th>GVA per head (£)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Caithness &amp; Sutherland and Ross And Cromarty</strong></td>
<td>6.6%</td>
<td>28.2%</td>
<td>65.2%</td>
<td>1,004</td>
<td>10,798</td>
</tr>
<tr>
<td><strong>Inverness &amp; Nairn and Moray,</strong></td>
<td>2.6%</td>
<td>26.2%</td>
<td>71.1%</td>
<td>1,665</td>
<td>14,598</td>
</tr>
</tbody>
</table>
The Highlands is considered an underdeveloped region, which makes EU Structural and Investment funds accessible for raising living standards in remote rural areas and encourages growth of sustainable rural economies (EC, 2015). New houses and infrastructure are required to keep pace with regional growth. In particular, Orkney, Argyll and the Inverness-shire areas in the Highlands and Islands are centres for growth and expansion (SE, 2005; Swales, 2009). However the Highland Council are making efforts to match infrastructure growth with multiple land uses that maintain landscape character, including agriculture, woodland mosaics and renewable energy (HC, 2012).

Forestry trends will continue to be dominated by environmental-social aims, which emphasise the non-market value of forests (Willis, et al., 2003; SG, 2006; SG(a), 2011). Grants and schemes will be vital for developing the forestry sector around multiple benefits encouraging alternative management approaches and accessing ecosystem services (MacIntosh, 2004; Haines-Young & Potschin, 2008). Economic incentive is central to supplying and supporting public goods (Slee, 2005; Daily, et al., 2009).

### 3.2.4 Policy

Policy drives land use through a complex collection of Conventions (i.e. European Landscape Convention (ELC, 2000)), EU Directives, Strategies, Regulations, Decisions, Recommendations and Opinions (EC, 2015). In Scotland overall policy objectives are transposed from international instruments and EU Directives to more specific strategies and frameworks (SG (b), 2006; CCDP, 2009; FSC/SG, 2007; SBS, 2004; SNH, 2011), which establish targets, action plans and expected outcomes. Grants (EU CAP, 2015; SRDP, 2015), market measures (MacMillan, et al., 2001; SG(a), 2011; Elliot, et al., 2014),
regulations and designations (SNH, 2012) seek to change or maintain specific activities in particular areas that are reflective of the policies. Many issues pushed by policy has led to this work being undertaken including the aims of the WEAG (2012) to meet woodland expansion targets through integrated and innovative approaches, as well as the Scottish Land Use Strategy (2011) that aims to integrate agriculture, sporting, forestry and energy objectives for the land. Meeting renewable energy of 11% for heat by 2020 is significance for woodfuel, as 50% of the renewable heat is set to come from woodfuel, which translates to between 2-3.9 million tonnes of woodfuel use (CCDP, 2009). In 2014 Scotland was using approximately 1 million tonnes of woodfuel emphasising the importance for generating increased supply and market penetration (FCS, 2015). This will also endeavour to alleviate Scotland’s fuel poverty, which is greatest in remote and rural communities, such as the Highlands (HC, 2006; Feliciano, et al., 2014).

3.2.4.1 Energy and Forestry

The Climate Change Delivery Action Plan (2009) has set a 34% emission reduction target by 2020, 80% by 2050 and includes an aim to derive 50% of gross electricity from renewable energy by 2020. The Climate Change Delivery Plan states the strategies to decarbonise electricity generation as (CCDP, 2009):

- Managing demand/changing behaviour
- Renewable electricity
- Micro-and small-scale production of electricity
- Large scale electricity generation

Land use management is dedicated to developing multiple approaches to securing Scotland’s energy future, which includes energy crops, hydropower, wind energy, biofuel conversion plants and the upgraded infrastructure. Bioenergy has potentially large implications for rural resource management (McKay, 2006; Andersen, et al., 2005) (Table 3.3). However, a continual supply of fast growing woody crops need to be sustainably produced to meet national and regional demands (CNPA, 2009; Rowe, et al., 2009; Dale, et al., 2010).
Table 3.3 – Main bioenergy options and opportunities (Adapted from sources in the Table and (Andersen, et al., 2005; McKay, 2006))

<table>
<thead>
<tr>
<th>Bioenergy opportunities</th>
<th>Status</th>
</tr>
</thead>
</table>
| Short Rotation Forestry (SRF) | • High density broadleaf species, fast growing conifer species  
• Thinnings and residues encourage a move from traditional forestry on shorter rotations.  
• SRF is suited to marginal agriculture land and can be integrated by using unproductive lands. |
| Short Rotation Coppice (SRC) | • A traditional system in the UK, which produces dense canopies of tall whippy, shoots (Tubby & Armstrong, 2002).  
• Last for approximately 30 years on rotations of 3-5 years.  
• Willow has the potential to produce high quality yields in Scotland but may be less productive on marginal and less productive lands as SRC require better quality land than SRF to produce effective yields (Andersen, et al., 2005; Bell, 2007).  
• Forestry Commission is trialling several species in geographically diverse areas around Scotland (hybrid aspen, sycamore, birch, alder, larch and eucalyptus) (FCS, 2012). |
| Energy grasses | • Miscanthus is grown extensively in other parts of the world cultivated on traditional farmland (Rowe, et al., 2009).  
• Scottish climate and growing season restricts its utility in comparison to its woody counterparts (SRF/SRC) (FREDS, 2005). Climate change may increase its suitability in the lowlands (Tuck, et al., 2006). |
• Supported by Scottish strategies (CNPA, 2009; DECC, 2009; FSC/SG, 2007; SCCAF, 2009; SG, 2010). |
Expansion of bioenergy crops could have a negative impact upon the landscape aesthetic (Verwijst, et al., 2013). Thus more integrated, multiple rotations and structures are encouraged (Holland, et al., 2015).

Potential forest growth beyond 2040 is seen as positive due to the availability of potential productive forests and timber supply (FC, 2016). However, ongoing restocking and new planting of productive forests will be important in supporting timber availability and meeting Scotland's carbon emission targets (FC, 2016). Consequently land managers have to be motivated to turn this potential into forests, which will require transdisciplinary and innovative approaches. The remit of the Scottish Forestry Strategy sets out a framework (Box 3.1), which crosses multiple sectors and creates a common bridge to deliver multiple and wide-ranging outcomes (SG, 2006).

**Box 3.1 – Main aims of the Scottish Land Use Strategy**

- Helping to tackle greenhouse gas emissions.
- Restoring lost habitats and adapting to climate change.
- Helping to manage ecosystem services.
- Underpinning a sustainable forest products industry.
- Supporting rural development.
- Providing community benefits.
- Enhancing urban areas and improving landscapes.

The Strategy aims to expand the current woodland area while managing and delivering ecosystem services (Haines-Young & Potschin, 2008). There is currently 1.3 million ha of land (16%) ecologically suitable for woodland in Scotland (FSC, 2006). A further 2.2 million ha (28%) is suitable but may conflict with agriculture land and wildland (Bibby, et al., 1991; WEAG, 2012). The scope for expansion would benefit from a landscape management framework to identity priority areas for planting (SG, 2011). The Scottish Biodiversity Action Plan (2004) and Land Use Strategy (2011) represent key contextual aspects for woodland expansion, with future planting/woodland regeneration offering considerable potential for developing native woodland networks and supporting the
protection and enhancement of biodiversity (SNH, 2015). Combining energy and forestry to create synergistic policy and practice over the landscape is a priority for the Scottish government, as the development of this relationship will be important for the future rural economy (FC, 2013).

3.2.4.2 Agriculture and Designations

The Scottish Agriculture Strategy (2006) recognises the need for diversification and encouraging rural businesses that incorporate multiple sectors (SG (b), 2006). As well as combining traditional production with diversification interests, such as forestry, recreation and tourism, there is also the need to improve communication amongst farmers that will facilitate adaptation to local conditions and external markets (Franks & Emery, 2013). Competitive markets and high environmental standards are core drivers for land use management (SG(a), 2011), however, Scottish agriculture also has to deliver a wide range of outputs through the EU Common Agricultural Policy (EU CAP, 2015).

In comparison to agriculture's contribution to the GDP and employment, the CAP is an unfunded mechanism (DEFRA, 2005). Agriculture is struggling to become more integrated to meet policy targets for rural development (Warren, 2009; Slee, et al., 2014). As the CAP is predominantly production orientated, environmental standards and regulations have at times exacerbated the issues the CAP was designed to combat (Swales, 2009). The Scottish Rural Development Programme (SRDP) is an economic, environmental and social policy mechanism, which distributes CAP funding through an integrated and cross-sectoral approach, designed to balance rural priorities and outcomes. Competitive mechanisms that meet national policy targets award contracts to those proposals best able to deliver regional priorities (SRDP, 2015) including:

- Business viability and competitiveness
- Water quality
- Adaptations to mitigate climate change
- Biodiversity and landscape
- Thriving rural communities
Potter (2006) argues that Scottish agriculture may diverge through political, regional and ecological variability. This could result in swathes of intensive production in the east and southern lowlands with diversified farms in the north and west, which are already diversifying their interests. Regionally compatible agriculture may separate markets that cater for niche farming systems giving rise to distinct farm types that focus upon productive, socio-environmental or non-market objectives (Potter & Tilzey, 2005). In the last round of the CAP regional/area based payments are being implemented, however this may disadvantage some farms in the north of Scotland, which may suffer a significant loss of payments (Ahmidi, et al., 2015). Analysis suggests that wider economic impacts of restructured payments will be limited, in part due to the relatively small size of the sector in the overall economy (Vellinga, et al., 2014).

In Scotland unlike the rest of the UK, a lot of farms are located on Less Favoured Areas (LFA), which receive additional financial support from the CAP. The current direction of the CAP may remove vital support for these areas making it difficult for farms to continue without alternative support (Warren, 2009), potentially resulting in land abandonment with uncertain social and environmental impacts (Hanley, et al., 2012). The Highlands and Islands support unique social farming systems such as Crofting, which are a part of the landscape’s cultural heritage (Lowe, et al., 2002; RSE, 2008). Greening measures were expected to provide a cushion for farmers transitioning from single farm payments (Warren, 2009). However, recent analysis shows that most farms net margins have decreased slightly and would decrease even further without the greening measures (Ahmidi, et al., 2015).

Scotland’s rich natural heritage is reflected in the host of designations over the landscape including Special Areas of Conservation (SAC), Special Areas of Protection (SAP) and Special sites of Scientific Interest (SSSI) (SNH, 2012). In Caithness, Sutherland and Lewis extensive RAMSAR (2014) designations (Convention on wetlands) cover the rich peat land habitats. National Scenic Areas (NSAs) are located mostly on the Western Isles, the west coast, Lochaber and the Cairngorms. Scotland’s two National Parks (Loch Lomond
and Cairngorms) have common objectives to deliver economic, social and environmental sustainability (CNPA, 2012; LLTNPA, 2012). Each of these designations will have different implications for land use and its subsequent constraints. Furthermore, designations like the Nitrate Vulnerable Zones, watershed areas and National Parks, which operate at landscape scale will experience broader impacts as change occurring beyond their boundaries has an effect (CNPA, 2012). Official designations mandates certain actions and creates limitations for the land manager but may not have the greatest influence over decision-making, as history of land use, local land manager knowledge and past practice, as well as land use classifications and suitability tools impose restrictions and disseminate knowledge on a landscape scale (Berkes, 2009). This supports the need for research that considers the full assemblage of processes and feedback for diverse systems and land manager types, which can expand our understanding of socio-ecological systems that drive policy and practices across various boundaries of influence (Carpenter, et al., 2009).

### 3.2.4.3 Policy synthesis

Land use policy has wide ranging implications for Scotland, which affect communities, markets and regional growth (Swales, 2009; SG(a), 2011; Slee, et al., 2014). Policies such as the woodland expansion strategy (2012), SRDP (2015), natural heritage designations (SNH, 2012), renewable energy and climate change strategies (SG, 2008; CCDP, 2009; SG, 2010) are influencing the shape of the Scottish landscape. The Land Use Strategy (2011) and Land Reform Review Group (2014), as well as National Park Authorities (CNPA, 2012; LLTNPA, 2012) all encourage ecosystem approaches and landscape management. These policies have both a singular effect on individual landowners and managers, and large scale impacts that aim for greater balance of economic, environmental and social priorities (Elliot, et al., 2014).

Current policy is pushing for specific goals and targets linked to national strategies, which are top-down dominated, such as climate change and woodland expansion (CCDP, 2009; WEAG, 2012). However, a bottom-up approach that directs these policies into meaningful practice that incorporates individual land managers into decision-making processes, which views landscape from a local perspective is important for realising national targets.
and aims. Creating an evidence base for local policy interpretations for land managers including economic and climate change valuation tools that connect to influential cultural factors, as well as situating woodland expansion within a wider landscape management context is vital to effectively translate policy into practice (Lawrence & Dandy, 2014). This may lead exploring policy design and implementation through the lens of regional variants and characteristics that use key landscape units to represent unique regional dimensions and socio-economic preferences on a local scale (Brown & Castellazzi, 2014). Planting and managing for woodfuel has the potential to address and combine multiple policy aims including woodland expansion, climate change and agricultural diversification. These cross over solutions will need support from both policy-makers and local managers to develop mutual practices to encourage uptake of integrated land use opportunities.

3.2.5 Culture, community and people
Cultural and social factors are increasingly important for the adoption and implementation of land management strategies. Various professions from philosophers to engineers have struggled to explain the complex relationship between humans and ecosystems (Schama, 2004; Berks, 2004). However, many dimensions of these relationships are based upon values and preferences, which are non-material and difficult to characterise within management issues (Satterfield, et al., 2013). Guillem, et al., (2015) show that the behavioural differences of landowners in the Lunan catchment in Tayside had direct implications for food and bioenergy provision, as well as local biodiversity abundance.

These intangible components of decision-making are increasingly recognised as an integral part of ecosystem services (cultural services), which are key to unlocking comprehensive landscape management approaches (Tallis, et al., 2010; Guerry, 2012; Tercek & Adams, 2013). However, incorporating social and cultural components of ecosystem services into research and practice is a continual challenge (Chan, et al., 2012; Daniel, et al., 2012).
The tradition and cultural attributes that develops alongside land use is important to land manager practice, (Warren, 2009), as human actions are driven by socio-political and environmental stimuli (Antle, et al., 2001; Lambin, et al., 2001). Land managers are influenced by strategic management aims (Miller, et al., 2009) as well as responding to market pressures and government interventions (Hanley, et al., 2012). Guillem et al., (2015) and Murray-Rust et al., (2011) argue that landscape scale issues cannot be understood by commonplace methodologies, they must include bottom-up approaches where each stakeholder is allowed to act autonomously and cognitively of external pressures. Furthermore, interactions between land managers and landscape cannot be considered independently, as they are often subject to interactive feedback, which have wide impacts on the areas being managed (Liu, et al., 2007; Beilin, et al., 2012).

A legacy of practice is left by ownership, management priorities and personal viewpoints, which represents a temporal connection between the environment and culture that reflects combined values of land management (Sandberg, 2005; Morgan-Davies & Waterhouse, 2010; Morgan-Davies, et al., 2015). For example sporting estates in the Highlands have been managed for the most dominant land use priorities of the last two centuries due to ownership type perpetuating management practices (Warren, 2009). However, estates are beginning to diversify, to enter new markets, and adopt new management approaches in response to a mixture of influential policies and individual ownership values. Thus decision-making is an ever-shifting process that impacts over uncertain spatial and temporal scales. Crofting represents a distinct land use culture in Highlands (Wightman, 1996; Warren, 2009), restricted to marginal, often less productive lands in the very north, along the coast and on the islands (Wightman, 1996). These Crofts (land holdings) are owned and managed by the land manager or rented to people who will work the land for the benefit of both the owner and manager, the balance changes over different regions. Around the Western Isles 84% of crofts are rented and in Orkney 90% of all land holding is managed by the owner (Miller, et al., 2009). The difference between ownership and management may affect the scope of investment and type of decision-making between Highland Crofters and therefore produce diverse cultural land use interactions, which affect landscape management priorities and character.
There is a strong sense of landscape heritage in Scotland valued for scenic rural areas. These provide recreation and tourism through the composition of traditional cultural landscapes (Solivia, et al., 2008). Hall, et al., (2004) found that the public wish to see agriculture in the landscape providing environmental services and traditional goods. In a study of multifunctional approaches Wilson (2008) encountered broad views from a cross section of society that supported shifts to public goods and environmental services, although this approach largely ignores the preferences and values of land managers. Farmers in particular have strong perceptions on land use that are resistant to change (McHenry, 1998; Beedell & Rehman, 1999; Unruh, 2000; Warren, 2009), as do other private landowners (Lawrence & Dandy, 2014). Perception shaped through cultural legacy and practice have strong effects upon the landscape, as demonstrated by the first action of the Forestry Commission in 1919, which still impact today (Slee, et al., 2014).

3.2.6 Land use drivers summary

In Table 3.4 the land drivers described in the previous sections (3.2.1-3.2.33) are summarised to provide an overview of land use barriers and opportunities.

<table>
<thead>
<tr>
<th>Drivers</th>
<th>Barriers</th>
<th>Opportunities</th>
</tr>
</thead>
</table>
| Environmental | • Limitations of land (classification and soil)  
• Interests heavily weighted towards a single sector (farming)  
• Historically short-sighted forestry policies (monocultures and exotics)  
• Limited species choice  
• North dominated by protected peat lands and marginal soil  
• Uplands dominated by grazing livestock  
• Focused deer management (browsing on natural regen) | • Climate change may provide better growing conditions and more prime land  
• Recognition of native woodlands and potential capacity of unproductive land (LFA)  
• Emphasis on land use to reduce GHG and increase carbon sinks  
• Recognising the potential of land use to alleviate reliance on foreign energy and create a strong domestic base  
• Potential restructuring and diversification of farm businesses  
• Smart woodland expansion  
• EA and ESS recognised and incorporated into planning and management |}

<p>| Demographic | • Low population density                                                                                                                                         | • Land and space for expansion                                                                                                                                                                                                                                                   |</p>
<table>
<thead>
<tr>
<th>Economic</th>
<th>Economic</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Significant migration of young people from Highlands and Islands</td>
<td>• Infrastructure can be designed around regional hubs of resources (smart growth)</td>
</tr>
<tr>
<td>• Lack of infrastructure in remote rural areas</td>
<td>• Population growth between 5-15% for Highland and Islands</td>
</tr>
<tr>
<td>• Limited labour skill base</td>
<td>• Focused training and investment around emerging and growing sectors</td>
</tr>
<tr>
<td>• Attracting investment</td>
<td>• Potential capacity and growth based upon sustainable development</td>
</tr>
<tr>
<td>• Aging population in rural areas, especially out of main settlements</td>
<td></td>
</tr>
</tbody>
</table>

| Subsidised farms | Rise in energy costs |
| World food shortages | Fluctuations in prices have highlighted paucity of traditional farm businesses |
| Agricultural price highs | Tourism and recreation replacing farming as primary land use |
| New and emerging land uses like bioenergy and carbon lack established market mechanisms | Diversifying land uses provides extra revenue, onsite energy and risk spreading opportunities |
| Bioenergy uncompetitive against agriculture crops | Regional and local market development |
| Social goods hard to value | Grants, incentives, schemes (SRDP, FC land leasing, woodland management, green recouping etc) |

<table>
<thead>
<tr>
<th>Policy</th>
<th>Policy</th>
</tr>
</thead>
<tbody>
<tr>
<td>• CAP production-led</td>
<td>• Wide adoption of integrated land use, EA and ESS</td>
</tr>
<tr>
<td>• Difficulties implementing national targets and balancing multiple objectives</td>
<td>• Substantive targets to be met through renewable sources (bioenergy)</td>
</tr>
<tr>
<td>• Woodland expansion decreasing, not meeting targets</td>
<td>• Encouraging regional markets and growth</td>
</tr>
<tr>
<td>• Mismatches of market growth and creating market supply without a strong infrastructure</td>
<td>• Woodland expansion through natives and wise planting as well as for woodfuel</td>
</tr>
<tr>
<td>• Danger of creating dichotomised agricultural systems and regions</td>
<td>• Integration of sectors under rural management and development</td>
</tr>
<tr>
<td>• Restrictive activity due to designations-conflicts of interest (northern peat lands)</td>
<td>• Highlands and Islands prime location for integrated sector growth</td>
</tr>
<tr>
<td>• Agriculture policy and food security as number one priority over other land uses</td>
<td>• Wind and SRF favoured avenues for renewable land use strategy</td>
</tr>
<tr>
<td>• Adaptation of crofting communities</td>
<td>• Land use policies integrated and working together</td>
</tr>
<tr>
<td>• Land abandonment</td>
<td>• Potential increase in biodiversity</td>
</tr>
<tr>
<td></td>
<td>• Designations may mould specific areas of integrated land use (NPA’s)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Culture, community and people</th>
<th>Culture, community and people</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Land ownership and large sporting interests</td>
<td>• Community groups</td>
</tr>
<tr>
<td>• Rights and activities of crofters and tenants</td>
<td>• EA and ESS approaches</td>
</tr>
<tr>
<td>• Traditional and pedigree mind-sets</td>
<td>• Diversification and new markets to encourage change</td>
</tr>
<tr>
<td>• Historical prejudice against forestry</td>
<td>• Collaboration over multiple private land parcels</td>
</tr>
<tr>
<td>• Traditional separation of farming and forestry</td>
<td></td>
</tr>
</tbody>
</table>
3.3 Opportunities for enhancing woodland use for landscape management objective

This section will review the current status and potential of forest energy (woodfuel), as part of a developmental approach to woodland expansion. In section 3.3.2 Farm forestry will be evaluated as an integrated management approach for typically conflicting land uses.

3.3.1 Forest Energy

Replacing the burning of fossil fuels with renewable energy can significantly decrease the levels of GHG’s, and reduce the threat of climate change (IPPC, 2013). Therefore renewable energy is regarded as a high priority for our society (Blaschke, et al., 2013). Agostini, et al., (2013) state that biomass is one of the most promising renewable options for reducing climate change impacts and is likely to be widely used in both the transport and energy sectors. Examples of forest energy are wood energy crops, such as short rotation forestry (SRF), short rotation coppice (SRC) and waste woodland including arboricultural/agricultural arising (Slade, et al., 2011). Woodfuel has been an important component of renewable energy production and domestic fuel independence for Nordic countries (Econ Pöyry, 2008). Scotland has a relatively high potential for wood energy production (Roser, et al., 2011), however high costs, complex logistics and supply chain management is limiting the expansion of the forest energy sector (Iakovou, et al., 2010).

In Scotland forest energy has the potential to alleviate fuel poverty in remote and rural areas, support a low-carbon economy and revitalise short-term woodland management (SDC, 2005). Currently the UK does not possess the capacity to keep up with woodfuel demand, evidenced in 2013 as 301,000 tonnes (an increase of 128% from 2012) of wood pellets were produced yet over 5.9 million m³ were imported (FC, 2014). This demonstrates the opportunities for forest energy markets in the UK and Scotland. In 2010
short rotation forestry trials were established in six case study areas around Scotland, including three in the Highlands and Islands (Orkney, Caithness and Argyll). The progress report (FR, 2014) identified Hybrid aspen and Larch as the most promising species; alder, silver birch and Sitka spruce show potential for some sites; whereas Ash, Sycamore and Sweet chestnut show higher tolerance to site conditions than most species, despite slower growth rates. Poplar, Downy birch, Mountain ash, Goat willow, White beam and Beech were used as alternative species for more northerly case studies, if others proved unsuccessful during the establishment periods (FR, 2014). Continual assessment of each site and their species will be carried out for the next 15 years, completing the twenty year rotation cycle.

The woodfuel demand usage report (2013) predicts a 58% rise in woodfuel usage by commercial and industrial operations from 2012-2016. As development continues, the Highland region will hold the largest amount of installations. However, according to the Sustainable Development Commission (2005) the most promising area for forest energy/woodfuel to make an impact in Scotland by contributing to climate change mitigation is through medium scale woodfuel heating. Scotland is ideally placed to incorporate forest energy due to its established woodland culture, supply of low grade timber, high demand for heat and high energy prices in rural areas (Feliciano, et al., 2013). The Scottish Government (2008) considers market penetration of the private sector to be vital to realising woodfuel heating capacity. This means engaging private landowners and linking woodland products into regional supply chains, which may require supporting multiple objectives of estates to ensure adoption of woodfuel management.

Forest energy has distinct advantages (Table 3.5) over its renewable counterparts (McKay, 2006; RCEP, 2004; SDC, 2005; Sherrington, et al., 2008):
Table 3.5 – Advantages and disadvantages of forest energy

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Almost carbon neutral</td>
<td>Poorly understood</td>
</tr>
<tr>
<td>Provides greater environmental benefits</td>
<td>Lack of wood supply chain</td>
</tr>
<tr>
<td>Stored and used when needed</td>
<td>Cost of installation and storage</td>
</tr>
<tr>
<td>Provides heat and power</td>
<td>Landscape aesthetic (negative)</td>
</tr>
<tr>
<td>Creates 5-10 times more jobs</td>
<td>Greater life-cycle analysis needed</td>
</tr>
</tbody>
</table>

In Northern Scotland growth in the woodfuel industry is obstructed by poorly developed supply chains and lack of a viable material from young coniferous forests. This has been partly blamed on undeveloped markets, difficulty assessing availability of woodfuel, and locating efficient regional infrastructure (WTF, 2008). Household uptake of woodfuel may be impeded by an undeveloped supply chain, but estates with a tradition of forest management and sustained supply of timber may be more suited to adopting and developing woodfuel systems and regional supply chains (Feliciano, et al., 2013). As stated in section 3.2.4.1 bioenergy has significant potential for rural resource management but needs fast growing woodlands to fill the demand within regional markets. This thesis methodological approach (Chapter 5) develops individual private landowners understanding of potential woodfuel production (woodland planning and suitability analysis) with market value for timber and carbon (Forest Energy Tool). These methods will support and help develop aims under the Scottish Climate Change Adaptation Strategy (2009), Land use Strategy (2011), WEAG (2012), Forest Strategy (2006) and Highland Council Strategies (Chapter 2.6.3).

3.3.2 Farm woodlands

The SRDP incentivises the move towards farm forestry (woodlands) through several programmes:

- Renewable Energy-Forestry
- Improving the economic value of forests
- Short rotation crops of willow and poplar

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Other incentives the SRDP aim to develop are infrastructure, supply chains and community cooperation, as well as supporting farms that are fragile and vulnerable (SRDP, 2015). Initially uptake of farm woodland related incentives was slow as farmers showed little interest, possibly influenced by persistent cultural divides and historic disparity of grant support between the two sectors (Anderson, 2006). Concerns around public access, increased deer damage and strong farmer identity underpinned the opposition to farm woodland development (Mather, 1996; Sanders, 1999; Scott & Palmer, 2000). Since 2002 the number of farm woodlands has increased by 51%, going from 209.9 ha in 2002 to 426.1 ha in 2011, with Scotland experiencing the largest uptake of farm woodlands in the UK (FC, 2012). Farming and woodland are difficult to compare as management inputs, economic impact and landscape contributions operate on different spatial and temporal scales. Economic drivers and farmer attitudes are influential factors impacting farm woodland success.

Wilson (2011) argues that four main factors have inhibited the development of farm woodlands:

1. Inadequate advice, overly complex grant schemes and lack of on-farm capacity, skills and motivation;
2. Resistance of farmers to tree planting, rooted in their professional identity (Burton, 2004), rather than economic rationale;
3. Dominance of fossil fuels working against development of domestic woodfuel heating;
4. Woodland having traditionally been the landowners’ right to manage and plant rather than the responsibility of tenant.

Stubbs, et al., (2010) identified the grant system and replanting obligations as barriers to farm forestry. Policy was also viewed as uncertain, bringing into question future support. Farmers preferred tree planting to fit with farm management rather than adhering to forest management demands. Lawrence, et al., (2010) highlight land manager personal preferences are not linked to low levels of tree planting, but rather a lack of belief in woodlands economic worth. They also note that landscape and wildlife, followed by
shooting are the highest ranked drivers, whereas production and profit feature lower on the list. Provision of public recreation was the lowest priority.

Forest energy and the Renewable Heat Incentive (RHI) have the capacity to attract production focussed land managers, as management of small woodland for logs, chips and wood pellets could use low grade timber, and connect to farm facilities and activities (drying areas for crops) (Slee, et al., 2013). Such rural revitalisation strategies that encourage connections between farming and forestry are strong objectives for Scottish rural regeneration (SG(a), 2011).

Table 3.6 – Economic impacts of different types of Farm woodland (Slee, et al., 2013)

<table>
<thead>
<tr>
<th>Woodland type</th>
<th>Impacts on income</th>
<th>Impacts on capital value</th>
<th>Further information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shelter woodland</td>
<td>Modestly beneficial but very difficult to estimate accurately</td>
<td>Modestly beneficial</td>
<td>High fencing costs as boundary</td>
</tr>
<tr>
<td>Production woodland</td>
<td>Lumpy returns except with SRC linked to RHI, major income stream possible with SRC</td>
<td>Modestly beneficial</td>
<td>Depends on site selection and good management – major savings on grain drying or domestic heating</td>
</tr>
<tr>
<td>Amenity woodland</td>
<td>Negligible and maybe negative opportunity cost</td>
<td>Potentially quite high in some situations</td>
<td>Highly location dependent</td>
</tr>
<tr>
<td>Agroforestry</td>
<td>No grant aid currently available therefore low, however incentives have been included in the SRDP consultation document</td>
<td>Modest because of impact on subsidy</td>
<td>Public policy incompatible with public interest provides advocacy for agroforestry</td>
</tr>
</tbody>
</table>

Table 3.6 summarises likely economic impact of different types of farm woodland. It indicates that amenity woodlands would be most beneficial to lifestyle farmers or diversified enterprises. Shelter woodland would suit windy sites for livestock rearing and areas with shooting priorities; whereas production woodland would be most valuable
where opportunity costs of releasing land from farming is low. Increasingly credibility is being given to the benefit of stacking ecosystem services (carbon, woodland production, biodiversity, shelter, water quality and landscape aesthetic), rather than looking at single land use avenues (Daily, et al., 2009; Deal, et al., 2012).

Forestry Commission Scotland operates a Woodland Grant Scheme (WGS) including Woodland creation and Sustainable forest management schemes that encourage integration and woodfuel uptake (FCS, 2012). One of the newest schemes to encourage woodland planting is ‘Land leasing’, which pays the land manager to lease the land to the FC, which handles the establishment, design, management and deliverables, after which the land is returned to the land manager at the end of the lease (FCS, 2015). The land manager can choose to have as much or as little say in the management process as desired; the costs will be covered and the land manager will receive an all-expenses covered diversified parcel of land and the FCS will increase woodland cover (FCS, 2012). The FCS provides technical assistance through free publications, such as ‘The creation of small woodlands on farms’, which has a Highlands and Island counterpart specifically targeted for Crofters (FCS, 2012).

Publications such as ‘Boost your farm business with well-managed woodland’ have produced solid exemplars of farm forestry (FCS, 2015). For example Corrimony in Glenurquart, Inverness-shire has a diversified 2,700 hectare hill farm on LFA. Farming remains the core activity, mostly livestock management, but both woodland and wind power contribute to the farms outputs (FCS, 2015). The woodland provides shelter for the livestock and converts grazing land that was difficult to manage for environmental benefits. However, the key woodland use has been to generate feedstock from a biomass boiler both for the farm and other local residents. This has produced significant savings across the properties in comparison to oil use. The diversification of income sources for the farm has ensured the long-term resilience of the business and has enabled the owner to consider further diversification, such as silvopastoralism for their high quality suckler herd. Additionally, Foulis farms on the Black Isle in Ross-shire have given over half of their 1082 hectare farm to woodland. This is used for commercial timber, primarily as
heating feedstock for their 10 properties and occasionally processed for floor boarding and fencing (FCS, 2015). The scale of woodland on the farm now provides irregular but important income, which significantly reduces fuel costs, and the diversified woodland structure, is now considered a valuable landscape asset.

Tenant farms account for 35% of all farms in Scotland and could contribute to woodland expansion efforts, providing owners and managers mutually recognise the advantage of planting trees (Warren, 2009). Crofting also represents a unique and important role for integration of farm and forestry practices. Scotland’s crofts represent 33,000 individuals in 17,500 registered crofts, 80% are tenanted rather than owner occupied (Edwards, 2007). In the Highlands and Islands they cover 12% of the farmland in some of the most remote and rural areas (Rennie, 1997). The Crofting communities encapsulate old forms of traditional Highland farming, based upon land tenure rather than use of small-scale arable land mainly for fodder and extensive common grazing land (Edwards, 2005). They are social systems that connect the land and the people, unifying communities and preserving traditions (Rennie, 1997). However, Crofts suffer from economic fragility, which may be compounded by future CAP reform. Despite these problems Crofts are symbols of deep cultural connection to the land, maintaining deep rooted aspects of Highland cultural heritage (Parman, 2005; Reed, et al., 2009).

The 1992 Crofting Act gave crofters the power to diversify their land with woodland and in 2003 they were afforded the right to buy (Birnie, et al., 2007). The 2007 Crofting Act, which was part of Scotland’s widespread land reform allowed crofters to diversify traditional common grazing lands and create new crofts. However, the social dynamic of the system was left undefined, leaving some confusion as to the relationship between community and individually owned lands (Warren, 2009). These recent reforms to Crofting rights and practice are important in promoting an integrated land management that focuses upon alleviating fuel poverty and increasing carbon storage capacity. Crofts are likely to be an important component of woodland expansion and rural energy resources in the Highlands and Islands (HC, 2012).
3.4 Further integration of land uses

3.4.1 Wind and hydro power

Scotland has the best onshore and offshore wind resources in Europe, accounting for a quarter of European resources (Troen & Petersen, 1989). There is great interest from private companies to take advantage of energy generation potential, which is encouraged by the Scottish Government as it helps to meet renewable energy targets (SG, 2008; DECC, 2009; SG, 2010). Many of the best onshore sites for wind farms are in upland areas that represent iconic Scottish landscapes. Therefore, concern for the impact of wind energy developments on tourism, ecologically sensitive areas and traditional, and ‘wild’ landscape aesthetics is paramount. The wind energy industry is booming in Scotland, with development outstripping any other country in Europe; however, Scotland began wind energy development later than most countries, such as Germany and Denmark (Szarka, 2007). In 2006 Scotland increased its wind energy production by 67%, in one year, while the rest of Europe increased by 23% (EWEA, 2007). In 2013 onshore wind energy overtook hydropower as the most significant renewable energy and continues to expand through both large and small-scale projects (SNH, 2011; SG, 2015).

Onshore wind power capacity stands at 5 GW, which is 69% of Scotland’s renewable generation (SR, 2014). An additional 7.6 GW of onshore wind farm projects have been granted permission or are in planning stages (SR, 2014). Thus onshore wind will continue to grow becoming more common in the landscape, as demonstrated in the farm woodlands examples (Section 3.3.2). The ‘Scottish Route Map’ in the Renewable Energy report (2011), includes a target of 500 MW generated by energy independent community ownership. As Scotland has more ambitious renewable targets than the UK as a whole, i.e. 50% of electricity generation from renewable energy by 2020 (8.4 MW), wind power will be expected to be the largest contributor. Although Scotland’s renewable energy capacity is estimated at 60 GW, Scotland’s target to reduce 80% of GHG emissions by 2050 is considered more ambitious (FSC/SG, 2007; SG, 2008; CCDP, 2009). Despite the clear benefit of wind power, the environmental and landscape impacts are viewed as unfavourable and uncertain for many land managers (Warren & Birnie, 2009; Slee, 2015).
In response to these threats the carbon savings approach for best practice in establishing wind farms on peatlands was developed by SNH (SG, 2014), including guidance on location and design (SNH, 2014). Additionally consultations on removing avian barriers have been conducted by the Scottish Government (SG, 2011).

Hydro power has been important for Scotland since the 1950’s when large scale installations were constructed. These generated safe and reliable electricity for Scottish homes and businesses (SG, 2011). By the end of 2014 hydro capacity was at 1.52 GW (SR, 2014). However, potential for another 1.2 GW of small-scale run of the river schemes has been identified. Hydro’s attraction lies in its predictability and energy pump storage, which can be generated as and when required. Grid access and connection are one of the major barriers, delaying the start of many projects (SG, 2010) and therefore leaking potential monetary and energy benefits.

The Highlands and Islands of Scotland are considered a rich prospect for mixed renewable energy schemes to support sustainable communities (SR, 2007; Rogers, et al., 2008; Murphy & Smith, 2013). Although the past approach was to build power generation far away from communities, now the opposite view is more dominant, which encourages local participation with energy generation (Walker & Cass, 2007; Devine-Wright, 2007). On the Isle of Gigha three community owned turbines (225 MW) provide two thirds of the island’s electricity requirements and has amassed an average of £75,000 net profit in the first eight years of operation (Isle of Gigha, 2012).

The Isle of Gigha has established a solid community model demonstrating that wind energy provides a realistic route to energy independence for remote and rural communities (Mackenzie, 2006). However, the Isle of Gigha Community Trust is currently £3 million in debt, which has caused internal conflict within the trust and between the residences (Stewart-Robertson, 2014). In 2008 there were 28 community projects exploring the feasibility of replicating the Isle of Gigha’s success (Gubbins, 2008), many from the western Highlands. On the Isle of Lewis, in Shawbost a 900 Kw turbine was erected on common grazing land becoming the islands first community owned turbine. It
will generate £100,000 initially, potentially rising to £250,000 profit annually to reinvest into the community's infrastructure and amenities (STV, 2012). However, several community projects in the Highlands and Islands (Skye, Beauly, Scalpay and Alness) have been halted due underdeveloped grid capacity, putting these projects on hold for eight years. Ecodyn Ltd helped establishment of turbines on Lewis and Shetland are aiding these communities by installing smaller 50 Kw turbines as community assets by accessing Community and Renewable Energy Scheme (CARES) funding.

Hybrid energy systems are shaped by the characteristics and capacity of communities in the Highlands and Islands, which create innovative partnership approaches to enable sustainable rural living (Murphy & Smith, 2013). The Isle of Eigg has an off-grid mix of wind, hydro and solar power to sustain their community; however, reliance on back-up diesel generators has resulted in higher costs than anticipated (Chmiel & Bhattacharyya, 2015). These smaller scale 50 Kw projects may be key to initiating wide spread community renewable energy, including integration of forest energy systems for heat in rural areas (FG, 2012; Murphy & Smith, 2013).

3.4.2 Integration of carbon management

The role of carbon sequestration in land use management is expanding (Bonn, et al., 2009; Shucksmith & Rønningen, 2011; Daily, et al., 2009). Scotland's Climate Change Strategy (2009) and low-carbon economy targets (2010) are central drivers in developing renewable energy production and ecosystem management. Scotland has a wealth of carbon stocks in organic soils and expansive peatlands in the north (Brown, et al., 2008). Additionally, forestry, farming and renewable energy can increase Scotland’s carbon capacity and reduce reliance on fossil fuels. Balancing land use priorities through integrated, rather than competing land use strategies will be central to a successful low carbon economy (SCCAF, 2009; SG, 2011). Such land uses include wildlife conservation, low intensity agricultural management, peatland restoration and sporting management, as well as intelligently planned woodland expansion (Woods, 2005; Dawson & Smith, 2007; SG(a), 2011; WEAG, 2012).
The WEAG (2012) Final Report stated that carbon was a compelling rationale for woodland creation and should be used to influence woodland creation. Encouraging managers to plan through carbon budgets could facilitate wider and more integrated management thinking. There are many projects under way that measure carbon sequestration of woodlands on a landscape scale as well as an individual tree scale (Daily & Matson, 2008; de Groot, et al., 2010; Tallis & Polasky, 2009). More research is required on land use for specific landscapes and management approaches. A viable objective would be the development of user-friendly and accessible means to enable managers to incorporate carbon management into their plans.

Sherrington (2010) suggests that widespread adoption of energy crops, particularly woodfuel, may bring about combined societal benefits, such as reduction of carbon emissions and increased energy security. Additionally using SRC for heat generation is a cost effective approach for reducing carbon emissions (University of Cambridge, 2005). The Forestry Commission Woodland Carbon Code is a scheme that recognises the importance of carbon in woodland creation and management (FC, 2014). Through the Code land managers could access financial markets, receiving extra income and gaining recognition for their contribution to Climate Change (WEAG, 2012). The Code also promotes collaboration schemes in order to meet carbon sequestration goals (FCS, 2012). Wilson (2015) emphasises the broad application of native woodland for carbon sequestration goals, such as (in situ) production of woodfuel (substituting fossil fuels) and high quality timber (substituting high embodied energy materials such as concrete and steel). However, improved silviculture compatible with biodiversity conservation, recreation and landscape amenity will be vital to realising these objectives.

3.5 Key issues for land use in the Scottish Highlands
The Highlands and Islands of Scotland have great potential for implementing ecosystem approaches. However, a history of dominant land uses, such as sporting interests, agricultural grazing (MacMillan, et al., 2001; Warren, 2009) and mixed ownership complicates ecosystem scale management.
Woodland expansion is a central issue for the Highlands, as significant areas of land are required to meet government planting targets (WEAG, 2012), due to the decrease of grazing and arable agriculture (SRUC, 2011). This strategy has been undermined by the dominance of sporting estates, redeveloping forestry sector and environmental limitations (Swales, 2009; SG(a), 2011). New economic approaches to management, such as forest energy that integrates woodland into the landscape are widely advocated by current land use reports (WEAG, 2012; Elliot, et al., 2014). These initiatives are being encouraged through Farm woodland schemes. These provide support for land managers diversifying their businesses (FCS, 2015). However, Forestry Commission examples use land managers with previously strong business models. These can be misrepresentative as the broader application of the schemes may vary (FCS, 2015). Initiatives like Farm woodlands need to reach out to land managers struggling to survive.

Wind and hydro power are central to helping Scotland achieve the 80% reduction of GHG's by 2050 (SG, 2010). Onshore wind power is now the largest contributor to Scotland's energy generation and continues expand in the Highlands due to large numbers of compatible sites (SR, 2014). Hybrid energy systems, including hydro, wind, solar and woodfuel are being used to create sustainable rural communities (SG, 2011; Chmiel & Bhattacharyya, 2015). Small scale hydro schemes are set to have an influential impact on land management. However, upgrades to the grid in remote areas are crucial for landscape connectivity. Aims to integrate carbon management into land use for sustainable communities are being explored by the Forestry Commission (FC, 2014) and other organisations, as carbon sequestration is a powerful driver in shaping ecosystem approaches.
3.5.1 Linking ecosystem approaches to Highland land use

*Figure 3.2* provides some insight into the potential structure of a Highland ecosystem approach based upon emerging land uses and markets in the region (Chapter 2.7-2.8 and 3.3-3.4). This draws upon the Energyscapes concept in Chapter 2.8 in which Howard et al., (2013) evaluate supply and demand of a region in light of local energy needs and land practice. Although *Figure 3.2* focuses upon energy as an integrating element of land use practice rather than a way to evaluate the supply chain of the region. This Highland based EA framing incorporates important principles and operational guidance of the CBD EA (UNEP, 2000) including principle 3, 2, which addresses decentralisation of decision-making and planning down to the individual estate land manager and transboundary considerations, which takes account of ecosystem function across human boundaries. Principle 4 places importance upon the economic feasibility and benefits of sustainable land uses that should align incentives accordingly and internalise costs. Whereas Principles 7 and 11 focus on the spatial planning aspect and the importance of incorporating local knowledge and encouraging innovative practice (Cumming, 2011; Collier, 2015).

The key operations identified in *Figure 3.2* are a combination of emerging markets (chapter 3.3-3.4) that link land managers to wider landscape and confirmation by land managers that these operations could generate profit centres (chapter 7.2), and be integrated alongside sporting uses (chapter 7-10). Both Hydro schemes and carbon sequestration are core partnerships identified by managers in chapter 9.5, which would provide greater latitude and economic stability for greater woodland management (chapter 10.4). Forest energy is described as being useful for sparking increased woodland management culture by providing early silviculture treatments and short-term financial returns (Roser, et al., 2011; Dandy, 2016). The additional stability of domestic energy production (hydro and woodfuel), as well as the added value of carbon sequestration creates a symbiotic and holistic land management option for private estate managers that acknowledges wider landscape contributions.
The operational guidelines highlight the interconnected functioning of the ecosystem (1), which supports multiple land uses that complement one another providing greater

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**Figure 3.2** – Framing of a Highland ecosystem approach involving emerging land use areas and markets

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<table>
<thead>
<tr>
<th>Forest Energy</th>
<th>Hydro Power</th>
<th>Carbon Sequestration</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Plant or regenerate woodland.</td>
<td>- Install infrastructure for hydro schemes (i.e. Grid connection, estate connection, Archimedes screw, energy converter) on applicable rivers</td>
<td>- Sequestered in new and managed woodland.</td>
</tr>
<tr>
<td>- Manage for multi-rotation and retention and restocking.</td>
<td>- Remote and rural grid connections with the capacity for current and future generation.</td>
<td>- Reduced carbon release from switching over from fossil fuels to renewables.</td>
</tr>
<tr>
<td>- Harvest raw timber for logs, chips or pellets.</td>
<td>- Agreements with energy companies (Tariffs).</td>
<td>- Tool to account for estate’s carbon savings/sequestration and storage.</td>
</tr>
<tr>
<td>- Extract, store, dry timber (facilities needed, in-house operations or local contractors).</td>
<td>- Estate buildings and potentially local infrastructure integrated into the system.</td>
<td>- Administrative set-up to gather, convert and trade and cycle back carbon credits and revenue.</td>
</tr>
<tr>
<td>- Process and transport material (unless sold from estate premises or regional hub.</td>
<td></td>
<td>- Integrated lifecycle analysis of planned operations necessary for complete transparency and efficiency.</td>
</tr>
<tr>
<td>- Sell stock, identifying community, sector and industry as well as estate needs.</td>
<td></td>
<td>- Organisations needed for access and operations: Regional clusters of estates, FC Carbon Code, CNPA, SNH (Partnerships and ESS Bundles).</td>
</tr>
<tr>
<td>- Burning of forest energy products in homes, businesses and regional plants.</td>
<td>- Energy transferred to national, regional, local grids for use (electricity).</td>
<td>- Traded, bought and collated in the form of carbon sequestered and translated into credits (surplus, deficits, regional carbon account).</td>
</tr>
<tr>
<td>- Restocking /new planting/regeneration of same areas harvested. Rotational system used.</td>
<td>- Continual flow of energy, maintenance and repair required.</td>
<td>- Revenue from carbon invested back into forest energy, riparian energy systems as well as upkeep of the landscape and its services.</td>
</tr>
<tr>
<td>- Yields may differ from rotations and changes in species choice/mix.</td>
<td>- Monitoring of any potential disturbances or changes to the riparian systems.</td>
<td>- Carbon for estates, communities, regions and national account.</td>
</tr>
<tr>
<td>- Feedback and recycling.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Increased operational efficiency and resilience over time.
benefit sharing (2), combining these land use mixes will require adaptive responses (3) from the land managers and estate structures, as well as new approach to spatial planning, which takes into account greater temporal variables in production and management regimes (4). Combining these three core activities alongside traditional management of sporting use and agriculture will require engagement and strengthening relationships with other sectors and a range of new working relationships (5), which are explored in chapters 7-10. This EA system aims to strengthen resilience through diversity of uses to provide stability and redundancy in an estates management structure (Laliberte, et al., 2010; Cavers, 2015). Such interpretations of EA could lend greater practical management meaning to both resilience and EA concepts, linking individual managers to global issues, as well as acknowledging the importance of local conditions (Walker & Salt, 2012). Another vital step to bridging the gap between individual land managers and understanding application of elusive management concepts is providing routes from these concepts to spatial planning (Chapter 7.4, 8.4-6 and 9.4) and balancing of multiple uses (ecosystem services) that clearly communicate the management implications and resultant benefits (Cumming, 2011; Waylen, et al., 2014). Such a transition could ease the burden of management, conflicts between traditional and emerging land use, as well as reducing the distance and relevance of policy.
Chapter 4

Connecting land managers to their local environment

4.1 Introduction

Increased pressure placed upon natural resources to produce multiple services for human populations has generated concern for environmental change and integrity for present and future landscapes (Daily, et al., 2009). Ecosystem services and management have provided policy-makers and scientists with core aspirations and language for developing of sustainable land use (DEFRA, 2007; Ellison, 2009). The Millennium Ecosystem Service Assessment (MEA, 2005) created an intellectual platform for understanding goods and services; however, challenges remain for both scientists and practitioners.

Understanding the interactions between services within an ecosystem and being able to adequately measure them for valuation and management purposes is becoming more important than simple framing and definition (Carpenter, et al., 2009). Ultimately, being able to value and understand the spatial extent and influences of ecosystems, both physical and culturally will enable greater conservation, protection and growth (Norton, et al., 2012). For this to occur stakeholders’ relationships and interactions with their local environment needs to be understood and connected to the efforts of the policy-makers and scientists. This chapter reviews participatory approaches used in land use research, focusing upon methods with strong geo-spatial elements, such as walking interviews. In section 4.2 a range of participatory techniques are examined to give a general overview of participative methodologies. The subsequent sections become more specific by exploring the applicability and utility of mobile methods (4.3) and collaborative techniques (4.4).

4.2 Participatory techniques

Participatory methods have become increasingly useful to researchers, policy-makers and practitioners for interpreting important information. In pursuit of real world
solutions to complex problems (mentioned above in 4.1, largely referring to ecosystem services) researchers are embracing diverse methodologies to integrate a range of knowledge and data (Bracken & Oughton, 2013). The combination of different methods involves the use of techniques and software as platforms for interrogating competing knowledge and perspectives (Debolini, et al., 2013). One of the greatest challenges is the integration of social factors with spatial contexts (McLain, et al., 2013; Forrester, et al., 2015; Karmi, et al., 2015). The Operational Guidelines of the CBD’s EA encourages the use of adaptive management practices (Chapter 2.3 page 15), as the level of uncertainty is increased by interaction with social constructs, which need to be better understood (UNEP, 2000). Therefore the EA must involve a form of learning that helps adapt methodologies and practices to the way in which the land is being managed. This part of the EA Operational Guideline supports engagement with those responsible for managing the land in order to recognise the diversity of social and cultural factors affecting natural resource use (UNEP, 2000). Smith and Maltby (2003) argues that successful use of an EA depends on participation despite effective and sustained participation presenting a significant challenge.

4.2.1 Identifying culture through participation

A continual challenge for research scientists and policy-makers is the integration and analysis of cultural factors into studies that inform management and planning processes. Implementation of management plans that incorporate the practical application of cultural and social factors remains a barrier to ecosystem management approaches (Forrester, et al., 2015). Participative methods have enhanced studies, which normally focus upon singular qualitative data. These studies represent stakeholder use or visitation by identifying cultural values for specific areas, therefore giving more insight into the significance of the land for users (Suckall, et al., 2009; Raymond, et al., 2009). These participative processes intend to understand the complexity of culture by identifying the composition over different locations (e.g. spiritual, aesthetic, tourism), which are elicited through questionnaires and interviews, forming common opinions and values. Raymond et al., (2009) combined interviews with a mapping task to assign quantified cultural values to specific places. This approach enabled greater insight into
the relationships that stakeholders had with specific areas of land and the potential for management activities within the remit of the spatially-identified cultural values.

Often cultural values fall outside the ambit of landscape/ecosystem management research due to the lack of measurable data and market applicability, which has omitted their inclusion in traditional analyses (Swinton, et al., 2007; Pejchar & Mooney, 2009). As many cultural values are based upon local and personal preferences they are viewed as incompatible with the quantifiable elements of studies, which has regularly precluded important local and cultural information from integrated land use research (Pejchar & Mooney, 2009). Participative techniques like interviews, questionnaires, surveys and focus groups have been used broadly in environmental management research. A multi-criteria decision-making method that assesses stakeholder up-take through a multi-attribute ranking system, over seven iterative stages, was used to gain insight into the overall and individual decision-making process of Galloway Fisheries Trust (Bray, 2015). Whereas Forrester et al (2015) combined Q-methodology with participatory mapping to explore the natural adaptive capacity of flood management in the Scottish/English borders. The approach was able to identify underlying beliefs behind stakeholders stated positions, allowing the complex socio-environmental issues to be unpacked, thereby improving management responses and stakeholder engagement.

Waylen et al (2015) looked at the potential prescriptive role of participation for resolving diffuse pollution problems for River Basin Management Plans. Participation was used as a tool to achieve management goals where regulatory and technocratic approaches had failed, as such reorienting core management concerns to social networks. Furst et al (2014) created a scorecard methodology to assess the efficient use of the ecosystem concept in facilitating planning processes by supporting consensus building and enhancing collective action. The scorecard identified critical aspects and advantages of the ecosystem concepts through temporal (short/medium term) and spatial scales (Regional/local) over two case studies, which aimed to refine collaborative decision-making for land use adaptation. They suggested that this approach aided the identification of advantages and shortcomings in the practical use of the ecosystem
concept. Practical planning implementation that incorporates social, biophysical and valuation assessments, supported by opportunities and constraints identification forms the next stage of this process, which can be achieved through scenario building.

Alongside scenario building and land use facilitation efforts stakeholder visualisations are being used to evaluate key responses and relationships to landscape types. Van Berkel and Verburg (2014) used photo visualisation to create scenarios of likely landscape changes. Complementary to the simulations were 'Willingness To Pay' and 'travel costs estimate' valuations. This achieved an understanding of the areas heterogeneity and indicated the value of assets delivered by landscapes, enabling planning prioritisation and insight into the importance of cultural landscape conservation. The representation of landscape function appreciation linked to composition and structuring of maps allowing for further analysis, which highlighted any contradictions with the non-spatial assessments (van Berkel & Verburg, 2014).

4.2.2 Participatory approaches to inform land use and practice

In Scotland elicitation of responses, reactions and formation of identities from photographic stimuli has been used to explore issues, such as woodland restoration and moorland management, as well as woodland landscape appreciation. Using the Strathspey area as a case study management professionals and members of the public were asked to narrow their discourse from landscape level to more specific management issues through a combination of semi-structured interviews and photo-verbal prompts (Fischer & Marshall, 2010). The intention was to provoke complex and ambiguous responses, therefore giving a realistic insight into the conflict surrounding management issues. They found that stakeholders often formed their own frames of the subject matter and placed themselves in between extreme perspectives. This led the researchers to advocate a more open approach that would allow stakeholders to express multiple and complex views, which might help shape more effective recommendations for land use policy (Fischer & Marshall, 2010).
Another study in the UK developed the photo-elicitation method even further by taking groups of stakeholders to three oak woodlands with different deer browsing pressures, the participants took photos and made notes, which were later used as stimulus for group discussions (Dandy & Van Der Wal, 2011). Through grounded approach (Maxwell, 2012; Charmaz, 2014) seven themes emerged concerning woodland appreciation that was directly linked to participant immersion within the environment they were discussing. This study highlights the importance of using innovative methods that place participants physically within the environment to elicit detailed and more complex responses to aid the formation of policy and management derived from greater analysis.

Ownership patterns and their response to shifting land use practices drives the shape of the visual landscape and can dramatically affect collaborative management efforts, social learning processes and diversity of rural economies. McMorran et al., (2014) used grounded participative techniques to investigate the impact of community ownership on sustainable land management in North-west Scotland. This included 77 interviews with diverse stakeholders, case study visits (exploratory and follow-up) and attendance of committee meetings and conferences in the localities. Through this participative engagement community ownership was found to be a powerful and positive agent for developing localised land use management, which was informed and shaped by regionalised narratives of sustainability.

Glass et al (2013) engaged seventeen mixed ownership upland estates in a participative process to identify sustainability principles that could be translated into operational practice. A Delphi technique was used to provide a forum for reflective research through a structured iterative process that enables a diverse group of stakeholders to deal with complex issues (Linstone & Turoff, 2002; Donohoe, 2011). A panel of participants were assembled to answer anonymous questionnaires designed by the researcher, after which feedback rounds refined the questions and answers to generate a common opinion/consensus about a particular issue or policy topic (Donohoe & Needham, 2008; Donohoe & Needham, 2008). The iterative and consensual nature of this research encouraged the development of a co-produced ‘Sustainability Framework Toolkit’, which
enabled diverse suite of land managers to assess their progress towards implementing sustainable land management practices (Glass, et al., 2013). Both of the methodologies previously mentioned tackled sustainable management issues in Scotland and suggest that participative and potentially collaborative processes not only help to identify the needs of sustainable management but encourage social mechanisms to implement practical outputs. The combination social learning, social capital and identification of managerial benefits, creates the basis for resilient rural communities with inherent adaptive capacity (Magis, 2010; Skerrat, 2011).

In this thesis a single stakeholder group of private estate land managers is used, as they are the main decision-makers within the boundaries of their estates although diversity of interests and management priorities do exist between owners within the same group (Higgins, et al., 2000; MacMillan, et al., 2010). Linking the group to Principle 2 of the CBD’s EA that management should be decentralised to the lowest appropriate level, taking a balance of local and wider public interests (UNEP, 2000). Forming case study areas composed of neighbouring estates that share borders links in with Principle 3 that, “Ecosystem managers should consider the effects (actual or potential) of their activities on adjacent and other ecosystems” (UNEP, 2000). Linking single estates with neighbouring estates supports Principle 7 that EA should be “undertaken at appropriate spatial and temporal scales” (UNEP, 2000). This principle emphasises the interaction between scales wherein boundaries of management will be defined operationally by users and managers, promoting connectivity (UNEP, 2014). Operational Guideline 4 highlights that the scale be matched to the issues being addressed at an appropriate level for implementation of management decision and actions (UNEP, 2014). For the private sporting estates decisions and actions regarding woodland expansion and use of estate land will be made by the land manager, identifying them as the central agent for decision-making over estate management.

The level or approach to participation varies and is reflected in the way that the researcher engages the stakeholders. This thesis' methodological design engages land managers to learn from their experiences and knowledge of their local landscape and
management practices but also works with them in order to identify appropriate woodland expansion areas (Chapter 5.2.3). In the later stages of the methodological process multiple land managers that share estate boundaries collaborate for consensus about potential transboundary land use practices (Chapter 5.3). Each scale (individual land manager and case study) aims to give detailed context to a set of issues, set priorities, evaluate options and formulates plans. This combines learning from and working with approaches that employs iterative and deliberative process of information exchange and exploration of values.

4.3 Mobile methods
The use of mobile methods was inspired by a talk given at a Sustainability Seminar given in 2012 on mixed methods walking interviews to explore the ways in which social enterprises are conceptualised as spaces of well-being (Evans & Jones, 2011; Muñoz, et al., 2015). This interview technique produced insights into productive and negative spaces explicitly linked with specific areas of the case study area, using thematic analysis and qualitative GIS mapping (Muñoz, et al., 2015). Such analysis would not have been captured by a static interview, which physically separates respondents from the subject of the interview. Additionally the case study approach produced micro-geographies through the use of mobile data collection and spatially informed qualitative analysis (Elwood & Martin, 2000; Muñoz, et al., 2015). This approach helps to define and explore meaningful perceptions of scale by land managers, which is supported by the WEAG’s (WEAG, 2012) aim to carry out analysis on a scale smaller than a region but large enough for strategic land use decision-making and uses boundaries relevant to existing data. These scales would focus on local need with strong links to particular opportunities or issues to be addressed (WEAG, 2012). Scott et al., (Scott, et al., 2009) highlights the importance of using an actor orientated, which provides rich information on landscape experiences, perceptions, and actions including underlying values and iterative reflection that represents individual demands and needs from their local landscape. They go on to state that researchers need to rethink and refine their approaches to integrate multidimensional aspects, as well as translate landscape perspectives into explicit assessments and evaluation that will be useful to policy-makers and practitioners (Scott,
et al., 2009). Qualitative GIS analysis may provide a potential avenue to develop assessment methods of perspectives and experiences in connection with land use practice and planning.

A wide range of innovative methodologies have been developed to tackle complex social issues and improve researcher’s ability to capture stakeholder perceptions. Mobile methods are one such area that has seen growth in recent years and has been employed as a method over various disciplines (Hein, et al., 2008). In the landscape perception field, such approaches have been in response to society’s expanding expectation of the rural landscape (Rogge, et al., 2007). The idea of studying life in motion is not a new idea, anthropological fieldwork and techniques often observe participants in their own environment instead of removing them from the study area (Jones, et al., 2008). These mobile techniques allow the ethnographer to observe normal spatial practices in the participant’s familiar environment, while accessing their interpretations and experiences (Kusenback, 2003). Most commonly mobile methods occur over a series of spatial scales from landscape (hunting rituals) to individual microcosms (relationships with specific areas).

A cultural divide exists between land managers’ interests in deer management, agriculture and woodlands, which shapes land use outcomes and often local tradition is a key influence on present and future land use practice (Slee, et al., 2014). Edensor (2006) purports that rurality (identity, values and activities) derive from the everyday actions of people who live and work in the countryside. Additionally, Carolan (2008) suggests that the ability to understand such areas is more than representational or conceptual, rather it is a lived experience and to ignore this factor will omit an important source of understanding from analysis. This establishes a strong move away from social constructivism, which relies on discourse to produce and reproduce ideas of rural activities and perception, providing a contingent and disputed representation (Cloke, 2006). Traditionally rural geography was associated with strong numerical data (Cloke, 1997), as well as positivist epistemology, which separates researchers from their subjects (predominately participant observation) rather than sharing the participants experiences
(Woods, 2010). However, since the 1990’s the influence of cultural perspectives associated with qualitative methods including semi-structured interviews, focus groups, participant observation, ethnography and thematic analyses has been growing (Hughes, et al., 2001; Pini, 2002).

4.3.1 Applicability and utility of walking interviews

Mobile methods have been used to study health issues, urban planning, sense of place, transportation patterns of the elderly (Van Cauwenberg, et al., 2012), influence of place on art (Heddon & Turner, 2010) and numerous other research fields. Walking (Anderson, 2004; Evans & Jones, 2011) or go-along interviews (Carpiano, 2009) have been used to gather explorative data where participants wander through the landscape conversing about specific predetermined locations. Immersing the researcher into the participant’s environment allows the interview to be guided by the participant’s connection to the landscape, encouraging the discourse to be triggered by the environment surrounding them. This approach draws from an oral history, which deepens engagement with individual’s narratives of change and as such, enriching the understanding of micro-scale dynamics of rural structures and management (Riley & Harvey, 2007).

Riley and Harvey (2007) used an ‘in-the-field’/’walking and talking’ technique, along with a series of group interviews and artefacts to capture the influence of neglected and marginalised elements of the rural environment. They found that capturing a nuanced perspective of the rural environment, rather than one-off snapshots (semi-structured interviews) through a place and practice driven approach produces a socially enriched viewpoint of the landscape and associated practices. Geographic Positioning Systems (GPS) are also useful in this context working in tandem with interviews, discussions and participant observation. Predominantly suitable for mobility research or mobile agents successful applications have tracked livestock mobility combined with pastoralist interviews and participant observation in Senegal to understand household livelihood strategies within rural spaces (Adriansen, 2002). In another example Danish farmers were interviewed about afforestation issues, which facilitated the creation of digitised maps identifying landowner typologies, which explained the location of new woodland in
the landscape (Madsen, 2003). This demonstrates that multiple/transdisciplinary methodologies can help research practices and individual stakeholder values to increase knowledge of rural space (Madsen & Adriansen, 2004). Lee and Ingold (2006) observed that walking/movement was a means of facilitating lived experiences, which allows the researcher to be a part of the intimate, mundane or customary practices of a specific place (Ross, et al., 2009).

In the land use context local values and attachment to natural resources were explored through ‘walk in the woods’ interviews and participatory mapping in South Africa (Cocks & Dold, 2012). This study highlighted the importance of the natural environment in maintaining cultural identity, local management practices and intrinsic heritage that could strengthen biodiversity and protect cultural enclaves. In Kenya walking transects and participatory mapping were used to gain insight into forming new adaptive collaborative management strategies (Kalibo & Medley, 2007). The participants took notes and photos that characterised the landscape, which identified opportunities and constraints for resource conservation. This type of research recognises the value of local ethno-ecological knowledge to inform better resource management and practice.

Many walking interviews involve an explicit spatial element that produces distinct areas with specific meaning, with these being transposed into transects and maps to interpret and display the results. Jones and Evans (2012) developed qualitative GIS analysis of walking interviews that emphasised connection with place (Evans & Jones, 2011), then in later work produced a spatial transcript in response to the failure of mobile methods scholars to incorporate the analytical potential of qualitative GIS, which offers grounded visualisations, aiding the analysis of spatial interview data. Greater use of qualitative GIS analysis with interview data could be used to advance concepts such as spatial resilience (Cumming, 2011). Spatial resilience focuses on the importance of location, connection and context for resilience, incorporating patterns and processes of spatial variation at multiple scales, which mutually influence and impacted by local systems (Cumming, 2011). Together, they offer potential for expanding the understanding of landscape
ecology and social-ecological systems through more effective display and interpretation of spatial variations of ecosystems.

In Sweden a connoisseur approach was used over three different forest regions, which included in-depth interviews located in the forests, walk and talk encounters, mapping forest areas and collaborative planning between the participants (Mellqvist, et al., 2013). This suite of techniques proved useful during introductory phases of planning, as it identified shared interests and created links between the various participants from diverse of stakeholder groups. Techniques like the connoisseur approach is one such example of increased efforts to instil local issues and character into landscape planning on a European level (ELC, 2000), essentially empowering local people to realise the potential of their local landscape and integrating their insights into top-down management planning processes. Mellquist et al., (2013) described the practices that emerged from their study as greatly dependent upon the walk and talk interviews, mapping exercises and field interviews, which all demonstrate the central importance of place stimulating dialogue and drawing out the interactions of practices and relationships within the landscape (Stephenson, 2007).

In Scottish land use research walking interviews with explicit spatial connectivity (evidenced by a literature search) has not been developed, as in other disciplines in Scotland and globally. This highlights an obvious gap in research methods used for connecting land use, landscape and perception. In Glass et al., (2013) a walking interview with a Crofter was performed to gain multiple perspectives from the community and private ownership, as part of a diverse upland estate structure. This approach emphasises the idea of co-generated experiences (Ross, et al., 2009), which subsequently could provide a basis for co-produced/joint management.

4.4 Collaborative approaches

The challenges of integrative, adaptive and ecosystem management are leading organisations to adopt participatory methods that enhance engagement and cooperation.
Collaborative management and governance is a process where stakeholders are jointly involved in priority setting, planning, implementation and evaluation (Koontz, 2006). This creates a forum for diverse stakeholders to resolve conflict, find solutions and develop comprehensive and mutually beneficial management plans. For collaboration to occur a common theme is required to unite multiple stakeholders and bring them to the table for problem solving, planning, implementation and assessment beyond the resolution of one particular issue (Leach, et al., 2002).

4.4.1 Drivers for collaborative research
Collaboration represents a further step to implementing the underlying structure of ecosystem-based management in which humans are the stewards of the environment. However, control and execution of stewardship is normally contested among multiple stakeholders. Methods that explore the role and impact of collaboration attempt to understand the process, trade-offs and positions of power that occur within a group of stakeholders. Takeda and Ropke (2010) highlighted the need for understanding of power relations to expose problematic relationships, inequality and dominance, which influence the planning processes. Further, they go on to question the normative approach to collaborative structures (power neutral forums and deliberative forums), stating that broader institutional and political structures that support the planning process constrain growth and effectiveness, these remain dominant influences in the planning process.

4.4.2 Application of collaborative research
Davies and White (2012) assessed the challenges of collaborative governance through the Deer Management Groups (DMG) in Scotland by using a combination of semi-structured interviews, surveys, participant observation and workshop reports over three comparative case studies. The unbalanced dynamics of power and influence between partners was regularly encountered in the DMG’s, as well as the need for greater understanding of the key connections that facilitate ecosystem-based and shared resource management. This finding emphasises the need for participative and deliberative strategies to manage an ecosystem approach at landscape level, which has
yet to be integrated into planning, decision-making and management frameworks (Prager, et al., 2012). Enhanced participative mechanisms to facilitate better understanding the DMG’s potential would be aided by participative research that focused upon linking deer management with an array of diverse uses important to local landscapes.

Arciniegas et al., (2013) evaluated the effectiveness of several collaborative spatial decision support tools that used a multi-criteria analysis to examine the spatially explicit trade-offs between stakeholder objectives. The participants found the individual qualitative maps, multi-coloured maps and maps with minimal information the easiest to understand and successfully represent information they wanted to convey. An interactive map on a single device, accessible by multiple participants provided the most productive forum for discussing and resolving conflict. Other studies have used interactive mapping tablets that have been successful in facilitating conflict resolution and generating more intricate spatial data (Alexander, 2012; Arcniegas & Jassen, 2013).

An interactive tablet allowed the participants to reach consensus for a peat meadow land use plan. However, the authors noted that a loss of control of the planning process could be experienced depending upon the mix of participants, which could inhibit interaction and bias the result of collaborative map. A main benefit of this approach was to create a friendly environment encouraging people to talk around the same issues while exchanging different types of local and expert knowledge which, when combined, could generate important information relating to management potential (Robinson, et al., 2006). Some drawbacks of using the interactive tablet included the time to become familiar with the technology, as well as participants ability and willingness to use digital mapping (Arcniegas & Jassen, 2013). Combining technological processes with hardcopies of maps and plans to annotate may offer potential to mitigate resistance to, or uncertainty of, digital software technologies.

Collaborative methods can capture qualitative data, stakeholder preferences and support the transparency of the planning processes (See (Vacika, et al., 2014)) for a
comprehensive review of 43 collaborative planning methodologies). However, many methods do not account for inherent uncertainty or stimulate creativity and innovation in the planning process (Khadka, et al., 2013). Time consumption and a type of participatory fatigue has been cited as creating diminishing returns and aversion to processes (Kangas, et al., 2010; Saarikoski, et al., 2010). This highlights the trade-offs between developing simplicity and complexity, as well as enthusiastic engagement and prolonged investment within methodological design. Planning for Real was viewed as one of the most promising methods, which involved participatory GIS as a planning aid. This enhanced involvement of local people assimilating qualitative data to better understand the problem of identification and policy development (White, et al., 2010). Other valuable attributes of collaborative methodologies included flexibility of approaches to incorporate participant’s experiences and tacit knowledge (Kajanus, et al., 2012), simplifying complex situations, stimulating social learning and creating an environment for knowledge exchange (Prewitt, 2011).

4.6 Summary
Participative methods as a means for evaluation, knowledge generation and collaboration are being recognised as key components of environmental planning and management. Researchers are looking toward more interactive methodologies, borrowed from anthropological research to increase the legitimacy, complexity and practicality of their work. Mobile methods (section 4.3) are being used over multiple disciplines and fields and are proving successful and valuable in advancing research questions and approaches, especially where human decision-making is central. At the landscape scale space is a dominant concern that directs and shapes management. This chapter has dealt with a combination of methods that account for spatial dynamics throughout multiple scales, from individual to landscape and from local to global.

The combination of walking interviews (section 4.3.1) and collaborative techniques (section 4.4) creates a multi-method approach that could connect people to their environment over cumulative landscape scales. The walking interview demonstrates clear capacity to capture more complex data to inform planning and decision-making, as
well as the use of spatial tools, such as GPS and GIS are integral in analysing and displaying this information. However, little work has been done in landscape management to incorporate qualitative data into spatial map constructs, which could aid interpretation and meaningful integration of land manager perceptions for planning and policy-makers. Increased and improved channels of collaborative activity are difficult to execute in practice, but crucial to the future of landscape approaches to land use management. Several techniques were reviewed, including interactive mapping with touch tablets. As well as the successful engagement of stakeholders, simplicity, inclusiveness and competent facilitation were mentioned as the vital factors in encouraging collaborative processes. A crucial point that emerged from the literature was the appropriate use and definition of scale that was meaningful to both the stakeholders and potential planning, practice and policy development. The role of the stakeholder or in the case of this research the land manager will play a vital role in defining scale into a meaningful metric, strengthening the connection between local and landscape scales.

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Chapter 5

Case study areas - Review

5.1 The Highlands
In the Highlands of Scotland private estates account for 43% of all land, predominately consisting of areas larger than 2,000 hectares (Warren, 2009). Other private holdings include those owned by farmers, government agencies, NGO’s and community groups. Figure 5.1 below displays the extent and composition of estates in the Highlands, including the four case study areas highlighted in blue (area) and red (boundaries). The twelve estates within the four case studies represent approximately 4.75% of the Highland area (See Chapter 6.1 for case study area selection). The following sections describe the main features of each of the four estate cluster case study areas.

Figure 5.1 - Map of estates and the four selected case study areas in the Scottish Highlands
The Highlands account for 40% of the UK’s priority species and over 75% of the priority habitats (HC, 2010). A number of key habitats are considered particularly important for the Highlands including native pinewoods, blanket bogs, arable farming, intertidal marine, montane habitat, and rivers, lochs and their associated habitats (HC, 2010). Currently the Highland woodland resource is dominated by low grade softwoods from conifer plantations, particularly in rural and remote areas, this issue has been identified by Highland Woodland Strategy, which promotes the diversification of the future resource and industry. However, the strategy goes on to identify community ownership and farmers as important targets for amenity and productive woodland expansion yet do not mention private sporting estates (HC (e), 2006).

One of the main barriers for Highland forestry industry is the prohibitive transportation costs, which isolates large areas from reaching traditional markets (HB, 2003). Development of local woodfuel markets is viewed as a strong option to increase rural development and resilience of the forestry industry, as woodfuel can create a demand buffer for less reliable markets (HB, 2003). The Highland Council (2006) supports the development of local woodfuel supply chains and recognises the need to identify important infrastructure improvements to ease the burden of transport costs and to increase the capacity of localised small-scale timber processing operations. A report commissioned by the Northern Woodheat in 2007 stated that short rotation forestry (SRF) offered a viable alternative to agriculture in the northern Highlands but more work was needed on translating the economic implications, suitable species choice and locally derived growth yields to growers (Ross, 2007). This information would demonstrate the viability and improve the confidence of investors. Improving the socio-economic resilience of the region through rural development, includes diversification and enhancing the productivity of the woodland resource. Whereas ecologically resilience is viewed from a tree health issue, aiming to safeguard the resource from such diseases as Dostistroma and Phytophthora (FCS, 2014).
5.2 Wester Ross

Wester Ross is valued for its rugged coastline and sweeping landscape views. Alpine and sub-alpine flora communities occur in the area, although it is dominated by acidic soils with pockets of limestone and rich mineral soil, which results in relatively diversified vegetation (WREN, 2014). There are over 1,100 Crofts, which incorporate extensive out-byeland (Common grazing), having potential for diverse cultivation options (WREN, 2014). Wester Ross has a prominent Loch and river system with twenty rivers and Lochs such as Maree, Carron and Monar providing extensive landscape features. Most watercourses in the area are stocked with Atlantic salmon, Brown and Sea trout as well as Arctic char.

Wester Ross is located within the Inverness, Ross and Skye Forest District, which includes 49,000 hectares (60.7%) of forest, 20% of which is broadleaves species, 29,000 hectares of open land (35.8%), and 3,000 hectares of farmland (3.7%) under Forestry Commission management (FCS, 2014). However, private woodland in Scotland accounts for 65% of all woodlands and 89% of all broadleaves, which indicates that over 60,000 hectares of private woodland (FC, 2015). Rough grazing areas for deer stalking dominate the region, especially in the west away from the Inverness area. Woodfuel is considered a good short-term and long-term objective goal for timber production in the region to meet renewable targets and generate employment. Developing the local markets with a focus on broadleaf resource, specifically through management and production of birch species. The region has two examples of strong woodfuel markets the Sleat Community Trust on Skye are working in partnership with the FC to secure a long-term supply of timber resource for their woodfuel business and the Balcas energy plant near Invergordon creates a demand for the resource (FCS, 2014).

5.2.1 Case Study Area – Wester Ross

This case study area is located on the west coast of the Highlands near Loch Carron and just north of the road to the Isle of Skye (Figure 5.2). All three estates are members of the Wester Ross Deer Management Group, which covers 96,000 hectares (DMG, 2015).
and are familiar with the status and the ongoing management activities of one another’s estates and within the region.

**Table 5.1 - Individual estate characteristics Wester Ross**

<table>
<thead>
<tr>
<th></th>
<th>Attadale</th>
<th>Inverinate</th>
<th>Glencarron</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Purpose</strong></td>
<td>Family estate bought for sporting use</td>
<td>Wildland – Purely for recreation, preserving traditional estate, including farming and stalking</td>
<td>Highland sporting estate for family and business</td>
</tr>
<tr>
<td><strong>Area (Ha)</strong></td>
<td>12,880.9</td>
<td>25,631.5</td>
<td>4,652</td>
</tr>
<tr>
<td><strong>Elevation range (metres)</strong></td>
<td>100 – 986 (two Munros)</td>
<td>20 – 1005 (Six Munros)</td>
<td>20 – 1009 (One Munro)</td>
</tr>
<tr>
<td><strong>Main land uses</strong></td>
<td>Deer stalking and recreation</td>
<td>Family retreat for recreation, walking and stalking activities</td>
<td>Sporting and recreation, fishing and some amenity forestry</td>
</tr>
<tr>
<td><strong>Unique characteristic</strong></td>
<td>Ornamental gardens (Tourist attraction)</td>
<td>Consolidated three estates, no commercial activity</td>
<td>No full-time staff, only seasonal and contracted stalkers</td>
</tr>
</tbody>
</table>

*Table 5.1* provides a comparative study area overview of individual estate characteristics, which presents a range of landowners, size and unique characteristics. However the landscape shows similar elevation ranges and the main land uses are all focussed around deer stalking and recreation with small areas of diversification. The only outlier was Inverinate estate, which is run without any commercial objectives and aims to recreate a traditional Highland estate, including working farms, sporting use for recreation and no productive woodland management (due to landowners preference).
Figure 5.2 – Wester Ross land use map (See Appendix H for A3 map)

As can be seen in Figure 5.2 the case studies are dominated by land management for rough grazing and amenity (Blue). Yellow shows the large area of common grazing land that is unused and fenced on Attadale estate, woodland (Green) and lochs (Dark blue) are the next most significant land uses in terms of area.
Box 5.1 – Pie charts displaying estate land use percentage splits (Wester Ross)

**Land Use Attadale Estate**
- 70.4% - Rough grazing/Amenity
- 5.0% - Woodland
- 1.2% - Loch
- 0.4% - Livestock
- 0.2% - Tenant farm
- 18.3% - Common grazing
- 0.5% - Riparian woodland
- 0.2% - Crofting Community
- 3.3% - Leased land
- 0.5% - Estate Lodge

**Land Use Inverinate Estate**
- 94.3% - Rough grazing/amenity
- 3.2% - Woodland
- 1.4% - Loch
- 0.5% - Farming
- 0.5% - Lochside amenity
- 0.1% - Inverinate Lodge

**Land Use Glencarron Estate**
- 87.0% - Rough grazing/amenity
- 8.7% - Woodland
- 1.5% - Loch
- 0.3% - Lochside amenity
- 2.0% - Regeneration
- 0.6% - Glencarron lodge
Box 5.1 shows that in the Wester Ross case study approximately 90% of their land is given over to rough grazing and amenity with woodland occupying between 3-9%. Farming had a very small presence on most of the estates (barely a consideration for Attadale and Glencarron); however, Inverinate maintained several farms and let various herds (sheep, cows and feral goats) roam around the estate. Figure 5.3 shows typical landscape views of all three estates, which highlight the bare ground that is kept in grazing but contrasts the dramatic views of Munros. Woodland in the photos is mostly lodgepole pine and Sitka spruce plantations except for the Glencarron photo on the left, which is planted Scots pine. The majority of the woodland is unmanaged, however, most land managers admit that management and restructuring is greatly needed but unlikely to occur.
Figure 5.3 – Wester Ross landscape views (taken during interviews)
5.3 Lochaber

Situated in a mountainous region on the west coast of the Scottish Highlands (almost directly south of Case study 1), Lochaber straddles the Great Glen and goes westwards to Ardnamurchan. Covering roughly 446,700 hectares, 29,000 of which is under woodland (72% coniferous), the Lochaber forest district produces 180,000 m$^3$ of softwood timber annually, 50% of which is sawlogs. The remainder is small roundwood, used mostly for pulp and paper (FCS, 2014). Private woodland in Lochaber cover approximately 34,500 hectares (FC, 2015). Fort William is the major urban centre of Lochaber with a population of 9,000 and is seated at the foot of Scotland’s highest Munro, Ben Nevis (HIE, 2014). It is served by local rail, ferries that connect peninsulas and the A82 that runs down the Westside of Loch Ness, following the Caledonian Canal. Many of the areas west of the A82 and Fort William have a handful of smaller roads connecting them to the main road network, which creates an island effect, resulting in less accessible land in some areas. The case study estates span three separate Deer Management Groups including Knoydart, Gleneig and West Lochaber.

A variety of geological formations result in a range of upland soil types including iron pans, deep peats on upland plateaux and peaty gleys and brown earths on the lower slopes (FCS, 2007). Rainfall is high with an average of 2500 mm per annum and land exposure is classed from moderately to severe. Key habitats found in Lochaber include Atlantic oakwood, upland birch woods, native pine wood, lowland blanket bog, lowland fen and upland heath (FCS, 2007). A small proportion of the land in Lochaber is under agriculture tenure, in crofts or small farms, only 667 crofts are registered with less than five hectares of in-bye land run in conjunction with shared grazing (LBAP, 2004). The FC in the Lochaber District plan to use at least 25% of the regions broadleaf woodland to produce high quality timber and woodfuel, which would translate to 2,000 hectares used for productive broadleaf woodland. A report produced by the Lochaber Environmental Group (2015) identify a resource base of raw material equipped to supply the local market, especially with low grade coniferous woodlands but inconsistency in product quality and supply to the consumer impeded development. Recommendations from the
report focused upon facilitation and communication improvements between the woodland owners and local market consumers to create local centres of productivity.

5.3.1 Case Study Area – Lochaber
These estates are located in the west of the Lochaber region, poised just north of the Argyll and Bute peninsula. Loch Quoich borders the north of the case study area and Loch Arkaig runs through the middle of Achnacarry estate (Figure 5.4). Loch Lochy connects to the east side of Loch Arkaig and Loch Eil is connected to Loch Lochy via the River Lochy and the Caledonian Canal (Great Glen Way).

Table 5.2 – Individual estate characteristics Lochaber

<table>
<thead>
<tr>
<th>Owner</th>
<th>Kingie</th>
<th>Glen Dessary</th>
<th>Achnacarry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Owner</td>
<td>Private owners from Perth (Campbell’s – Bought 1994)</td>
<td>Sir Patrick Grant of Dalvey (Bought in 1995)</td>
<td>Donald Cameron (In the family since around 1655)</td>
</tr>
<tr>
<td>Purpose</td>
<td>Family estate bought for sporting use</td>
<td>Run as a business</td>
<td>Family estate for recreation and homestead</td>
</tr>
<tr>
<td>Area (Ha)</td>
<td>6,488.2</td>
<td>7,034.1</td>
<td>26,316</td>
</tr>
<tr>
<td>Elevation range (metres)</td>
<td>150 – 1003 metres (two Munros)</td>
<td>50 – 1040 metres (Five Munros)</td>
<td>70 – 987 metres (One Munro)</td>
</tr>
<tr>
<td>Main land uses</td>
<td>Deer stalking and recreation</td>
<td>Sporting management (Deer)</td>
<td>Recreation &amp; sporting</td>
</tr>
<tr>
<td>Unique characteristic</td>
<td>Accessible mostly by water</td>
<td>Introduced Wild boar &amp; small commercial forestry operation</td>
<td>Clan museum &amp; leased out deer stalking to local stalkers on 15 year contract</td>
</tr>
</tbody>
</table>

Table 5.2 emphasises divergent ownership objectives connected to the driving purpose behind the estate purchase. All estates have strong recreation objectives that underpin management, including deer stalking. However, Glen Dessary run sporting lets over family recreation, whereas Kingie is more orientated toward family focused pursuits, letting out the estate lodge a few times a year. Achnacarry is wholly different to the other
estates as the estate stalking is leased to a local business for fifteen years. Kingie and Glen Dessary were once a part of Achnacarry but were sold off in 1994 to support estate revenue. The unique characteristics of each of the estates show distinctiveness through geographical location (Kingie), management choices (Glen Dessary), and personal passion with the need to adapt to increasingly restrictive circumstances (Achnacarry) (See Table 5.2).

Figure 5.4 – Lochaber land use map (See Appendix H for A3 map)

In Figure 5.4 three areas stand out:

1. Blue – Rough grazing and amenity dominates the landscape.
2. Dark green – Plantations of Sitka spruce and lodgepole pine.
3. Pale green – Commercial woodland of Sitka spruce being harvested and sold.
4. Yellow – A significant area of crofting land that is in close proximity to urban populations and main roads.

Woodland is spread over the three estates, including commercial operations and these woodland areas demonstrate greater (potential) landscape connectivity relative to the woodlands in Wester Ross.

**Box 5.2** – Pie charts of estate land use percentage splits (Lochaber)

![Land Use Kingie Estate](chart1)

- 93.2% Rough grazing/Amenity
- 6.8% Woodland
- 0.1% Loch

![Land Use Achnacarry Estate](chart2)

- 86% Rough grazing/Amenity
- 5% Woodland
- 1% Loch
- 7% Common grazing
- 0% Riparian woodland
- 0% Urban woodland
- 0% Lochan
- 0% Lochside amenity
- 1% Urban fringe
- 0% Quarry
Box 5.2 reiterates Figure 5.4 showing rough grazing and amenity dominance (as high as 93% for Kingie) and woodland on Glen Dessary comprising 10% of estate land, which is currently under restructuring operations (See Figure 5.4 and 5.5). Figure 5.5 displays landscape views of Lochaber, which highlight the greater presence and potential for forestry in the region than in Case studies 1 (Wester Ross) and 4 (East Sutherland). The second Kingie photo highlights the poor condition and extent of internal estate infrastructure.
Figure 5.5 – Lochaber landscape views (taken during interviews)
5.4 Cairngorms

The Cairngorms area represents Britain's largest National Park covering 452,800 hectares with a population of 17,000 people. It is the UK's largest Sub alpine/arctic mountain range with 5 of Scotland’s highest peaks and contains the largest area of contiguous semi-natural (native Scots pine) forest in the UK (CNPA, 2012). The park covers 6% of Scotland’s land area and is one of the most protected in Europe, possessing multiple overlapping layers of heritage and conservation designations (almost half of the park is under Natura 2000), together with the park’s managing authority, which coordinates strategic plans and partnerships to preserve and enhance the unique character and identity of the park’s environment and communities (CNPA, 2013).

The Park’s woodland is 79% native, representing 25% of Scotland's entire native woodland resource. Conifer plantations make up 50% of the woodlands in the National Park and represent a significant economic natural asset (CNPA, 2013). They are a mixture of Scots pine, Sitka and Norway spruce, lodgepole pine, Douglas fir and larch (CNPA, 2013). Other important woodland habitats include birch and aspen, wet and riparian, and upland oak woodland. The Tay Forest District, which encompasses the mid and southern extent of the case study area produces 170,000 m³ annually (FCS, 2014). The woodland resource of the CNPA covers 62,300 hectares, the private ownership accounts for 84% of this resource (FC, 2012).

A broad mixture of land uses is supported within the Park driven economic, environmental and social motives (CNPA, 2013). Conservation, wildlife protection and tourism are all elevated concerns, as well as opportunities to be incorporated into management. Woodfuel production and use is promoted within the Park under the Climate Change Initiative that focuses on carbon cutting activities. This highlights the effective use of woodfuel in making both money and carbon savings. For example a woodchip boiler heats one hundred homes in Aviemore and Drumuir estate saves £2,500 a year while finding a use for thinnings and windblown trees (NP, 2016). Alvie and Dalraddy estates converted the estate buildings to woodfuel and use thinnings from the pine forest to fuel the boilers, which saves them £10-15,000 annually on energy bills, the estate also runs a woodchip business, which aids woodland management (NP, 2016).
5.4.1 Case Study Area – Deeside

The Deeside cluster below (Figure 5.6) constitutes 19% of the National park, although a third of Invermark estate lies outside the National Park boundary. All three estates are within the East Grampian Deer Management group, which at 270,000 hectares, containing 34 estates is one of the largest in groups in Scotland (ADMG, 2016).

Table 5.3 – Individual estate characteristics Cairngorms

<table>
<thead>
<tr>
<th></th>
<th>Invermark</th>
<th>Balmoral</th>
<th>Invercauld</th>
</tr>
</thead>
<tbody>
<tr>
<td>Owner</td>
<td>Lord Dalhousie (In the family since around 1782)</td>
<td>British Royal family</td>
<td>Lord Farquharson since 1632, run by Invercauld Trust (Composed of eleven Trustees)</td>
</tr>
<tr>
<td>Purpose</td>
<td>A part of the family's assets, run as a working estate</td>
<td>Family Highland retreat</td>
<td>Run as a business</td>
</tr>
<tr>
<td>Area (Ha)</td>
<td>19,237</td>
<td>16,321.2</td>
<td>40,533.1</td>
</tr>
<tr>
<td>Elevation range (metres)</td>
<td>100 – 832</td>
<td>200 – 1155 metres (Seven Munros)</td>
<td>250 – 1179 metres (Sixteen Munros)</td>
</tr>
<tr>
<td>Main land uses</td>
<td>Deer stalking and grouse shooting</td>
<td>Deer stalking and recreation</td>
<td>Deer stalking, grouse shooting and Salmon fishing</td>
</tr>
<tr>
<td>Unique characteristic</td>
<td>Uses traditional deer extraction with ponies</td>
<td>Famous as Royal family's retreat, 3,237 ha owned by James Gordon and is a large tourism draw, which employs 70 staff</td>
<td>Comparatively extensive Caledonian Scots pine areas, operate sporting syndicates, and one of the largest estates in Scotland</td>
</tr>
</tbody>
</table>

The Cairngorms area has the most homogenous ownership pattern of all the case studies, with three aristocratic landowners that have inherited their estates. Balmoral is the only estate that is not run with an explicit economic priority and does not maintain extensive grouse moorlands. Longer ownership is more likely to sustain traditional land uses and...
management structures than newer owners due to the continuity of practices, which also appears to be the case for larger estates. Invercauld is larger than the entirety of the East Sutherland cluster. This case study area also has the highest and largest amount of Munro peaks, which attracts visitors but presents more management challenges due to higher average elevations.

![Figure 5.6 – Cairngorms land use map](image)

The estates in the Deeside cluster are dominated by rough grazing and amenity uses (Figure 5.6), which include deer stalking across all three estates. Invermark and Invercauld are also dominated by extensive grouse moors (See Figure 5.7). Invermark especially has a singular focus on grouse moor management and the head stalker was keen to introduce other sporting bird species. Balmoral in comparison is significantly diversified, possessing the largest woodland percentage of all estates in the study (18.3%
see Box 5.3). Caledonian woodland grows around the estate boundaries between Invercauld (9.1% woodland) and Balmoral, and also follows the A93 between Braemer and Ballater. This forms the most intact woodland corridor over the case study areas, predominantly consisting of Scots pine, some Larch and Douglas fir.

**Box 5.3** – Pie charts of Cairngorms land use percentage split (Cairngorms)
Land Use Invermark Estate

- 98% Rough grazing/Amenity
- 2% Woodland
- 0% Loch
- 0% Lochan
- 0% Urban fringe
- 0% Water treatment
- 0% Estate Lodge
Figure 5.7 – Cairngorms landscape view (taken during interviews)
5.5 Sutherland

Sutherland is both the Highlands and UK’s largest county at 600,071 hectares. Additionally, it is the most remote and sparsely populated county with a population of 13,778 and a density of 2.2 people per km² (HC, 2006). Sutherland is the home of the Flow Country, which contains Europe’s most extensive area of peatlands and 25% of the county is under natural heritage or conservation designations (HC, 2006). The county is famous for its wild flat landscape of peatlands, lochs and rivers (Figure 5.8 and 5.9). In the interior of the county where the case study is located, shooting and fishing activities dominate, and conifer plantations established in 1970’s - 80’s comprise the wooded component (LBAP, 2003). Crofting accounts for 100,048 hectares of the land (2000 crofts), as during the clearances people were moved from the inland settlements to narrow strips of fertile land on the coast, replaced by sheep grazing and deer forests, which persists today (LBAP, 2003). Farmland is mostly confined to the south-east of the region, as well as some of the more fertile Straths. Due to the decline of the agriculture industry a lot of crofts and small farms are being abandoned, which causes loss of rural skillsets and managed land (LBAP, 2003).

Sutherland holds over 74,200 hectares of woodland, most of which are recently planted non-native coniferous plantations (1960-80’s) with small pockets of broadleaves that exist in sheltered Straths and on the west coast including birch, hazel, oak, alder and other natives (LBAP, 2003), approximately 48,000 hectares of this woodland will be under private ownership (FC, 2015). Approximately 80% of all Forestry Commission woodland in the North Highland area (including Caithness) has been planted since 1960, average yield class for the Scots pine is 12, with potential for a mixture of high quality timber and woodfuel products (FCS, 2014). A significant factor affecting woodland expansion and management is the peatlands, which are being considered for World Heritage status and preclude any planting due to their conservation and carbon value (LBAP, 2003). Woodfuel potential is high due to the remoteness of the region and the significant amounts of coniferous plantations in poor health that could feed the market. North Highland District produces 250,000 m³ from thinnings annually (FCS, 2014) and a woodfuel and biomass combined heat and power plant has been commissioned in Caithness, which plans to use material from both FC and privately owned woodland,
harvesting lower grade timber that have no current market (HC, 2015). Such a plant will aid the necessary momentum to develop both the woodfuel market, supply and demand in tandem, as well as using low grade timber products.

5.5.1 Case Study Area – East Sutherland
The case study area accounts for 5.7% of Sutherland and is situated in the heart of the Flow country backing on to the RSPB's Forsinard estate and cross the East Sutherland Northern Deer Management Groups (ADMG, 2016).

Table 5.4 – Individual estate characteristics in the East Sutherland cluster

<table>
<thead>
<tr>
<th>Owner</th>
<th>Badanloch</th>
<th>Borrobol</th>
<th>Achentoul</th>
</tr>
</thead>
<tbody>
<tr>
<td>Owner</td>
<td>Family Trust (3 children), bought by Lord Leverhulme in 1953</td>
<td>Sir Michael Wigan (Bought by his grandfather in 1948)</td>
<td>Sir John Nutting (In the family since 1894)</td>
</tr>
<tr>
<td>Purpose</td>
<td>Family estate bought for sporting uses and flat rolling landscape</td>
<td>Family estate, run as a business and home</td>
<td>Family estate bought for recreation</td>
</tr>
<tr>
<td>Area (Ha)</td>
<td>14,217.5</td>
<td>9,382.5</td>
<td>9,488</td>
</tr>
<tr>
<td>Elevation range (metres)</td>
<td>20 – 400</td>
<td>50 – 434</td>
<td>50 – 580</td>
</tr>
<tr>
<td>Main land uses</td>
<td>Deer stalking and fishing</td>
<td>Deer stalking and recreation</td>
<td>Deer stalking and recreation</td>
</tr>
<tr>
<td>Unique characteristic</td>
<td>Large water resources (7 lochs) and is equipped for disabled anglers</td>
<td>Active Christmas tree business (lodgepole pine)</td>
<td>Historic cairns and extensive livestock (Two full-time shepherds employed)</td>
</tr>
</tbody>
</table>

These three estates have a strong family lineage, inherited and intended to be passed down within the family. Grouse moors were a significant land use when Badanloch and Borrobol were bought in the mid-twentieth century; however, due to habitat and grouse population decline the majority of land was turned over to stalking, which is reflected in the main land uses of the case study (See Table 5.4). In contrast to the Cairngorms case
study (section 5.4), the estates make up the smallest case study cluster by area and the lowest by elevation. However, this is countered by the peatlands and wetlands habitats that are highly valued and abundant within the Flow country. Each estate has a distinct focus, Badanloch with fishing resources due to its position on the river Helmsdale and extensive loch system (See Figure 5.8); Borrobol with the study’s only sustainable commercial timber-based operation (Christmas tree plantation – no usage of the timber, grown for aesthetic pleasure and tradition); and Achentoul with two full time shepherds and interchanging grazing systems with an estate further south (within the owners portfolio).

Figure 5.8 displays significant infrastructure connections with an A-road and B-road passing through both Badanloch and Achentoul (close to Borrobol). Furthermore running through Achentoul estate and close to the borders of Badanloch and Borrobol is a regional rail line. Woodland has a very small role within the estates (0.5 - 3%, Box 6.4), with some of the lowest woodland coverage of all estates in this study. The current woodland is fragmented and windblown with possibly some semi-ancient Scots pine on Achentoul, bordering pasture areas.
All three estates have improved pasture land that is either given over for deer feeding sites or livestock grazing; a few areas are vacant and unutilised (Figure 5.9). Regeneration schemes of mixed hardwoods have taken place on all three estates; Badanloch established an 80 hectare area of Alder, Borrobol Birch and Achentoul small patches of mixed broadleaves. These activities are fulfilling the biodiversity and amenity objectives of the estates.
Box 5.4 – Pie charts of East Sutherland land use percentage splits (East Sutherland)
Below in *Figure 5.9* note the flat rolling landscape valued by the landowners. A mixture of peatlands, pastures and lochs are shown. The Christmas tree plantation is shown containing fenced juvenile specimens flanked by livestock grazing areas.

*Figure 5.9* – East Sutherland case study landscape views (taken during interviews)
5.6 Summary

This chapter provides an overview of the Highlands, the Highland regions and the case study areas including land use with a focus on woodland structure and woodfuel potential. Many top priority habitats exist in the Highlands, which make many of the regions ecologically important and unique within both a UK and European context. Despite widespread crofting and tradition of agriculture in the Highlands, the industry is declining, leaving a lot of land unmanaged and vacant. This has been seen as an opportunity for woodland expansion and woodfuel production but the current woodland resource is often in poor health and harvesting is not cost effective, mainly due to prohibitive transportation costs in remote and rural regions. The Cairngorms National Park is the only region with significant areas of well-managed woodland, which is partly due to developing the Caledonian pinewoods. Private ownership accounts for 65% of the woodland resource and 84% of the broadleaves, which emphasises the importance of land holdings such as the case study estates in developing the woodland resource and generating sustainable supplies of timber products.

Successful woodfuel projects of varying sizes initiated by diverse landowners, such as community trusts, estates and local authority can be seen across the four regions. The Woodfuel development is a high priority for the Forestry Commission, using both the current conifer resource, as well as expanding the broadleaf resource to create a strong base across the Highlands. However connectivity between the grower, the consumer and the market is a major issue, as is consistency and quality of supply. Generally there is a lack networks, awareness and infrastructure that hinders more rapid and confident development.

Deer stalking is a dominant land use over all the case studies, even though the form and level differs from estate to estate (Achnacarry stalking lease, Kingie and Attadale family recreation focused, Glen Dessary business focused). Recreation is also a common driver for both owning and running the estates; mainly for the owner and their families. Public access and recreation considerations play almost no part in estate management. All off the estates are dominated by rough grazing land, which supports stalking activities, some
livestock and traditional landscape amenity. Most estates have over 70% of their land under rough gazing.

Invermark and Invercauld estates have significant land under grouse moors, and East Sutherland has greater areas of wetlands and peat bogs, which reduces the rough grazing areas. Inverinate, in Wester Ross is the only estate with no commercial activities, despite a diverse range of farming and sporting management activities being supported by the owner’s private wealth to create a traditional wildland aesthetic. Achentoul and Borrobol estate in East Sutherland supported active livestock management but for the majority of the case study areas livestock management practices were declining or absent.

In most areas lodgepole pine and Sitka spruce plantations dominate the woodland cover, with the exception of the Cairngorms, which possesses greater diversity due to a predominance of native Scots pine forest, as well as Sitka spruce, larch and Douglas fir. The majority of the lodgepole pine and Sitka spruce plantations are unmanaged and in poor health apart from the plantation area on Glen Dessary estate, which is being harvested over a five year period. East Sutherland is the smallest case study area at approximately 33,000 hectares and the Cairngorms the largest at 78,000 hectares. Glencarron is the smallest estate at 4,652 hectares in Wester Ross and the largest is Invercauld at 40,533 hectares.

Munros exist in all case study areas, excepting East Sutherland where the land did not rise above 500 metres. However, the Cairngorms has the greatest topographical contrast with twenty three Munros over two estates (Balmoral and Invercauld), with the highest point on Invermark reaching 832 metres. New ownership (bought by current owner) dominated in Wester Ross (Inverinate and Glencarron) and Lochaber (Kingie and Glen Dessary), whereas the Cairngorms and East Sutherland case study areas consist entirely of inherited estates, some of which (Invercauld) have been passed down through multiple-generations for over three centuries.

The next chapter will present the methodology used on each of the estates and case study areas, detailing a multi-methods approach incorporating participative techniques.
(partnership and consultation), mobile methods, GPS, GIS and collaborative techniques that aim to inform and develop insights into private Highland estates interpretation of an ecosystem system approach.
Chapter 6

Methodology – Walking the land

6.1 Introduction
This chapter presents the multiple method approach used to investigate land use decision-making and woodland expansion drivers on private sporting estates in the Highlands. Short rotation forestry (SRF) is a lens used to investigate woodland planning alongside existing estate activities, which aim to identify practical planting areas as part of a regional interpretation of an ecosystem approach. The methods consist of eight distinct stages of data collection, evaluation and critical review, which are listed below (See Figure 6.1).

1. Pre-fieldwork preparation
2. The field interview (estate)
3. Estate woodland planning
4. Forest Energy Tool (An aid to decision-making)
5. Displaying data through maps
6. Estate land use reports
7. Case study areas – Clustered land use collaboration
8. Case study areas analysis
Stage 1  Pre fieldwork preparation
- Identify case study areas
- Recruit sporting estates (clustered)
- Digitise estate boundaries

Stage 2  Field interview
- Landowner/manager walking interviews
- Cultural drivers spatially plotted
- New woodland planting and SRF jointly planned with landowner

Stage 3  Interactive woodland planning
- Ideal sites identified and located on tablet mapping
- Species and area defined
- Objectives and SRF contribution established

Stage 4  Forest Energy Tool
- Planting area attributes applied to Forest Energy tool
- Potential productive output
- Potential economic output

Stage 5  Mapping outputs
- Current land use
- Landscape resilience (cultural)
- Woodland expansion and compatibility

Stage 6  Estate land use reports
- Current management and activities
- Cultural influences and context
- Potential SRF, carbon and calorific value

Stage 7  Estate cluster collaborative discussions
- Feedback on reports
- Land use and collaboration discussion
- Identifying and mapping collaborative opportunities

Stage 8  Inter and intra-regional analysis
- Cultural driver analyses
- Woodland and carbon analysis
- Micro-regional (ecosystem approach) analysis

Figure 6.1 – Multiple methods approach
6.2 Estate level

6.2.1 Pre-Fieldwork preparation
Private sporting estates cover 43% of the Highlands (Warren, 2009), and are therefore potentially influential in developing woodland resources. The case study areas have been chosen to represent the diversity of the Highlands environmental conditions, management influences and specific local socio-economic contexts. They incorporate different geographical regions of the Highlands (See Figure 6.1) and constitute 4.75% of the region and 11% of private estates in the region. Due to the time and resource limitations one pilot and three case study areas were included in this research and the focus was exclusively on private sporting estates, as they have significant potential for woodland expansion whilst managing for historically competing land uses (Macmillan, et al., 2010; WEAG, 2012). Neighbouring estates were selected to explore case study areas’ potential for collaborative management across boundaries and as a regional network, which aids the creation of micro-geographies and identifying meaningful scales below regional but large enough to have a significant strategic decision-making potential (Elwood & Martin, 2000; Scott, et al., 2009; WEAG, 2012). The four case study areas are listed below with a rationale for their inclusion.

1. **Wester Ross** – Dominant deer stalking country, famous for west coast landscapes and crofting areas. Originally the pilot case study area, which was included due to success of methods used.

2. **Lochaber** – A more heavily forested area than most in the Highlands and relatively close to regional wood processing centres.

3. **Cairngorms (Deeside)** – Situated within the Cairngorms National Park with multiple natural heritage designations and management structures. However, Deeside is located in an area of the Park considered remote from core management activity in Aviemore and Speyside.

4. **East Sutherland** – The Flow Country has extensive peat bogs and conservation designations, as well as a history of contentious decision-making concerning woodland expansion and planning (Macmillan, 2001).
Suitable estates were identified through discussions with agency professionals (Forestry Commission, SNH and CNPA), academics (UHI) and people associated with land management (Land agents). However, recommendations and contacts provided by these groups were not always successful, therefore individual estates and land managers in the case study areas were sought out through other methods. Land managers were contacted by phone or e-mail (including a PDF recruitment flyer explaining the research and fieldwork commitments, see Appendix A), after which further contacts and introductions with other land managers followed that often led to neighbouring estates agreeing to participate in the research. Chairs of the local Deer Management Group (DMG) also provided contacts for neighbouring estates within a partnership area, which afforded the opportunity to target specific estate clusters. Once the estate agreed to participate in the research a time and date was set to perform the field interview and woodland planning.

Field interviews were organised with either the landowner or manager, and sometimes both, depending on level of involvement with land management decision-making, which varied from estate to estate. On some estates, the land manager was in-residence and actively managed the land; whilst on others the principal decision-maker was a manager, due to the owner’s absence. For comprehensive and comparable interview data both landowners and managers were asked to give feedback on the research outcomes and Land Use Report (Section 6.2.6), giving them the opportunity to add or amend any statements, spatial planning elements or researcher interpretations of the interview data.

Estate boundaries were then uploaded to a GIS App (GISKIT) on an iPad, in a KMZ file format, which facilitated identification of geographical features and potential woodland expansion sites. The boundary information was provided in advance of the interview by the estate or mapped from estate data on the website ‘whoownscotland’ (Wightman, 2013). Wester Ross originally formed the pilot study to test the methodology’s effectiveness and to modify any issues that emerged for the main case study areas. The fieldwork elements of the methodology worked as expected, however, interpretation of the socio-cultural data on a spatial level over the case studies went through several iterations before an effective method and analysis was reached (Detailed in 6.2.5). This
reflects the continual difficulty experienced in translating social and cultural data into spatial information often resulting in weak analysis within complex environments (Martin & Hall-Arber, 2008). A combination of factors contribute to this persistent issue such as mismatches between geographic and temporal scales, biophysical and sociocultural data, incompatible ways to measure and display the data, as well as an inadequate capture of the connection between people and landscape (McLain, et al., 2013). The prolific generation of biophysical spatial data in comparison to socio-spatial has become a barrier to effective socio-spatial representation and resulted in limited socio-spatial data to use in analyses (McLain, et al., 2013). This methodology aims to create a meaningful socio-spatial layer that connects the land manager to the landscape and constructs a significant geographic scale (micro-geographies – Chapter 4.3) that incorporates both sociocultural and biophysical data over the case study areas (CBD EA Principles 2, 3, 7 and Operational guidance 4 – Chapter 2.3).

6.2.2 Field Interview

6.2.2.1 Theory

The field interview builds upon the concepts of the Walking, Go-along and Mobile interviews employed in a variety of disciplines from health, recreation to urban planning (Anderson, 2004; Carpiano, 2009; Evans & Jones, 2011). Using thematic analysis, which is commonly used in land use research the interviewer uses a semi-structured interview approach with a focus on particular topics to prompt or guide the discourse during the more conservational land manager led interview structure (Skerratt, 2013; Raymond, 2015). This approach enables the researcher to draw out emergent themes from the interviews relating to each individual estate, case study areas and for Highland private sporting estates. Hitchins (2004) and Evans and Jones (2011) assert that walking interviews generate richer data, which provide insights that could not be captured in a conventional interview. This technique was adapted to explore land management issues and decision-making on a spatial level with the aim to identify dominant themes and core drivers of land use on participating estates and relate then to practice (Figure 6.1 – Stage 6). These themes will aid to develop understanding of land managers perceptions and
practice, which directly and indirectly connect to or undermine ecosystem approaches principles and application (Chapter 2).

The methodology uses a phenomenological approach in which the participants are observed interacting with their environment, rather than removing them from their everyday surroundings (Kivisto, 2008). This provides observational data of the participant within physical areas of the estate. For example a land manager demonstrate particular passion for a subject matter or area of land on the estate through tone of voice, gesticulation or general animation. Indicating a preference or an influential factor during decision-making, similarly the land manager may demonstrate negative preference for a land use or area of land despite communicating the benefit and public good. This nuance can be influential on the context of a statement and the resultant emergent themes. These observations are noted in a reflective write-up directly after the interview, so not to interfere with the conservational flow of the interview. The recorded observations are then incorporated into the thematic analysis during transcription and coding stages, which integrates their meaning into the final emergent themes in the results section (Chapters 7-9). Supporting this is an ethnographic approach, which explores cultural phenomena by partially observing land managers during the interview. In order to understand cultural phenomena, interpretations of the land manager's environment will be examined to deconstruct key relationships, symbolism and every day concepts embedded within estate management (Mann, 2008; Walker, 2011; McCune, et al., 2013).

The ethnographic approach describes the participants' perspectives and assigns meaning to practices and management areas of the estate. Social interpretation explains the narratives, which contextualise management responses and cultural drivers of the estate within the land mangers' decision-making mindset. Kusenbach (2003) maintains that social interpretation is rooted within five principles:

1) **Perception** (why things are a certain way)

2) **Spatial practices** (what action or activity happens where)
3) **Linkages between biography and place** (the role of culture and environment interacting as an entwined factor)

4) **Architecture of natural surroundings** (the scope and limitations of the physical environment)

5) **Social realms** (Environments constructed by social histories and the influence of current social factors)

Understanding the participant’s role in management includes history, interpretation of environment, perception of actions and consequences to the shape of future activities, which draws upon Kusenbach’s five principles. ‘Perception’ and ‘Spatial practices’ are central strands of the field interviews and woodland planning. ‘Architecture of natural surroundings’ are often pre-existing conditions less prone to change (Landscape aesthetics and traditional practices), which influence ‘Biography and place’, personal histories and connections that are flexible and immediate (Land manager’s connection to place and history). These connections are more susceptible to shifts, responding to the social constructs and power dynamics of the region.

### 6.2.2.2 Application

The Field interview uses the familiar environment and movement through the landscape to enhance the interview’s scope and effectiveness (Elwood & Martin, 2000; Carpiano, 2009). Rather than the interviewer leading, the participant guides the interviewer through daily management activities and various areas of the estate (Scott, et al., 2009). This exploratory interview but in-depth approach creates an informal atmosphere. A topic guide (Appendix C) is used as a point of reference throughout the interview, which lasts between 1.5 - 6 hours, depending on the size and accessibility of the estate. This factor creates a limitation in the study that not all interviews will be consistent in regard to time spent with the land managers and the level of interaction with areas of the estate will vary depending on the estate infrastructure. In order to minimise this inconsistency spatial land use discussions complemented the walking interview using large estate maps and the ipad GIS App (GISKit), before and after the interview.
Each interview was conducted through a combination of walking and driving around the estate with the land manager in a 4x4 vehicle, using accessible routes and visiting different land use areas. The discussions were recorded by two Dictaphones (one attached to the land manager, the other to the researcher for back-up), while the route of the interview was tracked on a GPS unit and pictures of the estate’s landscape and land uses was captured on camera (See Table 6.1). Interview script was then spatially linked to specific areas of the estate by a combination of spatial data from the physical map discussions and matching the recorded Dictaphone conservations with the GPS timeline across the estate, resulting in a spatial transcript (Jones & Evans, 2012). This process connected land manager perception and decision-making processes to physical areas of the estate and practices (See Figure 6.3). However, general themes were often discussed with no connection to the landscape, these points were included in the analysis without spatial reference on the estate maps. Also some land uses and areas of practice were referred to from a distance which had to be noted during the transcription of the interview and then connect that discourse to that particular element of the estate.

**Table 6.1 – Equipment for the Field interview**

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dictaphone plus clip-on microphone</td>
<td>Recording interview content and reference for spatial marker</td>
</tr>
<tr>
<td>GPS Unit</td>
<td>Tracking interview route around the estate – giving spatial references to interview transcript</td>
</tr>
<tr>
<td>iPad (with mapping app GISKit)</td>
<td>Uploaded with a map of estate boundaries to mark observations and potential areas of woodland expansion</td>
</tr>
<tr>
<td>Camera</td>
<td>Taking pictures of the land uses on the estate</td>
</tr>
</tbody>
</table>

The interview covered topics including history of the estate, management changes and visions, woodland expansion, forest energy potential, perception of ecosystem services, collaboration and management relationships, as well as any other topic that occurred
during the flow of conversation. These discussions were flexible and fluid to enable a unique picture of the estate to form. Additionally, the GPS tracking highlighted routes and roads accessible by 4x4 vehicles, these tracks displayed potential harvesting and extraction routes (See Appendix E), as well as highlighting limitations of accessibility and areas with potential for land use, which are locked up by lack of infrastructure.

**Figure 6.2** - Connection and utility of Field interview and woodland planning
Walking through heterogeneous landscapes generates diverse responses to discussions and narratives that elucidate the relationship between landscape, people and practices (Figure 6.3) (Solnit, 2001; Ingold & Lee, 2008; Jones & Evans, 2012). This builds a deeper understanding of land use change or permanence from landscape narratives, providing greater insight into complexities of decision-making and connecting them to internal or external cultural factors (Solnit, 2001; Ingold & Lee, 2008). Figure 6.2 above demonstrates the connection between the Field interview process and the woodland expansion planning section of the methodology, informing an integrated and holistic management approach (CBD EA (UNEP, 2000)).

Figure 6.3 – Example of field interview developing into a spatial transcript

6.2.3 Woodland expansion planning
The planning of new woodland areas was performed in parallel with the field interview. Areas of short rotation forestry and other woodland expansion areas were identified by the land manager immediately after the field interview in the estate lodge or the office,
using the iPad-mapping app, as well as a printed ordinance survey map. The estate boundaries were overlaid upon a Google Earth image (variable scale) on the mapping app GISKit, helping the manager to identify specific areas by landscape features.

During the planning process the land manager allocated the size of the planting area, species mix and the quantity of timber to be extracted for woodfuel at 20-25 year rotation. The remainder of the woodland was to be managed for amenity/shelterbelt or timber. These attributes of planned woodland were entered into the Forest Energy Tool (see next section), which produced multiple outputs, giving the land manager an approximate idea of the potential value and impact of the planned woodland. WEAG (2012) aim to ensure that all managers, not only those creating coniferous woodland, think about opportunities for future timber and woodfuel production.

6.2.4 Forest Energy Tool
The Forest Energy Tool was developed in response to gaps identified in Scotland’s Woodland Expansion Strategy (WEAG, 2012) and other strategic reports (SFS, 2006; SLUS, 2011; SCCAF, 2009). These indicated the need for land managers to understand the potential benefits of woodland expansion, and raise awareness of woodland management’s value to the landscape. A main focus of the WEAG (2012) report was the important role of support and different mechanisms to help deliver more resilient Scottish woodlands, emphasizing help with species selection, woodland management approaches, stocking densities and tying woodland design into future economic, environmental and social challenges. As mentioned above in section 5.2.3 woodfuel production is viewed as suitable objective for all types of Scottish woodlands. Roser et al., (2011) highlight that very few woodland managers in the north of Scotland receive income from timber but also suggest that increased energy use from timber could generate significant local markets. However, they go on to comment that lack of confidence is a key issue constraining market development and supply chains, which identifies a low knowledge base as a root cause, and the situation is unlikely to improve until land managers are presented with strong evidence for demand and profit (Roser, et al., 2011).
Numerous models have been used to help land managers predict the competitiveness and profitability of land use conversion to productive forestry (Frey, et al., 2013). Some models conclude that forestry has a competitive edge over agriculture on marginal and average quality land. However, the findings from models are dependent on the regional variations and characteristics (Huang, et al., 2004; Ibendahl, 2008; Frey, et al., 2010). More relevant to this research are several models developed within a recent Forest Energy COST Action (COST, 2013). These EnerTrees models predicted the costs of different operations in forest energy supply chains, including cost of various biomass harvesting choices, as well as the cost of thinning and logging residues (Forest Energy Portal, 2013).

The Forest Energy Tool was developed specifically for potential woodfuel markets in the Highlands of Scotland to give land managers a decision support tool that is regionally specific. Eight short rotation tree species were selected (See Box 6.1) as they are considered some of the most promising and productive species for short rotation forestry in Scotland (SRF) (FR, 2014). SRF trials underway in six different locations around the Highlands include several of these species (Harrison, 2009). As the trials are only in their fourth year of a 20 year project, an alternative was needed to predict growth yields, so local yield class information from Forestry Commission Scotland datasets was used at 20-35 year age classes (FC, 2013). The FET advances forestry productivity models by using parameters that define a specific region, including species growth, management costs, national incentives and environmental conditions. Additionally generating profit linked with potential economic and social carbon value from woodland creation provides evidence to compare with other land use options. Outputs such as woodfuel profitability and carbon value on a local scale directly connects strategic policy aims with an individual decision-maker and local land management issues. Previous models have focussed on the most suitable areas for woodfuel on a spatial level to inform the decision-maker (Sacchelli & De Meo, 2013) or assessing the best case scenario for harvesting forest residues in mountainous regions (Zambelli, et al., 2012), whereas this tool relies on the land manager to inform the tool of ideal areas for woodland expansion. Most economic models rely on
hard coding integrated into programming code, which makes it less reusable and extendable (Sapkota, et al., 2015). The FET in this research is based upon manually inputted equations and calculations transferred from readily available web resources (i.e. FC Carbon Code) for ease of modification and extension. Also being able to view the tools components and change some of the variables to match land manager experience increases the appeal for at least three quarters of the case study areas.

**Box 6.1 – Tree species options for short rotation forestry and woodland expansion (FR, 2014)**

### Conifers
- Scots pine (*Pinus sylvestris*) – Native [chosen for wide range and suitability in the Highlands]
- Sitka spruce (*Picea stichensis*) – Non-native, introduced in 1831 [Most effective productive species in UK forestry]
- Hybrid larch (*Larix x eurolepis*) – Non-native, discovered in 1904 [Grows well on many estates in the Highlands, popular landscape tree]
- Douglas fir (*Pseudotsuga menziesii*) – Non-native, introduced in 1831 [Fast growing species with great potential for production]

### Broadleaves
- Downy birch (*Betula pubescens*) – Native [Pioneer species, most proliferate species in Scotland, grows well in mixed stands and alone on poorer soils]
- Poplar/Aspen (*Populus tremula*) – Native [Fast growing, establishes well next to riparian areas]
- Hybrid aspen (*Populus tremula L. x Populus tremuloides*) – Non-native cultivar [Faster growing, significantly higher potential yields for production]
- Sycamore (*Acer pseudoplatanus*) – Naturalised non-native, introduced before 1500 [Fast growing species, successful in the Highlands]

As displayed in *Figure 6.4*, the Forest Energy tool gives the land manager multiple outputs of volume and value, produced by 62 input fields within an Excel file covering management costs, timber prices, SRDP grants and environmental factors (*Table 6.2*). This tool was used to give land managers an approximate answer to the question, “*What benefits will woodlands give me?*”
Table 6.2 - Forest Energy Tool fields and functions (See Appendix D for full set of fields)

<table>
<thead>
<tr>
<th>Overarching Fields</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environment</td>
<td>Soil and elevation, plus depreciation factors upon wood volume</td>
</tr>
<tr>
<td>Planting attributes</td>
<td>Area, species, stocking density, perimeter, rotation period</td>
</tr>
<tr>
<td>Grant inputs</td>
<td>Woodland creation grant, Sustainable forest management grant, SRDP. Forestry Commission grant calculator</td>
</tr>
<tr>
<td>Management costs</td>
<td>Establishment, fencing, restocking and ground prep, harvesting, extraction, processing and transport</td>
</tr>
<tr>
<td>Timber volume (m³)</td>
<td>Annual, 20-35 years, carbon sequestered (tonnes) annually, 20-35 years</td>
</tr>
<tr>
<td>Net Forest Energy value (£)</td>
<td>Based on local market prices for woodfuel 20-35 years</td>
</tr>
<tr>
<td>Carbon value (economic and social)</td>
<td>20-35 years. Economic=£5.6/tonne; Social=£52/tonne</td>
</tr>
<tr>
<td>Calorific value (MWh)</td>
<td>60, 40, 30% moisture content - Annually, 20-35 years</td>
</tr>
</tbody>
</table>

The tool was initially developed to match suitable species to areas of the estate, approved by the land manager. However, as the majority of management decisions are based upon economics, the next logical step was to consider potential economic implications. Decreases in timber volume were accounted for by land use class (Hassall, et al., 1994) and elevation (Worrel & Malcolm, 1990), following which a percentage of the area (20-45%) was identified as harvestable after 20-25 years by the land manager.
This percentage of the proposed woodland planting produced a market value for woodfuel, based on local prices per m$^3$ (FC, 2013), minus management costs (Valatin & Saraev, 2012) and including contributions from available grants (FCS, 2013). The next part of the tool produces three main outputs, net economic value, carbon value, and calorific value (Figure 6.4). Net economic value is the profit the land manager would make from selling the SRF crop locally. Current carbon price on the EU trading floor at the time
of research was £5.9/tonne (Reuters, 2014), whereas the social value, representative of
the comprehensive carbon value was £52/tonne (Valatin, 2010)\(^1\).

The conversion of woodland planting to carbon sequestration was achieved using
Forestry Commission Carbon Code look-up tables, which took into account species,
general yield class and spacing (FC, 2014). Volume of harvested timber from the planted
woodlands was converted into calorific value (MwH/m\(^3\)) for 30, 40 and 60% moisture
content for either broadleaf (1.4) and conifer (1.2) species (BEC, 2011). The combination
of three separate products, net profit from the SRF timber, carbon sequestration value
and energy generated from the timber supply provides a comprehensive analysis of SRF
value to estate management.

\subsection*{6.2.5 Mapping outputs}

\subsubsection*{6.2.5.1 Cultural drivers and resilience mapping}

A preliminary map of important cultural drivers that impact land management issues was
constructed using the correlation between GPS tracks and recorded field interviews. For
example certain areas are valued for their views and landscape aesthetics, others such as
corries and deer wintering areas are important for economics, recreation and estate
identity. Whereas other areas are viewed as possessing a personal aspect connected to
memory, history and specific emotions of the land managers, which may inform a type of
legacy and familial lineage that defines a particular area for an individual. During the
transcription process dominant themes were matched to time indexed spatial
coordinates, producing spatially explicit themes associated with practice, management
and land manager perception (Evans & Jones, 2011; Jones & Evans, 2012). These were
then grouped under four dominant concepts of resilience (See Chapter 2) (Haines-Young
& Potschin, 2010).

\footnote{Estimates of the social value of carbon are subject to wide variation. Current UK
government guidance for policy appraisal include central estimates for 2010 of £14/tCO\(_2\)e (£52/tC) for sectors covered by the EU Emissions trading scheme (ETS) and £52/tCO\(_2\)e (£190/tC) for non-ETS sectors.}
Resilience mapping is predominantly associated with climate, disaster, risk and health issues, normally looking at the comparative state of multiple population groups (Van Zandt, et al., 2012; Allen, et al., 2014; Shaw, 2014). Floodplain restoration has looked at longitudinal patterns that are influenced by biophysical and socio-economic characteristics (Hulse & Gregory, 2004). More recently within the forestry sector resilience mapping has been applied to fire disturbance regimes (Moritz, et al., 2011), patterns of pest and disease dispersal (Cavers, 2015; Ennos, 2015) and spatial patterns for silvicultural prescriptions at stand level (Churchill, et al., 2013).

In order to give the concept of resilience a meaningful connection to the local management scale the land managers defined four concepts associated with resilience to describe their estate on a spatial scale. This was achieved during the interview follow up sessions where the contents of the land use report was discussed (Section 6.2.6) and the associated concepts were defined by each managers according to their perception of estate areas and practices. For example areas in which deer wintered, such as corries along with feeding areas were perceived by all land managers as ‘Stable’ improving the strength of the estate’s overall resilience. This process resulted in land uses and practices being grouped under one of the four resilience concepts.

1. **Stable** (Perceived management strengths and areas contributing to the estates’ strength)
2. **Adaptation** (areas and practices of the estate recently, currently or soon to be under change)
3. **Transformation** (areas and practices of the estate in flux or most susceptible to or have the greatest potential for change, but no action or decision has been made as to their future role )
4. **Collaboration** (Areas of the estate under collaborative management activities)

These resilience concepts are a reinterpretation as applied to estates and the land managers point of view, thus their understanding of resilience may not completely align
with the resilience literature and rhetoric (see Chapter 2.5). However, this does create an insight into the land managers and case study areas perception of resilience on a scale that is meaningful to them. This approach minimised conflict between potentially conflicting land manager views as each estate was consulted separately, therefore individual views and perceptions could be mapped. During this process the researcher facilitated the land managers understanding of socio-cultural themes and spatial connection over the estate.

Each resilience concept was spatially mapped over the estates composing a mosaic of landscape resilience, which identified land managers perceptions of estate land use and practice. Landscape resilience mapping (Chapter 7.5) could help land managers view their estate through a developmental perspective, focusing future planning on suitable areas for management change and reconsidering areas of perceived strength.

Thematic analysis identified the main land use drivers (Chapter 7.2). Initially 168 themes emerged, which were included in the Land Use Reports for each land manager who participated in the interview. A follow up interview session focusing on the content of the report gave them the opportunity to comment and discuss the accuracy and validity of the researcher's interpretation. These reports were also sent to factors and owners to capture feedback from the entire management structure of the estate. After the feedback was incorporated these were reduced to 81 themes, 40 regional drivers and sub themes, and then seven overarching drivers were identified through cross-analysis and categorization (See Table 6.3 for coding and identification of themes). This was accomplished through five stages of coding after the transcribing of 31 hours of interviews, including the focused thematic analysis on woodland expansion and management issues (140,000 words). Various codes (e.g. WILD=wildland preference, EC=economic concern; I Dev=Infrastructure development; POL=policy) were eliminated or subsumed due to their similarity in meaning to other codes (See Appendix C for example of transcription and coding).
Table 6.3 – Demonstrating reduction of themes through coding and thematic analysis

<table>
<thead>
<tr>
<th>Thematic analysis for Highland private sporting estates</th>
</tr>
</thead>
<tbody>
<tr>
<td>168 themes</td>
</tr>
<tr>
<td>Associated with individual estate interviews (these were discussed with the land managers from each estate giving them the opportunity to comment, add and amend)</td>
</tr>
<tr>
<td>81 themes</td>
</tr>
<tr>
<td>After merging and grouping codes of individual estates</td>
</tr>
<tr>
<td>16 Regional drivers &amp; 24 Regional sub-themes</td>
</tr>
<tr>
<td>Codes were sorted into estate and regional tables to identify dominant regional drivers and sub themes, which represents the regional character of each case study</td>
</tr>
<tr>
<td>7 Drivers for Highland private sporting estates</td>
</tr>
<tr>
<td>Drivers and subthemes from regional analysis grouped into final drivers effecting land use management</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Thematic analysis for Woodland on Highland private sporting estates</th>
</tr>
</thead>
<tbody>
<tr>
<td>48 themes</td>
</tr>
<tr>
<td>These emerged from the original analysis of each individual estate</td>
</tr>
<tr>
<td>6 Drivers &amp; 7 Obstacles</td>
</tr>
<tr>
<td>These were the result of grouping the original 48 codes into separate positive and negative groups and then reclassifying them as drivers and obstacles for woodland expansion and management</td>
</tr>
</tbody>
</table>

6.2.5.2 Woodland expansion mapping

Woodland expansion maps identify potential planting areas on the estate according to land manager preference, these were constructed during and after the field interviews. These maps display the size and shape of areas, as well as the species mix to be planted (Chapter 8.3). Table 6.4 shows the classifications and criteria for productive forestry compatibility. The central themes of the criteria were constructed from economic, ecological and cultural factors that focused upon elevation, infrastructure, land capacity and conflicts with other land uses. These were based upon discussions with the land managers during the field interviews, land agents (Bidwells, Perth) and Forestry Commission operations managers (Smithton, Inverness) as being the most important factors in determining site compatibility for woodland and short rotation forestry. The researcher synthesized the combined responses in Table 6.4, which represents the collective view of all 12 Highland estates. However, the individual estates spatially classified areas of productive woodland compatibility after the new planting areas were identified. This face to face mapping approach was very time consuming and limits the application of this method on a wider scale although I would argue that the depth and
clarity of data collected from the individual is offset by the time commitment. However, not all manager perceptions of woodland range aligned. This was accounted for in the productive forestry map (Figure and Table 6.5), which is constructed at estate level with individual manager criteria. These maps account for 50% of the weighed overlay analysis. There was a difference in opinion concerning the elevation and slope maps, therefore the ranges were set by taking the median between the minimum and maximum limits provided by the land managers.

**Table 6.4 - Criteria for productive woodland compatibility**

<table>
<thead>
<tr>
<th>Land Classification</th>
<th>Woodland capacity</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compatible</td>
<td>Short rotation forestry, commercial, productive broadleaves, mixed native woodland</td>
<td>Low elevation, suitable soil, limited wind exposure, close to transport routes and estate infrastructure, current fencing, unmanaged land not conflicting with other uses.</td>
</tr>
<tr>
<td>Compatible but with constraints</td>
<td>Short rotation forestry with infrastructure, access and harvesting upgrades, potential commercial operations, native woodland</td>
<td>Similar to the Compatible category but may have less access to infrastructure and transport routes and higher elevation that will increase harvesting costs.</td>
</tr>
<tr>
<td>Moderately compatible</td>
<td>Hardy native woodland adapted to higher elevations, limited commercial or operational scope</td>
<td>Land that is suitable for SRF but has no access to estate infrastructure and borders other land uses-making it viable ecologically but not economically</td>
</tr>
<tr>
<td>Incompatible</td>
<td>Scrub woodland, limited Caledonian pine woodland, more valuable as grazing and open ground</td>
<td>Land that is neither ecologically or economically suitable but without any land use conflict</td>
</tr>
<tr>
<td>Very incompatible</td>
<td>Most valuable as grazing, open ground and amenity, too high, no access</td>
<td>Prohibitive land-High elevation rough grazing with no estate infrastructure, sizeable distance from transport routes, poor soil and aspect, conflict with wintering deer and other land uses</td>
</tr>
</tbody>
</table>

*Figure 6.5* displays an example of a productive woodland compatibility map, which identifies further potential for woodland expansion on the estates, including long-term productive areas and short rotation forestry. During the woodland planning discussions land managers often delineated between areas that would conflict with other land uses,
thus producing an expansion map that has greater opportunity for integration with main estate activities.

Figure 6.5 – Example of productive woodland compatibility map

A spatial analysis to identify potential woodland connectivity and types was performed using a weighted overlay tool in ArcMap 10.1 by combining the Productive woodland compatibility map with elevation and slope maps (See Box 6.2 for list of criteria). First the three maps were reclassified to accept raster integer values (1-5), secondly spatial aspects of the map were ranked from 1-5 matching the three maps criteria, as demonstrated in Table 6.5, and lastly each map was allocated weightings by the land manager. The productive woodland compatibility map was allocated 50% weight for consideration, because the majority of the criteria was included in this assessment. Elevation and slope were allocated 25% weight as influential topological factors. Land managers agreed that this was a fair and representative weighting of the criteria during feedback and collaborative case study area discussions. Consequentially landscape woodland corridors
were generated displaying suitable areas for four types of woodland over the case study areas (See Table 6.5 and Box 6.2 for criteria):

1. Short rotation forestry
2. Productive woodland
3. Amenity woodland
4. Montane scrub woodland
5. Open space

This spatial analysis offers land managers a baseline for potential woodland planning and management areas. A template for woodland planting and subsequent operations over the next 25-50 years is formed, including short-term aims of improving productivity, economic contribution and species diversity.

Table 6.5 – Ranking scores for weighed overlay analysis

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Weighed Overlay (Woodland Landscape Corridor Map)</th>
<th>Productive Forestry Map</th>
<th>Elevation Map</th>
<th>Slope Map</th>
</tr>
</thead>
<tbody>
<tr>
<td>Criteria</td>
<td>Rank</td>
<td>Criteria</td>
<td>Rank</td>
<td>Criteria</td>
</tr>
<tr>
<td>Compatible (SRF)</td>
<td>1</td>
<td>0-200 metres</td>
<td>1</td>
<td>0-10 degrees</td>
</tr>
<tr>
<td>Compatible but with constraints</td>
<td>2</td>
<td>201-300 metres</td>
<td>2</td>
<td>11-20 degrees</td>
</tr>
<tr>
<td>(Other productive forestry)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moderately compatible (Amenity woodland)</td>
<td>3</td>
<td>301-500 metres</td>
<td>3</td>
<td>21-30 degrees</td>
</tr>
<tr>
<td>Incompatible (Montane woodland)</td>
<td>4</td>
<td>501-800 metres</td>
<td>4</td>
<td>31-45 degrees</td>
</tr>
<tr>
<td>Very incompatible (Open space)</td>
<td>5</td>
<td>800+ metres</td>
<td>5</td>
<td>46+ degrees</td>
</tr>
<tr>
<td>50%</td>
<td>25%</td>
<td></td>
<td>25%</td>
<td></td>
</tr>
</tbody>
</table>
Box 6.2 – Criteria for woodland landscape corridor analysis

<table>
<thead>
<tr>
<th>Elevation (Overlay analysis):</th>
</tr>
</thead>
<tbody>
<tr>
<td>300 metres or less is suitable for woodland, Scots pine planted no higher than 550 metres. Landowners are reluctant to plant in higher areas due the landscape appeal (bare and heather hills) and access for machines.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Slope (Overlay analysis):</th>
</tr>
</thead>
<tbody>
<tr>
<td>SRF – 0-10% gradient; Productive woodland – 11-20% gradient; Amenity woodland – 21-30% gradient; Montane scrub – 31-45%; Open ground – 46%+</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Peat (Overlaid):</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peat soils with a depth deeper than 50 cm is mostly prohibited by policy. Due to peat’s sensitive conservation profile landowners are unwilling to plant in any peat rich soils.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Roads &amp; rail (Productive woodland compatibility map):</th>
</tr>
</thead>
<tbody>
<tr>
<td>The estate needs access to either B (2 miles) or A-roads (3 miles) within a few miles of the extraction areas for woodland to limit operational costs. However some B-roads have inadequate specifications to carry out viable timber loads. Rail tracks (1 mile) also have to be within close proximity of extraction points.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Tracks (Productive woodland compatibility map):</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internal estate tracks have to serve as extraction points and harvesting access (500-1000metres) with clear routes.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Riparian areas (Productive woodland compatibility map):</th>
</tr>
</thead>
<tbody>
<tr>
<td>Landowners stated that they wouldn’t plant within 50 metres of river banks. Others stated they were prohibited from planting around lochs by local authorities to preserve the view.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Other land uses (Productive woodland compatibility map):</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planting had to have little interference with deer movement, wintering and feeding grounds (small areas). Landowners would not plant former or current pastures as they wanted to keep traditional aesthetic alive. No woodland encroaching upon managed grouse moorlands. No conflict with hydro schemes so far.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Current woodland (Overlaid):</th>
</tr>
</thead>
<tbody>
<tr>
<td>Landowners wanted to restructure these woodlands if they had the economic incentive but were keen to link woodland across the estate or plant adjacently.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Landscape design (Productive woodland compatibility map):</th>
</tr>
</thead>
<tbody>
<tr>
<td>Landowners were eager that woodlands did not over power the landscape aesthetic or repeat the design mistakes of the past (1960-80’s conifer blocks)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Landowner preference (Productive woodland compatibility map):</th>
</tr>
</thead>
<tbody>
<tr>
<td>Taking in to account personal views and visions the landowner has for the estate and how different types of woodland and species fit into the estates management aims.</td>
</tr>
</tbody>
</table>
6.2.6 Development & dissemination of estate land use reports

After the field interview, a land use report was generated for each participating estate to present information on estate specific land use drivers and themes, woodland planning and Forest Energy tool and mapping outputs (an example of an estate land use report can be seen in Appendix G). This report offered the land managers an opportunity to reflect on the interpretation of the fieldwork results and confirm, disagree, add to or discuss the content. This stage validates the findings through continuous feedback and input of the land managers (Prager, et al., 2012) and provides a fluid process of continual interpretation and refinement to pinpoint significant areas or gaps in the analysis (Kwan & Ding, 2008). Each report contains:

**Current land use**

Background on history, environmental attributes and current management of estate, including a ‘Current land use’ map and pie chart displaying land cover.

**Woodland expansion**

Presentation of new woodland areas, species cover and impact upon estate land cover, including a ‘Woodland expansion’ map. Results of the Forest Energy Tool analysis including short rotation forestry net profitability over 20 years, carbon sequestered in tonnes and potential market value, as well as calorific output. A productive woodland compatibility map constructed from information provided by the land manager demonstrated the spatial scope for productive woodland.

**Cultural land use drivers**

The main cultural drivers affecting land use identified by the thematic analysis was presented (between 11-18 drivers) with the researcher’s interpretation.

**Micro-regional area**

A ‘Micro-regional’ map presents the case study area to signpost the next stage and scale of management considerations; the Estate cluster collaborative discussion (Stage 7, Figure 6.1).
The report focuses on presenting alternatives for marginal land that is unused, unmanaged or in rough grazing. Oil prices and subsidies for set-aside land were compared to provide context for land and energy use.

6.3 Case study area level

6.3.1 Case study areas – Clustered land use collaboration

Utilising the land use reports, the next stage aims to bridge the scales of individual land managers to a cluster of land managers from neighbouring estates, aiming to explore the potential of transboundary land use planning to cut management costs, strengthen social links and increase economic stability. Discussions focused on the links between spatial planning and cultural land use drivers to identify practical management innovations, such as hubs for regional timber centres, transboundary areas for woodland expansion and infrastructure upgrades. These discussions aim to foster a greater understanding of key connections to ecosystem approaches at case study level that will enhance multiple management objectives across the estates. Advancement toward such goals have been hindered by unbalanced influence and agendas (Chapter 4.4.2 – DMG), therefore these discussions are designed to strongly link deer management to woodland management and other land uses.

*Figure 6.6* presents the basic structure and process of case study area discussions, which were organised after all land managers in a case study area had been interviewed (Stage 2, *Figure 6.1*) and provided feedback upon their land use report (Stage 6, *Figure 6.1*). Prospective dates for the discussion were provided by the land managers from which a mutually acceptable date was identified. The location of the discussion group was determined by the land managers, as at least one, if not all three volunteered to host the discussion at their estate lodge, the most central estate was chosen out of practicality.

Group discussion aided the land managers to clarify management challenges, including land uses that drain estate resources, untapped land use potential and areas that could
benefit from transboundary cooperation. Further discussion determined whether these practical challenges could shape a mutually beneficial regional network, which would provide focus for practical ecosystem management activities within the case study areas.

**Figure 6.6 - Collaborative discussion process for micro-regions**

- Individual estate reports and maps aligned
- Discussion of land management obstacles and opportunities for case study region
- Construction of micro-regional maps identifying spatial cooperation and practice
- Group feedback
  1. Management approaches
  2. Integration woodland on estates
  3. Forest energy prospects
  4. Future impact of carbon
  5. Collaborative capacity
Each land manager was encouraged to give feedback on their individual land use report and highlight key issues and prospects for future management. Next the researcher asked questions on matters that had arisen from the field interviews, which subsequently became central management concerns (See Appendix F). The informal atmosphere created an informative and reactive discourse, which emerged from a combination of land manager experience and interview outcomes (Miaux, et al., 2010; Reed, et al., 2010).

An A1 size map with the three estate boundaries and woodland expansion areas was used for land managers to refer to during discussions (See Figure 6.6). This led to the creation of a Micro-regional map that identifies obstacles and opportunities within each case study area. As there was limited time with the land managers as a group a simplistic approach with a printed map was elected over an interactive tablet in light of the issues identified in Chapter 4.4.2 (Davies & White, 2012). As a means to prevent participatory fatigue the discussion groups were limited to an hour (Kangas, et al., 2010; Saarikoski, et al., 2010), encouraging an informal atmosphere to facilitate greater engagement with the material. The multiple methods approach helped the land managers to identify and delineate common areas of conflict, management difficulties, as well as disparities and commonalities in their decision-making process (Dennis Jr, et al., 2009; Connolly, et al., 2013). Reflecting Principle 2 and 3 of the CBD EA, which emphasises land manager consideration of adjacent ecosystems and managing at the appropriate spatial scale (Chapter 2.3 (UNEP, 2000)).

### 6.3.2 Case study areas analysis

The last stage of the research analyses cross-cutting themes and trends over the case study areas. The path to understanding the functions, operational parameters and benefits of an ecosystem approach requires the incorporation of multiple interacting factors (MEA, 2005; Berkes, 2009; Deal, et al., 2012; Austin, et al., 2014; SNH, 2015). This study uses individual land managers, estate management and woodland as focal points to analyse the interaction of influential factors.
Identification of management needs at different spatial scales (estate, case study area and inter-case study area) that remain relevant to the individual land manager is key to the study's central aim. This process includes iterative coding used to identify, merge and sort case study area themes that emerged during the thematic analysis of main drivers. Then a set of case study specific main drivers and prioritised cross-cutting themes were identified to inform individual characteristics of the case study areas. Comparing the main drivers and prioritised themes from all four case study areas identified dominant convergent and divergent themes, which clarified differences and commonalities between regional management considerations and identity.

Woodland expansion and management issues produce an additional set of drivers at estate and case study area level. These are used to inform the state of woodland management and the forestry sector from the perspective of estates, in order to develop an understanding of practical management needs for areas suitable for forestry on estate land. Essentially, the cumulative narratives that link estates and case study areas create a base for ecosystem management knowledge. An ecosystem approach could use the analyses of cultural land use drivers together with woodland planning trends to identify planting activities acceptable to estates and from a landscape scale management perspective.

Numerous studies have demonstrated that projects, which involve multiple land managers have a greater chance of developing social capital, cooperative working strategies and increased delivery of environmental benefits on a wider scale (Keenleyside, et al., 2009). Examining the relationships between and across multiple scales can help identify areas of mismatched management, which are the source of common misunderstandings, communication difficulties and reduced management capacity over a landscape (Cumming, et al., 2006; Satake, et al., 2008; McMorran, 2008).

6.4 Summary
This chapter presents a multiple methods approach, which includes mobile interviews and planning activities, iterative feedback and use of real world options to address
regionally relevant land management issues. The field interview (5.2.2) technique helps inform management decisions by capturing land manager perspectives and identifying linkages between specific estate areas, as well as land management practices. Woodland planning (5.2.3) components pinpoint areas, which align with estate management aims on both an environmental and cultural level. Additionally the Forest Energy tool (5.2.4) provides insights into potential markets for land managers to mitigate some uncertainty about undeveloped markets. Outputs from this tool could strengthen woodland expansion rationale, which is further supported by added value and integration of carbon sequestration into woodland management. The connectivity of these methods contributes to the case study collaborative discussions (5.2.7) and subsequent implications for identifying and developing legitimate components of an applied and locally relevant ecosystem approach.
Chapter 7

Cultural & spatial drivers behind land manager decision-making

7.1 Introduction
This is the first of three chapters that will present the analyses and results for the case study areas; including management challenges, perceptions on woodland expansion, woodfuel markets and potential collaborative structures. Each of the chapters are structured to build upon one another to inform a localised interpretation of an ecosystem approach. Following the order of the research questions in Chapter 1.1 and the methodology (Chapter 6) dividing the results chapters into themes (below) that cut across all four case studies, logically traces the bottom-up approach and connection of scale from the individual land manager, assessment of estate capacity for woodland expansion to potential meaningful collaboration between estates:

1. Estate manager perceived land use drivers and spatial resilience of case studies (Addresses research question 1)
2. Woodland expansion and energy – looking at planting areas, value of woodfuel produced and productive woodland suitability (Addresses research questions 2 and 3)
3. Carbon management and collaboration – examines value of carbon sequestered from planting and potential of transboundary activities (Addresses research question 4 and 5)

This chapter presents the analysis and results of the land manager field interviews (Chapter 6.2.3), which identified multiple cultural drivers (7.2-7.3) that emerged from the collective case studies. Regional variations and resilience dynamics for each case study are presented in sections 7.4 and 7.5.
These drivers were placed into a case study specific matrix to identify regional variations and uniqueness (4 drivers and 6-8 sub)

Figure 7.1 – Pathway and reduction of thematic analysis for estate land use drivers
Data collected from the twelve field interviews were distilled from 168 individual drivers identified across all twelve estates, to a reduced list of eighty-one drivers after cross estate study area synthesis (Figure 7.1 – full analysis structure). Further analysis identified seven overarching factors which drive land manager decision making processes (defined here as cultural drivers), which represented the private sporting estate decision-making landscape (7.2). These seven drivers were integrated into a private land manager decision-making (resilience review in Chapter 2) and adaptive management concept (7.3). This thematically structured representation of the land managers’ decision-making processes shows the influence of interacting elements that affect estate level considerations. Informing the challenges and opportunities for integrated land management approaches. Section 7.4 presents drivers and themes that shape distinct regional character for the case study areas, identifying convergent and divergent themes that emerged due to variant pressures that characterise local management responses.

The final section (7.5-6) addresses the role of culture in relation to practical management and physical areas of the case study areas by correlating the spatial tracking of the interviews (GPS) and Dictaphone recordings. Spatial areas of the estate were assigned dominant cultural themes (i.e. strong history of agriculture practice), which were linked to land use practices and estate management by the time indexed interviews with GPS track. Each case study area was then mapped through the lens of related resilience concepts (referenced in Chapter 2, 7.3 and 7.5), which were then connected to operational, biophysical and spatial characteristics of the estate. Finally, common landscape trends were used to identify case study specific land use characteristics that could aid the development of an ecosystem approach framework.

7.2 Main drivers affecting land use on private sporting estates
The main drivers in this section were the result of twelve field interviews with estate land managers (Chapter 6.2.3). The interviews were transcribed verbatim and were thematically coded for each estate. Initial analysis formed the ‘Cultural Drivers’ section in the ‘land use reports’ (6.2.6) produced for each participating estate (See Appendix G and I). Stronger themes progressively emerged throughout the analysis by merging
themes and grouping them under common thematic headings. Finally, the analysis of 37 hours of land manager interviews accomplished (140,000 words) by walking the individual estates, produced seven main drivers that characterise estate management over the four case study areas. Description of the drivers is supported by interview quotes in the following section (7.2).

**Driver 1 – Central landscape narratives**

Evidence supported strong land manager views on the composition, practice and appearance of the landscape. All land managers viewed woodland negatively, which influenced their perspective on potential capacity, range and use in the landscape. Most of the negative woodland structures referred to unmanaged conifer plantations. “*These woodlands provide no benefit for anyone and only scar the landscape*” (Borrobol).

Perception was influenced by the history of the local area, personal experiences of land use practices and passed down traditions. “*For me this is the Highlands, the bare hills, sweeping landscape, it was here when I was a boy and hasn't changed....more trees would diminish the scenery*” (Attadale – highlighted by *Figure 7.2*). Persisting landscape imagery has become a marker of preferred landscape composition for land managers. Powerful
landscape imagery possesses associated narratives, which inform successful or failing practices, and influences core traditions (MacDonald, 1998; Schama, 2004). Unhealthy woodlands, herds of deer, Munros, wind farms, large lochs and open ground have a strong influence over land managers, which trigger deep-rooted opinions. These opinions and values are the base for practices and personal tradition, which combine to form estate management, “This area has been a famous deer forest for centuries and doesn’t fit the interests of other uses” (Kingie).

**Driver 2 – Owner Engagement**

The type of ownership structure was a major driver that influenced objectives and management of the individual estate (Warren, 2009); some estates were run by owners that grew-up, lived and ran the estate (homestead – 4 in the study, 2 owners had lived on their estates since birth) and some by owners that visited once or twice a year (absentee – 8 in the study). This has a large influence on engagement and involvement with estate management, planning and business development.

![Figure 7.3 - Normally unsustainable farming practices and facilities on Inverinate - absentee owner (Wester Ross)](image-url)
The owners’ that actively ran a business were open and interested in the economic incentives, as well as different silvicultural approaches to improve woodland productivity. “I’m very interested in the possibilities, if it could provide shorter term returns, target diverse markets and enhance woodland in general” (Glen Dessary). Whereas the absentee owners were unconvinced by economic arguments (See Figure 7.3) and required climate, landscape, sporting management or recreation considerations to justify further investment in woodland. These non-economically orientated landowners were motivated by landscape aesthetics and restoration of traditional Wildlands. “The owner wants no commercial activity whatsoever, do nothing with the woodlands, keep the farms running, stock the estate with deer and fish...he says he wants a Scottish wildland” (Inverinate). Whereas an owner that lives on the estate and runs the operations may benefit the local rural economy as a by-product of delivering cost effective management that focusses upon relevant issues and management challenges that affect the local landscape and community, “I’ve been here since I turned 27 and have lived on the estate for over 30 years and I try and do lots of little projects to help the estate and improve things for the local area. I constantly look at different ways to make the estate profitable and conserve the unique environment here” (Borrobol). This suggests that the level of owner engagement and contact with the estate increases the chance of diversification and management beneficial for the local area. Whereas owners with less contact pursue big picture aims attached to landscape level management, climate change and relevant conservation issue, which are disconnected from business activities.

Driver 3 – Key profit centres
The majority of land managers spoke of profit centres as the estate’s core driver, vital for sustainability and the rural economy. Managers with significant private wealth focussed on recreation opportunities, enhancing conservation and tended to employ more staff than would be possible, if the estate was run as a sustainable business. These profit centres represent a range of activities including traditional centres such as deer stalking and other sporting uses (fishing & grouse). Some included forestry and agriculture as main activities but not as profit centres, as they often became a management cost. “Most things that estates do lose money and you need profit centres to carry the cost...there are
major over heads that you wouldn’t get in a normal business that means you have to have profit centres that pay for those things” (Invermark).

Hydro-schemes were seen as a future profit centre, which is predominantly driven by policy and subsidy much like wind power, however this emerging profit centre is viewed as having the potential to stabilise estate finances, facilitating the release of funds for other land uses and estate restoration. “We are hoping that new hydro-schemes will alleviate some of the baseline costs and give us more room to enhance the estate” (Glencarron). Dominant profit centres, such as deer stalking are embedded within the Highland estate tradition, making them culturally significant and therefore tremendously resilient to change (See section 7.5), shifting markets and policy objectives (Macmillan, et al., 2010). Sporting use and tourism (a relatively new profit centre associated with recreation) are further protected as a profit centre, as they are supported by private money (sporting syndicates and lets) and rarely rely upon public funds or subsidies. They are driven by passion of both the landowner and the consumer (protects from land use conversion, see Figure 7.4), which taps into and targets private wealth. This highlights the persistence dichotomy between delight from and use of the land, which perpetuates single and reduces wider landscape benefits (Morgan-Davies, et al., 2015). “Sporting syndicates are leased by fanatics who are passionate about their grouse sporting and will pay huge premiums to have their own private piece of ground” (Invercauld).

Figure 7.4 – Improved grassland: Exclusive deer feeding sites suitable for productive woodland
Woodland was generally viewed as a loss to the estate rather than a profit centre, contributing to the estate's decline or running costs. Woodfuel, Christmas trees and thinnings were small areas of economic value for some estates, value was also determined by the quality of shelter provided by woodlands, which cultivated healthy and more valuable deer (Armstrong, 2015). Combining these factors could point to further enhancement of productive woodlands on estates. The smaller business-run estates were more open to woodland as a potential profit centre but were sceptical about long-term returns. “I won’t see a return from new woodland in my lifetime, so it’s not an apparent priority” (Glen Dessary).

**Driver 4 – Influence of policy and grant system**

There were mixed views among land managers about the influence of policy and grants upon the structure and management of estates. Two managers emphasised the generosity of the grants and the comparative effectiveness of recent policies to the ones of the past. “I've taken advantage of several woodland grants for regeneration and planting native woodlands, they were very generous – they suit my needs” (Glencarron). However, the remainder of managers viewed the same grants as narrow, vague, unstable and difficult to interpret. “I know many people who often find the applications an unappealing prospect due to their confusing nature, so I most likely won’t do them” (Invercauld). The grant system itself was viewed by some as an obstruction to the policies it supports, rendering the system ineffective and undependable, which inhibits long-term development of woodland resources (Thomas, et al., 2015).

Support provided by the grant system (SRDP) was viewed as confusing, bureaucratic and overly general to appropriately support some management activities. This has left many landowners unsatisfied and reluctant to pursue grants, especially for woodland expansion and operations that would help to improve the current resource.
Over half of land managers strongly suggested that policy was constantly out of step with management requirements and responses. “Things you did yesterday now only becoming visible and the fashions change, so they’re not popular anymore, like loosely stamped spruce woods on the side of a hill... Now those priorities have changed but the way we’ve designed the countryside is for yesterday’s purpose and it doesn’t look so good today” (Invermark). Land managers perceived these retrospective policies to have hindered their ability to diversify and adapt to shifting management environments (Figure 7.5 demonstrates the inability of policy to adapt to past strategies and land use decisions, which highlights the need for policies to be increasingly forward thinking). Other land managers viewed certain grants as beneficial suiting their needs, such as the native woodland and natural regeneration schemes, which fitted in with the aims and priorities of the estate. This highlights the importance of tailoring and targeting grants, linked with wider management and landscape aims.
**Driver 5 – Perceived role of institutions**

Government agencies (FC/SNH) and larger non-governmental organisations (RSPB/JMT/NTS) interact frequently with estates. Working in their capacity as land use experts (directed by particular agendas), consultants, lobbyists, and adjacent land owners, they can have a significant influence upon landscape management. The attitudes of land managers towards these bodies range from outright animosity to good rapport, with established relationships and joint planning with agencies and external organisations evident in a number of cases. “We have a good working relationship with SNH and FC mostly, occasionally there are misunderstandings and a lot of effort required to make them understand the reality of things….we get on the same page eventually” (Balmoral). However, many land managers expressed displeasure at the distancing of organisations from their former on-the-ground activities to an increasingly centrally-based office structure. This displeasure is strongly connected to the lack of continuity and experience of project officers, which often generates declining levels of confidence in competency and indicates a limited knowledge of locally specific issues. “There is a quick turn-over of officers who don’t know the history and you have kids straight out of college giving recommendations with no practical experience…” (Invercauld – in reference to SNH).

These organisations are commonly seen as inconsiderate to cross-boundary management issues and are often cited as inhibiting estate activities. Tension arose between the John Muir Trust (JMT) and one of the estates through the Trust’s non-fencing policy, subsequent out of season shooting and the perceived disruption of the local Deer Management Group. “I don’t approve of what they’ve done in this process because they’ve divided the group, removing a critical mass of relevant decision-making….. they have made the DMG dysfunctional at the same time they are running around lobbying the Scottish Government to make participation mandatory” (Glen Dessary). The Forestry Commission (FC) was cited as having too much power over estates, using grants as leverage, as well as selling unmanageable stands of non-native conifers and then failing to support improvement of those stands. “Many estates don’t want to offend the commission or ruffle their feathers as they want the grants they offer, this makes them scared to bring relevant issues up to discuss” (Kingie). However other land managers saw the FC as appealing and
trust worthy partners and participated in hydro, woodland planning and land lease schemes. Despite this the land managers acknowledged the FC’s focussed agenda prevented them from working more frequently with them on wider land use issues. In the Cairngorms case study area all three land managers trusted and spoke highly of the CNPA and its staff. Citing their understanding of cross cutting issues and supporting a wide range of rural land uses that supported and enhanced the local economies. An organisation such as the CNPA without the influence of a government driven top-down agenda is “less restricting and does not come with strings attached” (Balmoral). The CNPA could be a bridging organisation that facilitates integrated land uses and ecosystem approaches aims (Chapter 2), increasing land manager buy-in and providing a gateway to unreachable markets and land use management.

**Driver 6 – Managing for legacy**

Land managers referred to tradition, rural practice and protection of the rural economy as aims to be passed on to the next generation. Without exception the land managers viewed themselves as guardians/stewards of the landscape, which included preserving land practice traditions (Hindle, et al., 2014). With the expectation of some small variations sporting resources and maintaining the Highland landscape (visual) were seen by estates as the most important traditions (Figure 7.6 shows a traditional Sutherland landscape valued by the landowner). Thus rural practice, economy and tradition are encapsulated by sporting management and the landscape it conserves (MacMillan & Leitch, 2008). “Deer stalking and the lets are what the land is geared towards and has been for centuries and will remain the heart of the rural economy, especially in the Highlands” (Badanloch). Furthermore, half of the land managers associated hill farming and livestock grazing as integral land uses to be preserved as traditional aspects of the landscape,
whether or not they generated profit or extra management costs (Morgan Davies, et al., 2005).

A few land managers (5) describe woodland legacy as small patches of broadleaves and Scots pine, but never explicitly with production objectives. “Trees and small areas of broadleaves are beautiful, as are individual trees, I think they are something that can be a reminder of that generational connection and mean a lot to my family” (Achnacarry).

Woodlands are consistently referred to as having limited production capacity and sustainable timber supplies as a diminishing component of rural economies. This perception (ecologically and financially) appears in part to be the result of damaging and aggressive woodland expansion policies in the recent past (Flow country), which has cultivated the opinion that productive forestry belongs to the past and cannot be recovered. However, this perception is common to all case study areas and resultant management difficulties or species loss has not generated significant concern or public recognition. “There used be a time when timber was used for all sorts of things in the local area and there were a lot more hardwoods around but the landscape and environment has changed, woodlands can no longer fulfil the same function and return against sporting management” (Kingie). Therefore current woodlands on estates create an undesired
legacy for estates, effecting decision-making and woodland practice across the region, as well as generations. In general Scotland has a low level awareness of forestry culture, which inevitably hinders acceptance of development and new approaches (Mather, 2003), and legacy of past decisions has a significant impact upon current landscape management.

**Driver 7 – Future prospects**

The immediate priority for land managers is the survival of the estate (breaking even economically or continuing current practices) and any money left over is invested into the restoration and improvement of estate facilities. The vast majority of estates chose to enhance their sporting resources and property lets before any other activity, as these are the immediate revenue streams. A large proportion of funds were used for this purpose, along with structural restoration and maintenance. “It took me over 10 years to restore the estate up to a certain level where money could be generated but most of my aims and money are channelled into improving the buildings and sporting resources [deer stalking]” (Glencarron).

Discussion of future prospects during the field interviews was dominated by hydro-schemes on almost every estate (Individual estates were developing/installing between 1-10 hydro schemes at a time). These schemes were seen as the ‘golden goose’, providing energy for the estate and generating a surplus to sell back to the grid (Figure 7.7 shows hydro scheme installation – this constitutes the highest level of landscape impact after which the landscape remains relatively undisturbed). “We are looking at various locations for hydro schemes. They will be the main activity or change for the foreseeable future” (Achnacarry). Renewable energy, including hydro, wind, solar power and biomass is viewed as one of the core agents for of realising local empowerment and development, increasing skills and social capacity creating sustainable rural economy (Rennie & Billing, 2015). Identifying locally driven renewable energy schemes key drivers for resilience strategies in Scotland and the Highlands.
All estates in this study, without exception, looked upon wind power unfavourably. Wind farms were viewed as eyesores upon the landscape, representing inefficient technology and temporary solutions to current policy challenges that would have lasting repercussions on the ecological integrity of the region, which highlights the importance of embedded relationships between land and life across the landscape (Pasqualetti, 2011). Land managers found their proliferate use as distasteful “A lot of land has been broken up enough already with wind farms, which essentially sterilise big areas and a lot more” (Borrobol). This has made many land managers sceptical about other shifts in management strategies and policies endorsed by the government (specifically connected to renewable and climate change objectives – this is also reflected in responses toward the applicability of short rotation forestry for energy use).

7.3 Private sporting estate: Adaptive management response

This section incorporates the seven main land use drivers described in Section 7.2 and links them to private land manager decision-making, in the context of adaptive management. The field interviews (Chapter 6.2.2), land manager feedback sessions (Chapter 6.2.6) and collaborative discussions (Chapter 6.2.7) in parallel with resilience
concepts (Holling, 1973; Walker, et al., 2004; Folke, et al., 2010), inform the adaptive stages in Figure 7.8.

The first stage recognises the sporting estates’ ‘Perceived management strengths’, such as sporting use and recreation that provide the economic and management stability. Evidence from the field interviews (Chapter 6.2.2) indicates that ‘Fluctuations’ potentially affect the estate strengths through catalysts for change and new management considerations. The rise and fall of market prices, shifts in policy support for land use practices (woodland expansion, hill farming), and new regulations that affect sporting management (i.e. Culling quotas, mandatory deer management plans) create the necessary catalysts or combination thereof to initiate adjustment of management planning. Adaption facilitates the interpretation of fluctuations into structure of estate management practices. These catalysts or societal levers have emerged due to fragmented policy environment, which is currently insufficiently integrated to achieve coherence between land manager choices and wider public ecosystem services (Everard, et al., 2014). The land managers preferences and use of different societal levers will determine local interpretations of ecosystem approaches.

The ‘Fluctuations’ (Figure 7.8) can either support the current strengths through caution and risk aversion tactics or open up greater avenues for shifting approaches and management through more opportunity-based decision-making. Opportunity-based decisions will look to diversification or new markets to re-stabilise estate economies, as well as aim to circumvent planning challenges due to heightened regulatory restrictions. ‘Fluctuations’ provide core connections to the adaptive cycle, whereas ‘Changes’ (Figure 7.7) generate longer-term adaptive cycles due to ongoing negotiation of sustained conflicts. Potential changes in the balance of estate management priorities provoked mostly negative responses from land managers. “Too many issues to be resolved” (Achnacarry).... “Investing time and money in new management areas would be a loss of resources and money” (Invercauld).... “There is an uncertain future there against a certain one we are currently operating in” (Attadale).
Land managers acknowledge that tradition shields against smaller fluctuations and prospects for change as the certainty of familiar management approaches are “tried and tested” (Badanloch). “Aye, it’s always been done this way here and we want to continue to do things this way, even if profits drop, we’re maintaining an important tradition” (Kingie). However, if fluctuations become increasingly disruptive to estate practices over longer periods (market prices and policies, i.e. livestock subsidies), a level of uncertainty will be reached that encourages land managers’ to re-evaluate diversification in order to address the compromised strength of estate activities and enforce resilience. One land manager lamented the fact that a neighbouring estate had changed their land management strategy, “Aye Loch Choire are planting trees all along the boundary there…the owner has changed the place, used to be a marvellous deer forest but now there will only be trees, it’s waste, it’s a shame” (Badanloch). This land manager regarded the loss of sporting use and replacement with woodland as a change in the estate’s resilience. Sporting use was viewed as a long-term sustainable land use, whereas woodland establishment and management were considered to lower the resilience and value of the estate to both the local landscape and economy. As a society woodland expansion is a top priority and important for strengthening resilience, which as shown here does not always match local manager perspectives yet again demonstrating incompatibility and disconnect between management scales (McMorran, 2008; Blackstock, et al., 2012).
As adaptive responses to new land management dynamics are arranged into different working structures, a new layer or shape of resilience is formed (Figure 7.8) that transforms the estate's strengths and core activities. "It would take a long time for woodland to become valuable on this estate again, things would have to change and maybe stability from hydro schemes will enable us to refocus on long-term management goals like timber production" (Glen Dessary). This land manager highlights the importance of
multiple factors working in unison to create enough momentum for change (adaptive management), and that increased resilience requires restructuring and time to become a part of the estate’s main management norms. Adaptive management is enabled by the heterogeneity of opportunity such as emerging carbon markets, flood risk management and water catchment management, which allow for changes in societal preferences over time due increased knowledge base, environmental range and capacity, and socio-economic conditions (Everard, et al., 2014). Ultimately a local interpretation of an ecosystem approach would align and integrate wider societal aspirations with local management perspectives.

7.3.1 Perceived resilience of private sporting estates
There are many interpretations of the role of resilience and the varying components that influence land use management (robustness, durability, resistance, threshold, disturbances, restoration, recovery, intervention) (Haines-Young & Potschin, 2010). Stability, Adaptation, Transformation, and Collaborative adaptation represent the most consistently used concepts to describe the resilience process, as discussed on Chapter 2.5 (Folke, et al., 2010). Collier (2015) explores the emerging role of novel ecosystems, which have been significantly impacted by human intervention and represent never before seen regimes that demonstrate an adapting system implementing practical resilience. Private estates in the Highlands could be regarded as a novel ecosystem consistently impacted and changed by human intervention over the centuries. Ecosystem approaches and sustainability underpin novel ecosystems bridging multiple disciplines through collaborative landscape governance (Curtin, 2014).
Resilience is explained through the combination of the sporting estate’s character (landscape, personal preferences and traditions) and drivers (Section 7.2) from the viewpoint of land managers. The land use drivers in Figure 7.9 (Section 7.2) are embedded within the sporting estates character and remain core influences upon the land manager’s decision-making process but will also shape the management and planning priorities. Management response (Figure 7.8) acts as the dynamic aspect of the diagram, representative of the actions, implementation and ongoing practical management of the estate. More notably they form the trade-offs, negotiations and
mechanisms employed to tackle and resolve reoccurring management issues, e.g. DMG structure and remit, infrastructure developments, woodland expansion, conservation requirements and tenancy benefits. Feedback loops transmit adaptive management impacts and incorporates resilience response. Prager et al., (2012) highlight the importance of participatory and collaborative approaches to facilitate communication negotiation and feedback, which aid provision of ecosystem services and effectiveness of landscape scale management.

Effective resilience of private sporting estates involves economic stability, landscape priorities and land manager preferences as core concerns. Therefore resilient land use has to consider an element of personal investment from the land manager to be sustained through fluctuations and uncertain periods of establishment and management, if change is to take effect in the long-term. “The sporting estate is my personal piece of Scotland, where I get to pursue my passions and give something back, I don’t do anything that doesn’t interest me or benefit estate activities….there needs to be that connection” (Glencarron). This attitude would explain the land managers' aversion to wind power and pursuit of such projects as ornamental gardens and wild boar breeding, as resilience and adaptive management responses are shaped and sustained in part by the manager and their connection to the landscape. Estate managers are constantly represented as rigidly adhering to traditional aims, practice and values with little motivation for change (Macmillan, et al., 2010), in contrast the land managers’ personal preferences are linked to innovation and small areas of change according to their personal values and interests.

7.4 Regional variations
Highland sporting estates are often characterised as being very similar in their common pursuit of deer stalking, grouse shooting and fishing (Macmillan, et al., 2010). In this section each case study area is progressively broken down into main drivers and cross-cutting themes that identify regional and cross-regional characteristics. At the end of this section, convergent and divergent drivers are displayed to highlight the complexity of smaller management scales.
7.4.1 Wester Ross

An emphasis on maintaining landscape aesthetics and generating an economic return from deer stalking dominated these estates (Figure 7.10). Extensive west coast uplands (panoramic viewsheds), large lochs and watercourses featured heavily and any significant woodland establishment that impeded the view or deer movements was considered “overpowering”. All three estates were originally bought for recreation and family enjoyment and very little commercial activity occurs, a part from deer stalking.

Figure 7.10 – Wester Ross regional drivers and crossing-cutting themes
Economic stability was the main objective of the two northerly estates, whereas the southern estate’s objectives were solely amenity driven to recreate a ‘traditional wildland’ (*Figure 7.10*) without any commercial activity. Significant private wealth allows this owner to maintain an idyllic vision of a Highland estate without the pressure of creating revenue (MacMillan, 2000). The priority for all estates was to maintain the Highland landscape through a mixture of sustainable business models and private wealth – A Highland landscape where woodlands are a very small amenity component. This trend is supported by the literature in this field that generally classify estates land use practices as narrowly focussed upon traditional sporting resources (Wightman, et al., 2002; Warren, 2009; MacMillan, et al., 2010). However, there are very few wild places left in Scotland and a Highland estate that has been changed by human management and grazing cannot be considered anything but a human shaped landscape (Mather, 2003; Nijnik, et al., 2007).

**Prioritised Themes**

These themes emerged as the most influential elements (after the core drivers) of land use decision-making for Wester Ross (*Figure 7.10*), as a result of the thematic analysis and codes, which were sorted into case study matrices (Chapter 6.2.2).

Hydro schemes were seen as the most immediate economic concern for the estates; these have little impact upon landscape aesthetics or deer stalking activities. For two of the estates hydro was viewed as important for increasing economic stability; however the other estate (wealthy absentee owner) saw no need to pursue hydro schemes, especially if they were in partnership with third parties, as these were viewed as undesirable and encroachment upon their privacy.

Grazing sheep and cattle were once main land use activities for all three estates but two estates had to drop the activity as it became economically unsustainable (SRUC, 2011). The estate with the wealthy absentee owner maintains three farms and multiple areas of
grazing livestock including sheep, cattle and wild goats. Livestock management is maintained on this estate as part of the ‘traditional Highland wildland’ aesthetic.

The personal land use preferences are reflected by the prioritisation of deer stalking, landscape aesthetics and maintaining a wild Highland aesthetic but had little impact on main economic activities, as some uses, like wind power go against the desired aesthetic and others, such as hydro schemes are less objectionable.

Woodlands were viewed as possessing little benefit for the estates against the expected loss from management costs and land taken out of grazing for deer. Two estates applied for multiple natural regeneration and mixed native woodland planting grants. However, they saw little benefit from woodland management, as this was not viewed as a key component of the regional landscape.

Uncertainty and risk prevented all land managers except one, from pursuing diversification, such as investment in woodfuel production and installations. Taking a risk on expanding management activities was seen as unnecessary and a hindrance to the main management priorities of the estate.

Diversification was at times driven by personal interests of the manager (Attadale Gardens) but was mostly reliant on management activities proven to generate stable income.

Knowledge of forest energy installations, potential regional demand (and therefore profit) was very low amongst the land managers. One manager had a very low opinion of forest energy as an effective way to deliver domestic energy supply for the estate and region. “It wouldn’t work, there’s not enough wood and it just can’t compete on the same level as other things like energy sources” (Inverinate). This highlights a common disinterested attitude of landowners, which is related to forestry industry in general, as well as increased management (Urquhart, et al., 2012).
7.4.2 Lochaber

Deer management and income generating land uses were the priorities for Lochaber, however, low confidence in woodland as a beneficial resource to either the landscape or the value of the estate was also prevalent (Figure 7.1). Small-scale areas of woodland were considered important for deer shelter but to a limited extent as managers expressed strong views on the woodland expansion rationale and its negative impact upon sporting use. This was viewed as presenting a shifting policy environment that was not encouraging to managers with long-term integrated land management plans. Additionally there was wide discontent across estate boundaries in the region due to different approaches to woodland management, which has negatively impacted the effectiveness of the local DMG. These divergent management approaches have, in the view of some land managers, undermined the collective deer resource and principles of the DMG leading to a break-down of communication and collaborative scope in the region.

In this case study area the mix of ownership dominated the way in which estates adapted their land management. For example Achnacarry’s owner is increasingly immobile due to declining health and therefore business aspects of the estate are being leased. Kingie’s absentee owners, only use the estate for recreation, thus the estate development and management activities are fairly static and Glen Dessary has an owner open to diversification opportunities, such as restructuring woodlands, wild boar breeding and increased tourism. These differences in ownership and resultant management strategies possibly undermine the effective of communication and potential cooperation, highlighted by the unsuccessful attempt to bring all owners around the same table for discussions.
The most dominant theme that emerged from Lochaber was the sense of geographical isolation and remoteness, despite being relatively close to Fort William. The lack of infrastructure and accessibility created an island effect. "Out here we're kind of cut off there's only one Forestry Commission road that runs small way into the estate, the rest of the time we have to access it by boat". Lacking adequate road networks and ease of connection cuts off this estate from markets, communities, as well as opportunities for
greater growth. In a sense this isolate hermetically seals an estate from outside concerns and inhibits development.

Hydro power was important for all three estates and Lochaber had numerous suitable sites, many of them in partnership with the Forestry Commission and private energy companies, where the estate receives rent for the land (Hindle, et al., 2014). However many schemes have been held up due to poor grid connections, which is costing the estates potential income. “Without the grid connection we are losing money all the time” (Glen Dessary).

Funds channelled into deer stalking and sporting lets absorb the majority of investment capacity, which leaves little capital for diversification. “New investment includes improving the sporting lets and adding another property to the estate for increased stalking capacity. This leaves little money for anything else” (Glen Dessay).

Woodlands were viewed as a hindrance to the operational and management capacity of the estate, as they were considered too dense for deer shelter, which made it difficult to plan further activities. “These woodlands are worthless, not only too dense for shelter but interfering with deer movements over the estate” (Kingie). Contrastly Glen Dessary and Achnacarry practiced forest management, thinning and harvesting spruce woodlands planted by the Forestry Commission. Both land managers expressed frustration in the difficulty of maintaining management activities due to uncertain and unprofitable markets.

Fencing was a significant issue for all estates, a focal point for the conflict between sporting management and woodland expansion (Thomas, et al., 2015). Whenever fencing was mentioned by a land manager “cost”... “damage to deer”... “taking land out of production” and “no other choice” were used. This pre-existing disadvantage for woodland persists due to the fencing requirements when planting and normally for 15-20 years thereafter. Additionally no fencing approaches are met with similar negativity as this attracts deer to unfenced areas away from other estates with fenced woodland. Either
way fencing is perceived as an ongoing problem and can create conflict within a region over contrasting management approaches and aims (Lawrence & Edwards, 2013; Armstrong, 2015).

Most land managers cited risk and uncertainty as being the main reasons not to pursue diversification. “There’s just too much uncertainty to take any economic gamble on other activities, wood prices aren’t high enough, woodfuel market isn’t developed, and still somewhat an unknown” (Glen Dessary). However, the majority of diversification on estates is linked to land manager’s personal pursuits (e.g. History museum, wild boar introductions, estate gardens etc), which generates little or no extra revenue at best. Therefore diversification on many of the estates has less to do with commercial enterprise than personal land manager vision (Morgan-Davies, et al., 2015).

The importance of history and connections to tradition emerges as a prominent consideration for management (Higgins, et al., 2000; Wagstaff, 2014). One land manager maintained a Clan museum for personal pleasure, despite the lack of profit generation but felt a responsibility to highlight his family’s long history in the area. “The estate’s been in the family for over 400 years, I feel a responsibility to the area and future generations to maintain the lineage and the connection to past events” (Achnacarry).

Multiple leased activities on one estate are the result of the land managers increasing lack of mobility and decreasing economic feasibility of business operations. The estate is dominated by leased land (Deer stalking, farming, Crofting, Forest crofts), which encourages community-led, start-up businesses as it provides opportunity for entry into markets within an already established land use set-up (McMorran, et al., 2014).

Due to the leased land uses, historical focus, woodland restructuring and boar introduction on Glen Dessary (designed to be contained within the estate), Lochaber demonstrates a propensity toward shifting practices and diversification. This could all be traced back to the Achnacarry owner selling off land for extra funds, which in turn became smaller neighbouring estates with different management objectives. Glen Dessary,
especially has an active and diversified business plan that has developed over the past seventeen years.

### 7.4.3 Cairngorms (Deeside)

The main drivers for estates in the Cairngorms cluster included economics priorities and sporting management (*Figure 7.11*). Grouse moors added to the dominance of sporting use in the Cairngorms with profitability of £9,943 per day far out competing deer stalking (£7429, this increased the separation and marginalisation of woodland as grouse management views woodland as detrimental (damaging) to the habitat despite continued pressure for integration (McMorran, et al., 2014). “The management don’t want any mixing with woodland on grouse moors or even around the edge if can be helped….woodlands are seen to house vermin harmful to the grouse and people are very passionate about moorland and birds around these parts” (Invercauld).

Woodland range and capacity is dominated by Scots pine and species such as Larch, Douglas fir, Sitka spruce and mixed broadleaves, which have small ranges within the case study area. “This area is a Scots pine stronghold and conservation of that woodland type is priority, however management and production are viewed as low and unprofitable activities despite the potential for productive woodlands from various broadleaves, Larch and Douglas fir” (Balmoral). Each land manager from the case study area highlighted the strong influence of policy in shaping current practice and planning, and that different approaches are adopted in accordance with policy objectives and available grants. However, long-term planning and estate aims tend to remain the same. “Policy tends to only affect short-term activities to secure grants but rarely affect the longer-term goals and planning, as shifts in policy change quickly and changing estate activities takes time to occur, policy timeframes and flexibility are not compatible with this” (Invercauld)

Hydro power was a high priority for all three estates, which currently are developing and installing hydro-schemes to power the estate buildings and sell energy back to the national grid. Each estate emphasised the appeal of low landscape disruption and the utility of a present and abundant resource.
The Cairngorms case study area was steeped in tradition, which aims to conserve the heritage of traditional management. Despite the influence of the National Park and tourism centres, the area was cited as being “frustratingly anachronistic” with regard to land use management, as tradition often hindered potential opportunities for diversification. The driver for greater diversity of approaches appears to be undermined by the size and scale of estate activities, whereas other areas (Lochaber 7.4.2), which have newer and smaller estates demonstrate greater drive toward diversification and integrated use. This correlates with relatively new ownership and smaller management scales that might be less prone to following traditions. This correlation runs contradicts some literature that suggests larger estates are more prone to diversification due to abundant resources and greater scales of economy (Glass, et al., 2013; Hindle, et al., 2014; Macmillan, et al., 2010). However this could be a regional phenomenon and will need further investigation.
Private trusts that run the estates have invested in sporting syndicates (mainly for grouse shooting) to revitalise the once declining industry, which also stabilised a traditional area of employment (game keeping).

Due to National Park status the area is subject to increased natural heritage designations and landscape pressures. Estate management has to negotiate conflicting agendas that promote tradition, wildlife conservation and innovative sustainable development.
approaches. These multiple considerations form a template that is similar to an ecosystem approach (Stockdale & Barker, 2009; Dick, et al., 2011). However, the case study area’s character and management focus was dominated by the tradition of grouse moorlands and diversification of bird species for increased sporting opportunities. “Ninety percent of the land is under designations, which makes it harder most of the time to justify, plan and implement activities as there are so many interests to balance – this can inhibit potentially productive interests in place of conservation priorities” (Invercauld).

Deeside has more woodland cover than any other case study area and two estates practice small scale thinning operations. Most thinnings were described as tokenistic gestures, to offset policies pushing native woodland restoration. The majority of land managers held the opinion that scoping for further woodland expansion in the Highlands should be shifted to the west coast due to precipitation levels and the lack of grouse moor management, which was cited as being “a habitat of European importance”. The grouse moors hold vast areas suitable for woodland, however stringent protection (by owners) of the moors for grouse shooting deny opportunity for integration or low impact plantings (McMorran, et al., 2014; Wightman, 2015). Nevertheless, potential appeared to exist for estates to increase the contribution of woodfuel areas to estate income streams through timber production as regional demand was high and supply was low, “I have to import wood from other regions to sell over here, I can’t get my hands on timber fast enough, especially hardwoods” (Invercauld).

Woodfuel was viewed as a promising option and potential market for estates but investment into an undeveloped market in comparison to more stable options was considered unwise (McMorran, et al., 2014). “We could expand our small estate operation of logs but the bigger plants are too far away and don’t offer flexible or financially attractive contracts” (Invercauld). One land manager emphasised the importance of timing and long-term planning within the estate plan, “At times it’s just the wrong time and demands of third party contracts do not offer to work with the estates…further consideration may be given in subsequent management plans, if the technology and markets improve” (Invermark).
7.4.4 East Sutherland

Although the main drivers remain similar (prioritising economics, management inhibited by policy, negative perception of woodland and different management approaches required, *Figure 7.12*) there are subtle differences that can be explained by the landscape of East Sutherland. The low density and remote populations combined with low elevations and high profile peat conservation efforts (Flow country) gives the region a different sense of priorities and land potential. Originally each estate was bought with dominant grouse shooting objectives, but habitats have since declined, to be replaced by deer stalking (*Pearce-Higgins, et al., 2016*). Policies and grants were described as narrow and unfocused across all three estates because activities were constantly considered in separation rather than linked together and included within common applications and time frames. Two estates held strong views that woodland grants and expansion policies are penalising and reducing the importance of traditional uses, which could be the result of separate but parallel land use cultures developing in close proximity yet rarely integrating (*WEAG, 2012*). In general policies are seen as restrictive due to their inconsistent focus, the scale on which they operated and their inflexible structure (*Lawrence, et al., 2011*).

A notable absence from this case study area is hydro scheme development due to lower elevations, joint ownership of the river Helmsdale, wetland conservation restrictions and less significant development opportunities. Negative views of woodland management are common throughout East Sutherland, partially caused by the backlash against woodland plantings in the 1970’s and 80’s (*Warren, 2000*). Furthermore the remaining stands have suffered severe windblow and recent harvesting operations on the estates were deemed inadequate, making it difficult to prepare the land for continual use. These factors as well as the continued existence of visually unattractive and low value woodland decreases the case study area’s confidence in woodland as a relevant land use.
Land managers have mixed views on the role of woodlands for the estates and landscape. Badanloch’s manager is keen to see more shelterbelts and broadleaf woodland in the right place, as was the manager of Achentoul, who possessed a passion for broadleaf trees. This is supported by the increased interest in native woodlands in the last 20 years, where broadleaves have risen by 4% of the woodland resource (22%) (WEAG, 2012). Borrobol estate was the only estate over the case studies that had an active tree crop with purely
commercial objectives in the form of Lodgepole pine Christmas trees. In spite of the success he believes the estate woodland to be at maximum capacity and any further expansion would be detrimental to deer stalking and landscape interests. Short rotation forestry has been the only successful productive woodland use in the case study, and for some may result in less of a negative landscape impact, which bodes well for forest energy development.

The flat, expansive, rolling characteristics of Sutherland are described as a Highland wilderness. All three landowners are eager to conserve this wilderness and isolation the landscape provides, which indicates a strong personal preference for landscape aesthetics and amenity woodland (Lawrence & Edwards, 2013; Morgan-Davies, et al., 2015).

Maintaining a tradition of livestock management is an important objective for all landowners in East Sutherland, described as “a duty to protect public desire for tradition on the hills”. Borrobol employed one shepherd and Achentoul two, “Most estates can’t keep even one shepherd but we have two, the boss likes the livestock, feels they’re important to keep on the land”. This case study area demonstrates strong preferences for livestock investment, which is subsidised by the land managers. The desire to maintain perceived traditional landscape management mitigates the unsustainability of the land use as a business (SRUC, 2011; Tanentzap, et al., 2013).

Although an important priority, deer management does not emerge as the most important driver compared to other case study areas. The combination of activities such as fishing, livestock maintenance and conservation pursuits reduce the core significance of deer stalking, despite sporting lets and stalking being the main financial contributor to the estates.

East Sutherland is considered a wilderness area by the three land managers due to remoteness, low population and peatland conservation. “This area is a rare wilderness and unique that’s one reason the owner bought the estate, nothing quite like it…wild, flat, no one around…” (Badanloch). Perception of wilderness is a powerful narrative with all land
Managers, despite the land being intensively managed, wilderness in their mind is driven by visual perception, population size and proximity to larger communities (Deary, 2015).

Market accessibility is considered to be a difficult prospect by the land managers, which reduces the feasibility of commercial operations (FSC/SG, 2007). Woodland is viewed as being too remote to benefit from processing centres and regional markets, “It’s not worth it, everything is too far away and transport cost up here are astronomical, maybe with more development costs would reduce and markets would be closer” (Borrobol).

Woodfuel is viewed as having too many uncertainties (practice, operation and markets) to be a serious consideration. Markets are viewed as undeveloped and unreliable, which emphasised the land manager’s low awareness of operational supply chains and the technological sophistication of biomass installations (Feliciano, et al., 2014). There is a mixture of scepticism and curiosity for short rotation forestry (SRF) as a potential land use. SRF is considered to be both traditional and modern land use, the short rotation factor is economically attractive but from a landscape perspective SRF is viewed as unattractive by most, however, the appeal of Borrobol’s Christmas tree plantation may contradict that assertion. A rail line located at the epi-centre of the case study area has been an option for increased management activity, “The rail line was going to haul lots of timber out of here at reduced transport cost and could have become a sustained use for the area but there was no collective will” (Borrobol). This quote highlights the importance of collective action and the potential importance of estates working together in the region (Glass, et al., 2013).

7.4.5 Convergent and divergent factors

This final section focuses upon the differences and commonalities over the case study areas, which identifies distinct regional characteristics that impact management and decision-making. Each case study area is compared in Tables 7.1 and 7.2, highlighting divergent and convergent theme. Convergent themes refer to commonalities that the estates share, although with some minor variation between the estates to what degree
they share these common areas (*Table 7.2*). Divergent themes identifies areas in which the case studies demonstrated greatest differences (*Table 7.1*), which may explain various uses of the land resource, management approaches and perceptions.

*Table 7.1* – Case study areas divergent themes

<table>
<thead>
<tr>
<th>Divergent themes</th>
<th>Wester Ross</th>
<th>Lochaber</th>
<th>Cairngorms</th>
<th>East Sutherland</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Landowner priorities beyond economics and sporting use</strong></td>
<td>Landscape improvement and wildland aesthetic</td>
<td>Land leasing, diversification and infrastructure development</td>
<td>Conservation of Caledonian pine woods and other key species/traditional communities</td>
<td>Livestock management and conservation of wetland habitats</td>
</tr>
<tr>
<td><strong>Diversification of land use practices and business enterprise</strong></td>
<td>Medium</td>
<td>High</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td><strong>Landscape connectivity (social and physical)</strong></td>
<td>High</td>
<td>Very low</td>
<td>Medium</td>
<td>Low</td>
</tr>
<tr>
<td><strong>Receptiveness to potential woodland expansion for forest energy</strong></td>
<td>Interested</td>
<td>Very interested</td>
<td>Moderately interested</td>
<td>Low</td>
</tr>
<tr>
<td><strong>Dominant influence on current management</strong></td>
<td>Landowner preference, and owner engagement</td>
<td>Ownership type and infrastructure</td>
<td>Grouse management tradition and large scale historic estates</td>
<td>Water resources, wetlands and owner engagement</td>
</tr>
</tbody>
</table>

*Table 7.1* demonstrates that estates tend to diverge after economic and sporting management considerations, at this point other regional characteristics become more apparent. Habitat types drive some regions more than others like the extensive grouse moorland of the Cairngorms or Peatlands in East Sutherland, thus powerful narratives (section 7.2) correlate with economics, tradition and conservation that maintain and support estate use. Wester Ross has strong affinity with a wild landscape aesthetic, only one landowner has utilised woodland grants to plant woodland. Whereas Lochaber shows greater adaptability for business diversification, due to mixed ownership types and infrastructure impacting accessibility to areas of the estates, rather than a distinct identity
driven by a dominant habitat concern. Topographical variation occurs between the Cairngorms and East Sutherland in the form of clustered Munros (Cairngorms) and land that is under 500 metres (East Sutherland), yet both have multiple layers of conservation and heritage designations. The role of identity emerges as a central theme, as each case study views their area (if not their estate), as a separate and distinct region within the Highlands subject to different management influences. Diversification prospects are low in case study areas with greatest conservation focus (Cairngorms and East Sutherland), which also aligns with a propensity toward traditional activities. However, diversification seems to correlate with complex balance of level of private wealth, landowner knowledge and interest in practical land use, presence of landowner, political climate and cumulative impact of successional owner’s individual agendas.

Landscape connectivity is viewed through the level of infrastructure links and social connectedness to other landowners, communities and services. Lochaber and East Sutherland are considered very disconnected. This creates the privacy sought out by land managers but has become increasingly impractical for land use expansion. Case study areas on the west coast demonstrate higher receptiveness to woodland expansion and SRF due to the land managers greater interest and land availability. The low interest in East Sutherland is likely the consequence of the existing state of woodland in the area, which is damaged and costly to remove. Wester Ross has individual land managers with singular influence and visions for their estates, whereas a relatively recent change in ownership in Lochaber shifted the mix of land uses. Additionally a combination of circumstances including benefits from emerging markets and the decreased physical mobility of the Achnacarry manager changed the estate from a predominantly in-house run operation to one dominated by land leases (Stalking, shooting, properties, tenancies, Forest Crofts). The Cairngorms and East Sutherland areas are shaped by dominant habitats (grouse moors and wetlands) and land use aims, which have formed strong management identities based upon environmental conditions and tradition.
Table 7.2 – Case study convergent themes

<table>
<thead>
<tr>
<th>Convergent themes</th>
<th>Wester Ross</th>
<th>Lochaber</th>
<th>Cairngorms</th>
<th>East Sutherland</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reliance on hydro development as economic stabilising factors</td>
<td>High</td>
<td>High</td>
<td>Medium</td>
<td>Low</td>
</tr>
<tr>
<td>Sporting management is at the heart of estate concerns</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Negative view of woodland potential and benefit for estate management</td>
<td>High</td>
<td>Medium</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Estates role as important rural economy contributors is unappreciated and unrecongnised</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Protective over traditional Highland landscape</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Aversion to wind power prospects</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Policies and grants ill-equipped to support desired business expansion</td>
<td>Medium</td>
<td>Medium</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Livestock management viewed as important to estate management</td>
<td>Medium</td>
<td>Medium</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Awareness of woodfuel potential</td>
<td>Low</td>
<td>Medium</td>
<td>Medium</td>
<td>Low</td>
</tr>
</tbody>
</table>

Deer management is the dominant shared priority, with the exception of the Cairngorms case study area, which focussed on grouse shooting (Table 7.2). Hydro scheme developments and future economic stability is important to all case study areas except East Sutherland, which has poor prospects for hydro use. In contrast woodland is viewed as a detriment to financial stability due to negative landscape impact, the potential cost of
management and poor stumpage prices (Armstrong, 2015; Wightman, 2015). Therefore productive woodlands are viewed as an unlikely development. The majority of land managers consider their estate’s role in rural management and the local economy as undervalued by the public and policy-makers (Davies & White, 2012). Land managers generally agree they deserved recognition for the personal cost they input into the estate and subsequent benefits to rural areas, and want their contributions to be recognised as good practice and valuable to the landscape.

Maintaining the Highland landscape is heavily influenced by sporting use, traditional livestock management and native woodland restoration for amenity purposes. Despite the low sustainability of livestock management it is viewed as a key landscape component, emphasising the preference for tradition over practicality. Despite the focus upon economic stability and profit centres, land managers view wind energy as an unacceptable activity due to potential damage in ecological and landscape terms. The inaccessibility and incompatibility of grants, as well as the policy that supports them was a common complaint amongst land managers, which in their opinion require increased flexibility and specificity. Generally woodfuel was seen as an unwise investment due to land managers’ common perception that woodfuel as an energy source and service is less developed and more unreliable than alternative choices. Uncertain market developments and potentially increased management inputs also deter greater land manager consideration.

7.4.6 Regional responsibility
Responsibility to maintain a region’s distinctive landscape and practices emerged as a central theme across the case study areas. “Grouse moors are what people want to see, they’re a part of the tradition, landscape and management in this region for a long time, an important land use on be preserved” (Invermark). However, the regional responsibility extended beyond the land manager’s own area, as the majority of managers identify particular responsibilities of other regions, which are compatible with or traditionally symbolic of the landscape. “We haven’t the room over here for woodland expansion, there’s too much land in sporting use….let them worry about the trees over on the west where there’s
rain and more space” (Invercauld). Even from an energy perspective regional divisions are being formed, “There’s not too much hydro potential here as elsewhere but Angus has some of the best solar power potential in the country, equal to that of southern England, I think we have a responsibility to explore that use” (Invermark). East Sutherland are motivated by the regions fishing strengths, livestock management and ecologically important wetlands. However, no case study area or land manager perceives a particular responsibility to woodland management or developing the productive forestry industry. In the Cairngorms conservation of Caledonian pinewoods and planting of river catchments are viewed as worthy woodland management activities. “We have the Scots pine, we like the Scots pine and are involved in the Ballochbuie river scheme but woodland isn’t that important here, we had one [a forester] here once and he moved to a place where he could manage big Sitka spruces, I feel sorry for foresters up here” (Balmoral). No land manager in any of case studies views woodland expansion as their responsibility, more woodland and active management does not equate to an improvement or move toward ecosystem management.

7.5 Landscape resilience

This section presents the mapping outcomes of the field interviews (Chapter 5.2.2 and 5.2.6), which focussed on linking the recorded interview scripts with specific areas or land uses on the estates (cultural-spatial practices). Land use drivers with the strongest spatial connections were plotted onto the estate in ArcMap, representing links between practice, ecology and culture. Resilience concepts (Stability, Adaptation, Transformation, and Collaboration) (Gunderson, 2000; Folke, et al., 2010; Cumming, et al., 2006; Cumming, 2011) have been applied to align with the plotted areas. In conjunction with supporting data from the field interviews, these have formed explicit spatial areas of resilience over the case studies areas.

An additional concept ‘Static’ emerged from the field interviews, as a significant area of land remaining unmanaged and unchanged but not considered stable or desirable by the land managers. At times nature is seen as static, unable to fulfil societal potential and remaining fixed in time and predictable, lacking inertia to move with developing
This emergent concept was applied to the maps alongside the established resilience concepts. **Stability** represents the perceived strengths of estate management activity, as defined by the land managers (*Section 7.3*) including areas that support sporting use (further elaborated upon in this section). **Adaptation** areas are experiencing land cover change and responding to management plans for the estate (i.e. harvested/planting areas), whereas **Transformation** represents land uses and areas of the estate most disposed to potential change or continually under development (i.e. farmland/pasture, long-term projects). **Collaboration** represents areas under joint management or subject to joint partnership agreements (i.e. transboundary woodland).

The following section demonstrates a novel approach developed during this research to analyse and interpret landscape resilience, which links cultural influences (defined by the land managers) to ecological boundaries, management practices and regional operations. Similar to current resilience models, such as the Sustainable Livelihoods capital approach this analysis of resilience involves human (land managers, history, narratives and perceptions), natural (land use and management), social (networks, collaboration, communities and decision-making), physical (capacity, compatibility of the land and infrastructure) and financial (economic implications and value) capital to provide insight into and identify ‘ways forward’ (Hamilton-Peach & Townsley, 2004). More recent multidimensional models continue to focus on people as the central chord incorporating individual, relationship, community, cultural and physical ecology factors and contexts (RRC, 2016). Unlike other resilience models this approach provides a method to transpose elements of resilience onto a spatial scale that encapsulates local perspectives, which can then be linked to regional and national priorities. In later chapters the outcomes from the landscape resilience maps are used as a component to inform regionally specific ecosystem approach for Highland estate land managers by identifying perspectives and aims of resilience in a local context, as well as triangulating potential avenues for fostering strengthened estate resilience.
7.5.1 Wester Ross

Wester Ross is driven by landscape aesthetics associated with sporting use. Each estate has stands of lodgepole pine and sitka spruce that remain unmanaged and static (Brown areas in Figure 7.14) in the landscape despite the land managers desire to remove or restructure the stands. Common grazing areas are vacant with no plans to for further management activity. Other static areas include the interface between estate borders and inaccessible high ground. However, these areas are only static from a socio-economic perspective and ongoing ecological processes, as well as functioning habitats support stable systems for various species (Gunderson, 2000). Inverinate estate has several farms and livestock grazing in the east, which are represented as static rather than stable due to the owners wish to support the farms at cost, without any meaningful revenue being generated. No profit is gained from these farms or their activities; however they provide permanent jobs, which help to preserve the traditional wildland (in their view) and small pockets of local employment, and will continue to persist in their present state. The land manager acknowledges that these activities and level of employment would not be possible for an estate, without support of private wealth.
Attadale estate has two small parcels of former grazing land (areas of yellow in the west Figure 7.14) and an unproductive tenant farm whose relationship with the estate is deteriorating, with the tenancy agreement coming to an end in the near future. An ornamental garden with plans for a tearoom, which continues to expand and attract more visitors (undergoing transformation) represents a dynamic area of management for Attadale. Whereas the other estates’ transformative potential identifies riparian areas with the aim to plant trees, therefore stabilising banks and regulating the river environment (Figure 7.15). This aligns with river basin and catchment management objectives being widely adopted (Rouillard, et al., 2015). Adaptive areas (Orange) are identified as recently established woodland and a couple of areas of natural regeneration that will require further management to aid survival and encourage healthy stand structures. The remainder of the region was considered stable (Blue), which translates to
deer forest, lochs and landscape viewsheds, which is in keeping with land manager’s main management priorities (Macmillan & Phillips, 2010).

### 7.5.2 Lochaber

Lochaber is the case study area most favourably disposed to diversification (supported by Figure 7.16 and 7.17 and section 7.4), which corresponds to smaller estate size, the recent changes in ownership priorities and response to new management fluctuations (Figure 7.7). This trend seems to be influenced by new managers coming in with new ideas and aims (Glass, et al., 2013; Hindle, et al., 2014), however the scale of the estate and changing capacity of the Achnacarry manager in combination triggered this redistribution of land and its potential change in use. Kingie is dominated by deer management but is more geographically isolated than other estates, as access is limited to a small road through Forestry Commission land that enters and finishes only a small way into the estate’s eastern border, otherwise access is entirely limited to a single boat crossing over

![Figure 7.15 - Indicative grouping of resilience areas and related land use practices](image-url)
Loch Quoich. The single transformation area on Kingie is a stand of lodgepole pine at the end of the track, which requires restructuring, supporting suitable land for continued woodland expansion that is otherwise limited in other areas of the estate.

![Case Study 2 - Lochaber landscape resilience](image)

**Figure 7.16 - Lochaber landscape resilience**

*Adaptive* land is prominent on Glen Dessary as a large area of woodland (700 ha) is being harvested and replanted over the next five years – this has been made possible by the combination of increased timber prices and a recent grant for upgrading the forest road. The area surrounding the current activity has become increasingly susceptible to alternative management options, owing to the disturbance and new land cover composition. Therefore increased access and infrastructure opens up opportunity for future planning where ecological networks could be enhanced and supported by the development of strategic road networks. *Static* areas continue to be located around estate
borders, inaccessible land and viewshed areas; however one area of transformation covers contiguous estate borders, as it links the road and ongoing activity that may provide impetuous for further management planning. In many other countries deforestation and forest fragmentation is associated with extension of road networks (Liu, et al., 2015) but in the case of Highland estates this would provide incentive for greater expansion and management.

Achnacarry is the parent estate to Kingie and Glen Dessary, which were sold off in the last 40 years to generate income. The estate is relatively inactive as the land is leased to private businesses; the only resources they manage are woodland, as well as developing hydro-schemes, which are both partnerships. Adaptation represents the increasing predisposition of lease management opportunities and transformative areas, which are prominently viewed as small woodlands (vulnerable to windblow and deterioration) and areas along Loch Arkaig that have the potential to link them. The combination of land leasing and partnerships is an emerging trend, increasingly land use management for business purposes is only feasible in partnership with other organisations, trusts, companies, agencies or individuals.
Crofting ground in the south-eastern corner of Achnacarry is a transformative as well as an adaptive management opportunity, which includes the opportunity to develop Woodlands In and Around Towns (WIAT) through community land use initiative. Static areas are around the border areas and remote parts of the estate, as well as undesirable woodland that possess an unclear objectives. Re-investment in land businesses and enhanced use of crofting land is hoped to be one of the outcomes of increased community ownership under the Land Reform Act initiating diversification and regeneration of community in remote areas (Hoffman, 2013).

### 7.5.3 Cairngorms (Deeside)

In Figure 7.18 static areas are classed as roadsides and some accessible points, close to large stands of woodlands (Scots pine and larch), which could provide valuable timber products. This again is the result of socio-economic drivers, as the estate is unwilling to
invest in silvicultural treatment and infrastructure restrictions prevent operations taking place (requiring road upgrades with insufficient match funding grants). This has resulted in declining woodland health and habitat, as thinning operations are not performed. Over time this has normalised a non-intervention (thinning and other management activities) policy for the woodland perpetuating non-management culture and the quality of timber produced from these stands. Conservation and expansion of Caledonian pinewoods may be a priority for the Scottish Government (RPS, 2016) but the lack of management is damaging the future health, quality and benefit of these woodlands.

![Case study 3 - Cairngorms landscape resilience](image)

**Figure 7.18** – Cairngorms landscape resilience

Other common static areas are high elevations, which in the Cairngorms are more widespread than any other region, as over thirty Munro peaks (sixteen on just one estate)
populate the case study area. Estate borders continue to be an area devoid of activity or management consideration.

*Stable* areas encompass greater range of uses than the other case studies due to the areas to the high tourism profile (See Figure 7.19). There are significantly more farm tenancies (productive) in Deeside. Eight thousand hectares of Balmoral estate is owned by another land manager, managed for livestock grazing, which reduces the opportunity for diversified management on a landscape scale. Large tracts of land on both Invercauld and Invermark are under grouse management with resources dedicated to cultivating game bird habitats. Invermark estate is also interested in re-establishing Grey partridge populations. Sporting syndicates on a fifteen-year rotation have proved lucrative and have no shortage of interested parties willing to sign up for leases, which has stabilised land and management that was in decline in the recent past and is another example of land leases supporting the rural landscape.
These relatively short-term leases exclude woodland development and integrated land use due to the singular focus on grouse shooting. The lack of interest from the temporary managers, planning requirements and potential returns does not provide significant motivation to implement integrated management approaches. Areas considered important for deer shelter, wintering, feeding and grazing remain an active and stable part of the estate activities. A ski centre at the south-westerly arm of Invercauld continues to be one of two winter sports centres in the Cairngorms, attracting tourists and supporting the regional economy.
Adaptive practices include a recently established and newly approved three hundred hectare woodland (Invercauld), which is described by the estate forester as, "a rare victory". Small harvesting operations and hydro-schemes are being installed over small areas of the estates and new gas boilers are being installed on Balmoral. Two distinct areas of potential transformation exist on Invermark, which include plans for a potential deer farm close to the estate entrance and a Highland/wildlife educational centre.

Planted woodland along riverbanks have suffered high mortality rates due to poor maintenance, these could have been considered adaptive areas but are returning to a former condition before planting began (absorbed into the large stable grazing areas). There are many small areas (2-20 hectares) around roads and tracks, as well as improved pastures (transformative) that could support alternative management but remain empty, as disconnected planning of small areas is considered economically unwise and time consuming. Deeside has the only example of transboundary collaboration across the case studies; this involved woodland planning between the National Trust Scotland (Mar Lodge) and Invercauld estate (See purple area in Figure 7.18).

7.5.4 East Sutherland
East Sutherland is the most northern case study area and unlike the rest of the case study areas elevation does not exceed 450 metres. The opportunity for adaptation and change is limited due to its position in the heart of the Flow country and peatland restoration priorities. In many ways large areas of the case study is suitable for woodland expansion but are met with resistance, as stringent conservation measures and the visible failure of past woodland expansion schemes inhibit current expansion (Warren, 2009; Bunce, et al., 2014).
Figure 7.20 shows most of the area (70-90% of estate land) is considered to be stable or unable to change (Static). This gives little scope for potential change and transformation of estate management. Figure 7.20 characterises the static areas as wetlands, protected heritage areas, windblown woodland and inaccessible land. The areas in yellow and orange delineate distinctive corridors of land under change, in flux or possessing an uncertain future (Figure 7.20). However, due to its small area, adaptive and transformative land is considered to be a premium within the decision-making process, which makes it more susceptible to risk aversion management strategies and therefore more likely to support current management that generates tangible income (See Figure 7.8).
7.6 Landscape resilience trends

*Static* land is located around estate borders throughout the case study areas as high elevation, rocky terrain, difficult access or limited practice restricts management. Corresponding evidence across case study areas identifies a buffer zone of non-activity, as estate boundaries often follow higher ground, ridges and edges of watersheds. Three alternatives could explain the unused areas in parallel with geographical constraints:

- Non-infringement policy that respects private ownership and avoids unnecessary conflict or potential land use issues around borders. This would actively prevent transboundary activity and inhibit the development of an ecosystem approach (CBD Principle 3).
- Conserving and improving the wildland aesthetic, which allows relatively untouched land to develop through perceived non-interference from human management.
- Aims to create unimpeded landscape for deer with no barriers or fencing to modify the roaming patterns of key estate resources (within this study).

Unhealthy woodland is a common static area on all estates. Unmanaged and windblown lodgepole pine remains economically unviable to perform management treatment or restructuring. Healthy woodland is perceived as native stands, such as Scots pine woodland in the Cairngorms, however some continue to be static due to an absence of thinning (socio-economic perspective). Most estates have an inappropriate infrastructure for management operations, which could not offer significant profit margins. Therefore Scots pine woodland continues to be perceived as healthy from landscape and amenity point of view, as well as providing conservation value.

Areas with heavy conservation objectives have reduced capacity to implement active management, as multiple heritage designations interfere or restrict potential development. In East Sutherland peatlands and historic Cairns restrict activity, whereas the Cairngorms are subject to a combination of wildlife habitat restoration, protection and improvement measures. Thus a combination of boundaries and transition or buffer areas surrounding them complicates the potential use of the land, as well as the value that can be gained by increased management.

**Stable** areas are delineated by sporting land. Whether deer or grouse, these habitats, although visibly bare are considered important as feeding, wintering, nesting, rides and free roaming areas for sporting species. This expansive area represents the iconic landscape for which the Highlands are famous; the Munro peaks, bare or heather dominated hillsides, and visible Lochs. For the majority of land managers this land is productive and stable with no need for modification or integration of other land uses.

Farms and grazing areas are considered stable elements in some areas despite the weak state of upland farming. The majority of land managers possess legitimate passion and nostalgia for livestock management and believe it to be an important cultural asset. The only woodlands that are considered stable by the land managers are broadleaf
regeneration sites and one commercial Christmas tree operation. It is interesting to note that the woodland with the strongest connection to a stable land use was a short rotation commercial operation. Indicating that the introduction of SRF for woodfuel production may be compatible with estate operations, as long as woodland provides a sustainable income.

**Transformation** areas consist of small woodlands, their size and position on estates exposes them to disturbance and clearing. Areas close to internal tracks and A/B-roads have a higher chance of being considered for use, as the proximity to transport routes and infrastructure reduces potential costs and access difficulties. Old pastures, recently abandoned agricultural land and some unproductive tenancies have land use development potential, as they remain inactive and unused. Riverbanks are prime areas for planting small woodlands across the case study areas, considered beneficial to fishery interests and amenity.

**Adaptive** practices relate to small-scale hydro schemes, which have small spatial impact and therefore create insignificant landscape disturbance. Woodland harvesting and replanting for the creation of shelterbelts or grant aided regeneration areas are the most common adaptive woodland management responses. These woodlands are rarely developed or managed with productive goals in mind, therefore timber quality and woodland structure is limited due to land manager objectives and ongoing perceptions of woodland management capacity. Upgrading facilities and repairs that focus around sporting lets are a priority for estates, as generate significant income. Some adaptive practices are difficult to delineate, for instance the introduction of wild boar on Glen Dessary that have been moved from pens to controlled feeding stations may have caused individual boar to migrate across other estates and the region. Adaptive practices in this sense represent diversification including modifying angling facilities to attract publicity and a wider range of clientele (Badanloch), however for the most part potential adaptive practices remain as potential, alternative options and future plans rarely impacting the estates on a spatial scale.
Collaboration (explicit) exists on only one estate on a spatial scale, which is transboundary woodland project, planned by Invercauld estate project in partnership National trust. This indicates that a mixed agent or agenda approach is necessary to drive the collaborative processes, providing a catalyst for integrative approaches to project management. DMG’s and neighbouring sporting estates share similar goals and rarely find the need to modify their approaches for better working relationships, whereas NGO’s often have different interests, stakeholders and mandates that originate from different land use objectives (Glass, et al., 2013; Foirini, 2013).

7.7 Summary

In Chapter 2 ecosystem approaches encourage decentralised decision-making to the lowest appropriate level, involving spatial and temporal considerations that take into account the functional ecosystem (UNEP, 2000). Highland estates are a unique ownership structure with a history of sporting interests dominating the landscape (Warren, 2009), however, public interests, societal pressure and emerging impacts are increasing the need for diversification and landscape wide management approaches. This Chapter captures personal perceptions and preferences that form narratives, which heavily influence decision-making and land managers interpretation of resilience and beneficial management on a landscape scale. Private wealth and history of recreational use perpetuates these estates and limits adaptive management responses, as tradition reinforced by the wealth provides a shield against fluctuations of markets, policy and societal levers that would normally drive change. A combination of personal preferences, narratives and tradition informs local interpretations of ecosystem approaches – shaping novel ecosystems in response to the influence of human management (Collier, 2015).

Greater nuances affect decision-making and the ability of estates to subscribe to diversification or innovation of land use. Even though economics, tradition, personal and landscape narratives form a foundation (7.2), other factors such as connectivity and ownership elements impact the scope of estate activities and contribution. Degrees of private wealth, contact time with the estate, motivations informed by interests and personal landscape narratives diversify estates from one another. This also impacts
knowledge, understanding and concern over local conditions, community and ecosystems. Contact time with the estate increases knowledge of local environment and management diversification (Glen Dessary, Attadale Borrobol), in contrast absentee owners such as Inverinate, Kingie, Invercauld and Achentoul) show least diversification and greater idealism about wildlands and traditional use. Smaller estates also show tendencies for greater diversification with some larger estates unable to manage operations and employ in-house management. Adaptation to the growing inability to manage in-house operations and land has led to the increase in land/business leasing, as well as partnership approaches. For example Stalking and grouse shooting leases or syndicates, hydro-scheme development, Forestry Commission land leasing initiative, DMG’s and catchment cooperation schemes (River Dee). Seeking alternative frameworks is a clear strategy for diversification and coping with change.

This mix of ownership can also benefit or hinder the cohesiveness of local management and cooperation. Emphasising the importance of social connectivity in mobilising and expanding management potential. Coupled with social connectivity is physical connectivity of estates, as some felt some remote and disconnected than others, which often impacted the ability to access and actively manage the estate. Infrastructure and road networks that facilitate access effects estates ability to act and on a larger scale networks allow consideration of alternatives and in place of fragmenting the land may provide greater connectivity to enhance management options such as woodland expansion and management. The dichotomy between land manager perceptions of woodland expansion and government aims highlights the disconnect between management scales and the ability of strategies to integrate knowledge and cultural considerations of an individual decision-maker. Forming effective connections between landscape units, land managers and mutual landscape narratives is central to aiding adaptation and building novel approaches and ecosystems (discussed in Chapter 10). These issues with scale and cultural considerations are supported by Section 7.4 wherein regional responsibility emerges as the result of land manger perception, traditional land use narratives and private wealth (perceived as a strong adaptation strategy) emphasising that each region focused upon a single land use and management as their
regions responsibility and allocated other responsibilities to different areas, emphasising the unwillingness to see past single management mentality and relate to responsibility for an ecosystem or wider landscape.

Landscape resilience combined land manager perceptions and theoretical management concepts that are innocuous in land use policy both globally and locally to produce a meaningful interpretation of the local ecosystem, which could develop resilience practice and inform plans for diversification and cooperation (CBD Principles: 2, 3 and 7, as well as 1, 2, 3 and 4 of the operational guidelines). This approach identified static areas of the estate alongside established resilience concepts, which describes unused or locked areas of the estate not considered stable from a socio-economic perspective. These maps could also provide insight for policy-makers into the values and rationales of land managers to better target and modify policy. Developing this approach even further could help interpret ways forward for local ecosystem approaches and identify adaptation actions that would not interfere with main estate priorities.

The next Chapter presents results from woodland expansion planning, which links land manager perception and decision-making to practical outcomes informing ways in which diversification and woodland management can be enhanced alongside traditional use.
Chapter 8

Woodland expansion & energy prospects on Highland estates

8.1 Introduction
Woodlands are a significant land use in the Highlands (Smout, 2003; Hobbs, 2009), occurring within a diverse matrix of rural land uses, with a range of different and overlapping social, environmental and economic considerations (Hobbs, 2009). This chapter presents results from the field interviews (Chapter 6.2.2), which focus upon woodland expansion and forest energy themes. From these themes drivers and obstacles are identified and described in section 8.2. The results of interactive woodland planning for short rotation forestry (SRF) (Chapter 6.2.4) and an analysis of the expansion impact on larger scales are described in 8.3. Supporting information is provided alongside the woodland expansion maps to provide context, including planning strategy, species choice and reconsidered areas for each case study.

Section 8.4 presents results from the Forest Energy Tool (Chapter 6.2.2) with regard to timber volume harvested areas, net revenue and calorific value for estate and case study area. Land compatibility for SRF and other woodland types is shown in section 8.4, which are informed by land manager preferences, forestry professionals and landscape planning considerations. The last section 8.5 presents landscape corridor maps (potential estate capacity) for the estate clusters. These display four types of woodland (two commercial) produced using spatial analysis, which incorporates biophysical, infrastructure and cultural factors (See chapter 6.2.5).

8.2 Drivers and obstacles of woodland expansion
Woodland creation on private sporting estates is dependent upon a number of drivers (SG, 2006; SG, 2011; Davies & White, 2012). Chapter 7 presented drivers linked with land use conflict, land manager preferences and economic stability (SG, 2006; SG, 2011; Davies
& White, 2012), which inform the following drivers and obstacles for woodland expansion. These emerged from the discourse in the field interviews pertaining to woodland expansion, commercial woodland prospects and forest energy. Tensions not only exist between ownership types (Chapter 7) but between woodland types and uses. Robins and Fraser (Robbins & Fraser, 2003) referred to this phenomena as a schizophrenia in forestry where two types of incompatible culture has arisen to coexist alongside one another in the same geographical and cultural region. The competing management regimes within forestry (monoculture plantations and conservation of native woodlands) is greatly heightened by the dominance of sporting interests (Wightman, 2015). A landscape focal point has developed, which casts new management regimes, such as river catchments against woodland from former forest policy that stubbornly remain (Robbins & Fraser, 2003). Subsequently this tension and dual nature of landscape and woodland has been adopted by land managers, which has led to a schizophrenic approach to woodland culture, its management and decision-making. This can be seen in the following sections as land managers have both negative and positive views of woodland expansion.

8.2.1 Drivers

Driver 1 – Shelterbelts enhance sporting resources
As identified by the interview data, deer and grouse management is a core estate objective for sporting estates, having significant implications for woodland planning. “It would be good to get the wood out and create better shelter for the deer and the regen scheme is for another shelterbelt” (Kingie). It is difficult to plant woodland in isolation, without consideration of deer, riparian or grouse habitats. “The current woodland has been removed and redesigned in patches for deer shelter” (Glen Dessary –See Figure 8.1).
Further diversification of the woodland resource is also connected to enhancing deer health; it is embedded within the mindset of estate management. “If we could get some decent forest in there…..mature conifers with hardwoods, it would provide good cover for the deer” (Badanloch).

**Driver 2 – Woodland grants**

Woodland grants are vital for driving woodland expansion and encouraging land managers to create forest and woodland cover (SFS, 2006; WEAG, 2012). Without the availability of grants the attraction of planting new woodland would dwindle rapidly. SRDP grants encourage natural regeneration and native woodland mixes, which aligns with amenity and shelterbelt objectives for estates. “Woodland grants were very generous, so I took advantage and ran a few schemes, mostly regen and native woodlands” (Glencarron). Land managers follow government led woodland expansion strategies through the SRDP grant system, as long as the grants align with the central interests of the estates, such as landscape aesthetics, sporting resource enhancement as well as recreation and wildlife habitats (Schama, 2004; Lawrence, et al., 2011). Grant formation is often a response to the current sociopolitical climate and state of markets, as policies
are restructured to suit fashionable management aims at the time, influencing the productivity and management direction of the sector (Slee & Snowdon, 1999). “Grants are very favourable for what’s in fashion at the time but this can change very quickly but we’ll follow the money and plant the type of woodland the policy advocates” (Invermark).

**Driver 3 – Future generations & legacy**

Legacy and tradition remain deep-seated elements of decision-making and woodlands represent a land use capable of connecting generations due to their longevity in the landscape (Schama, 2004; Antrop, 2005). “My parents were passionate about trees, they planted some avenues of maple and plant where it’s appropriate” (Achnacarry). During the interviews it became clear that the majority of land managers viewed woodlands as a visual connection to both the past and the future (See Figure 8.2 for legacy hardwoods). “If they had planted more suitable woodland, we would now have a more valuable piece of land…and it would look a lot better” (Attadale). Only a minority saw woodland as a potential sustainable economic enterprise that could provide meaningful revenue for each succeeding generation (Oosthoek, 2013). The land manager saw the value in successional management of woodland, “If they [Landowner] would just plant now or have planted 30 years ago they would have something here instead of nothing, if every generation did it for the next it would be something good and worthwhile” (Badanloch).
Additionally the majority of land managers viewed legacy woodlands as hardwoods planted in small and well-spaced areas, valued for their aesthetics and ornamental appeal. “Boss wants areas of hardwoods and more woodland to pass on to his grandchildren, something for the future” (Achentoul).

Driver 4 – Small planting areas
Land managers have lost confidence in the value of large forest blocks due to a perceived lack of value (evidenced by lodgepole pine stands in Figure 8.3) and harvesting and extraction difficulties, resulting in management costs that exceed the timber value (Static estate area (see chapter 7.5 landscape resilience)). Such woodlands are the result of past policy and decision-making (Cameron, 2011). “We are designing the current woodland into small areas mainly for shelterbelts and landscape appeal, getting away from the large blocks and more to a sustainable mosaic” (Glen Dessary). Smaller areas are viewed as a positive influence on the landscape aesthetic, requiring minimal management input as well as serving the sporting interests of the estate (See Figure 8.3). Larger plantations are viewed by land managers as possessing minimal biodiversity and landscape value, as well
as producing a diminishing economic return, and unpredictably effecting deer movement over the estate, which interferes with stalking activities (Putman, 2012; Lawrence & Edwards, 2013). “We wouldn’t want to plant any extensive woodland for fear of driving the deer off feeding and wintering sites and away from the estate – it’s hard to predict their response” (Kingie).

![Image](image.png)

**Figure 8.3** – Minimal value fragmented woodland area found on Glencarron estate, Wester Ross

Land managers perspectives on large woodland blocks are ambivalent as they were seen to cause negative impacts to deer behavior and health, including transmission of disease and increased mortalities (Putman, et al., 2011). “A lot of people see woodlands as a habour for vermin that is damaging to sporting species” (Invercauld). However land managers also admitted that increased presence of better-managed woodland could have prevented high deer mortality rates during the winters of 2011/12, "More woodland with greater canopy cover would have benefited the deer and their chances of survival, they need homes and better shelter during harsh winters." (Badanloch).
Driver 5 – Passion for trees

The majority of land managers conveyed a sense of passion for trees and the great enjoyment they take from seeing them in the landscape. “I’m very passionate about trees, love seeing them on the estate and elsewhere, they’re beautiful” (Achnacarry). However, there was a point at which a few trees transform into woodland for a land manager. Even self-confessed woodland advocates land managers become adverse to the prospect of management responsibilities and sacrificing otherwise valuable land for sporting use or grazing, which explains their reluctance to entertain any medium to large-scale woodland planting scheme (Lawrence & Edwards, 2013). “I like woodland but only in the proper place and in small areas that are sympathetic to the landscape” (Attadale/Kingie). Figure 8.4 shows a parkland setting with mature oak trees, this type of setting that cultivates mature ornamental trees around estate lodges is considered to be desirable by land managers. Broadleaves were also more frequently associated with land manager passion and attractiveness, the only conifer associated with aesthetic attractiveness was old growth Scots pine.

Figure 8.4 – Mature oaks thriving in a parkland setting on Highland estates (Invermark)
Most of the land managers are interested in planting small areas of native species on their estates, including areas of regeneration and small patches of hardwoods. “I would love to see more native broadleaf forests, they’re visually stunning, diverse and could produce valuable hardwood resource but productive hardwood forests seems to be a foreign concept to most up here” (Invercauld). Any mention of larger or potentially productive woodland was interpreted as large non-native conifer monocultures, and therefore detrimental to the ecological integrity of the estate and the wider landscape, this statement represents common manager views from across the interview transcripts and is supported by the literature (Ratcliffe, 1999; Midgely, 2007).

This evidence suggests that apparent passion for trees relates primarily to the land managers personal view and understanding of local woodland, which is not entirely compatible with the main government woodland expansion drivers. A tree or a few trees is a passion or a preference “I love trees and forests they’re great, I am very passionate about them. I sit on the tree council but they can only be so useful to estate activities” (Glencarron). Woodland planting and management regimes infringe upon dominant estate interests, making woodland expansion a low management priority or better avoided for the safeguarding of sporting interests. Most pro-woodland managers seem to be newer owners or owners that spend more time engaged with the estate activities, these managers demonstrate greater understanding of issues and management. Whereas managers that are more absent and committed to recreational pursuits appear to be disengaged from woodland expansion.

**Driver 6 – Rising timber prices**

All land managers identified increased economic value as an important woodland expansion driver. “It’s simple, greater profit or timber prices would make woodland expansion and commercial forestry more attractive” (Invermark). In recent years timber prices have risen due to rising oil prices, tariffs on timber from Eastern Europe and the strength of the pound against the euro (Cameron, 2011), making forest operations possible and channeling timber into local markets. Figure 8.5 shows the only harvesting activities observed over the case study areas. These have been harvested due to rising timber prices and a large grant to upgrade the estate’s forest roads. This emphasises the
dependency of local timber market on infrastructure development, "At the moment the biomass market is mostly looking for debris and by-products at very low prices rather than better quality timber – this tactic will not support a sustainable or growing market" (Invercauld).

A Lochaber land manager directly links the rise in timber prices to the current harvesting operations, which began in early 2013 and will finish in 2017. "It's quite a significant operation, 700 hectares of woodland removed over 5 years, this is possible due to the prices, a transport grant and an upgraded Forestry Commission road that runs close to the property, certain conditions have increased the viability and appeal of woodland management". (Glen Dessary) (Appendix H woodland restructuring operations). This statement highlights the crucial role of infrastructure development for emerging markets, as well as the influence of agencies such as the Forestry Commission upon operational capacity of estate forests, which can cause localised increases or decreases of the timber resource due forest road planning and permitted use of agency owned roads (WEAG,
“The Forestry Commission aren’t bad but are a crucial factor in whether our forests retain or gain any value and a lot of landowners are aware of that…” (Achnacarry).

8.2.2 Obstacles

Obstacle 1 – Eyesore upon the landscape

Coniferous plantation blocks, in the view of all land managers in the study, negatively contribute to the Highland landscape, and were created as a result of post Second World War expansion strategies (Cameron, 2011). “So that’s a 350 acre mix of lodgepole and spruce planted in 1970, three-quarters blown over. We’re left with an eyesore, a forestry embarrassment in European terms, it’s a complete disaster” (Borrobol).

Figure 8.6 – Lochaber woodland, unhealthy and unmanaged creates a homogenous perception of commercial woodlands

This aversion towards, or negative association with, woodland has been incubating for 30-40 years (Lawson & Hemery, 2007). “It’s a mess, nothing worth salvaging there, looks
unhealthy and shabby” (Attadale). Mitigating these opinions of woodland will be difficult as most land managers are continually influenced by the sight and deteriorating health of local woodlands that remain unharvestable. In their view woodland damage the estate aesthetic, created by decades of sporting management (Van der Wal, et al., 2014). The current state of woodland has caused land managers to question the value of productive forests and their contribution to local biodiversity and landscapes. “I would plant a lot more if I could...not those horrible square plantation blocks for commercial forests, which ruin the landscape but more native mixes” (Glencarron), evidenced in Figure 8.6. However, Sitka spruce is often implicated as the main culprit for the demise of the native woodland landscape in Scotland due narrow-sighted planning and policy to increase commercial forest coverage quickly. “We’re trying to restructure the woodland and remove even aged Sitka spruce, which the owner doesn’t like and looks horrible, so we’re trying to move in time to continuous cover woodland” (Balmoral).

Obstacle 2 – Long rotations and limited returns
Main concerns for all land managers when considering woodland expansion is the slow growth rate and distant economic return. All land managers that considered productive forestry expressed similar views, “I won’t be able to see the woodland in its prime or see return within my lifetime, so planting and the end result seems too distant and unhelpful to me right now” (Glen Dessary, Attadale, Borrobol).

Highland woods are perceived as having exceedingly long rotations (120 years for Scots pine – Figure 8.7 shows an older Scots pine stand) for producing good quality timber. “You are on an average 100-year rotation, good dense timber but you’ll be lucky to see a return in your lifetime (Invercauld). The land manager goes on to describe forestry as a “hard sell” to the estate Trustees due to low economic return, reduction of grouse moors and having to fence out deer for twenty years (Wightman, 2015). The Glen Dessary land manager views Sitka spruce as the only viable commercial option due to its growth rate and shorter rotations in comparison to native conifers. “Sitka spruce is the only one I can see having commercial, biggest tonnage per hectare, grows at the right rate and it seems to be more disease resistance.” (Glen Dessary).
Cameron (2011) advocates the use of genetically enhanced Sitka spruce as a cornerstone for Scottish productive forestry. On Inverinate estate in Wester Ross the land manager explained that they had good timber aged 35-40 years (lodgepole pine and Sitka spruce) but it could not be removed, as the owner wants no active management of estate woodlands taking place. Highland Council regulations on road tonnage limits compound the situation by reducing cost-effectiveness of timber transport. “We have some good stuff in there around 35 years-old and could get into the market but the amount we can take out at once makes it unviable and will just go to waste” (Inverinate). In other regions like the Cairngorms there were further restrictions, “It’s slow growing here, 120 years but good dense material... I think the balance of the objectives change...deer value just stays the same, however designations stipulate long-term natural regeneration cycles, which can put establishment of decent woodland back years” (Balmoral). Broadleaves are not considered as commercial or productive species by any of the land managers, except the Invercauld manager who supplied and sold hardwood timber for woodfuel. However, productive
broadleaves are re-emerging as a priority in Scottish woodland creation policy to bolster and expand the forestry sector’s production and diversity (RPS, 2016).

**Obstacle 3 – Remoteness, infrastructure and transport costs**

The Highlands are the most remote region of the UK; some areas have 2 people/km² (HC, 2012). The majority of land managers, even those in more populated areas, feel remote and disconnected from areas beyond their immediate locality. “We are very isolated here, out on a limb with very little connection” (Glen Dessary). This has a knock-on effect to potential market access and the opportunity to develop profit centres (Chapter 7.2), which are reliant on extensive transportation supply chains. “The markets are too far away, they need to be within at least a 30 mile radius, then I could start making money... Transport costs are a killer, especially here in the Highlands, you’re so far away” (Invercauld).

Kingie estate, especially felt very remote for the land manager (View from the eastside of Kingie estate, Figure 8.8), “There is only a Forestry Commission road that allows us to enter the very edge of the estate but that soon runs out and the only other way the estate is accessed is by boat over the Loch. We are out on a limb here... very little road connection and an estate mostly accessible by foot only can make things difficult and restrict activities”.

![Figure 8.8](image_url) - View from eastside of Kingie estate with little road access creates a feeling of remoteness and isolation for the land manager and limits estate activity
The transport costs are cited by the majority of land managers as prohibitive and responsible for realising little profit after harvesting the timber (Roser, et al., 2011). “Due to our location up here we are far away from everything making costs of taking anything away not on the cards, too expensive and we’re not set-up for it” (Badanloch).

Strongly connected to the remoteness of the Highland region was the undeveloped infrastructure affecting the majority of estates, within and outside their borders (connected to Driver 6 on page 217 and Chapter 7). The lack of investment and will to upgrade roads and routes have affected the potential growth of the forestry sector. “There has been an effort by a few landowners to coordinate timber extraction rail, we have 44 tonne timber wagons and the railway line is right there but there has been little support or interest… it’s been an ongoing nightmare” (Borrobol). This example highlights the difficulty arranging collaborative operations with multiple stakeholders, despite clear management and economic benefits.

Additionally the Highland road system is not equipped to support a substantial or growing forestry market. “The A-road along Helmsdale was improved but the connecting B-roads down here haven’t had any work done for ages, they’re continually getting worse and the loads coming down it are getting heavier and more frequent… tearing up the roads” (Badanloch). Both the roads and market are likely to require investment before a stable supply chain can emerge. “There are limited routes into the estate to extract any woodland, there might be a bypass planned, which would open up some possibilities but currently there aren’t the roads” (Attadale)... “I don’t think it would suit us as we’re so remote... Wood chip, timber markets need to be closer... By the time we’ve harvested, extracted and transported there’s barely any value left” (Glen Dessary). All land managers view the distance and substantial cost as a prohibitive factor for investing in productive woodlands.

Obstacle 4 – Lack of market competitiveness and income potential from the SRDP
The majority of land managers do not equate woodlands with profit or economic stability. Productive forestry is a low priority for most land managers and for some the concept of profitable forestry is comical due to past experiences and the current state of the resource.

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“As supply begins to exceed demand it will cease to be competitive just as it will have to compete with oil and coal... we said we’re not planting at the moment because it can be used for something else.” (Invermark). The few that could see some profit in timber production thought a one off sale was the best case scenario but could not see producing a sustainable timber supply due to the unreliability of markets.

There was a clear consensus from the land managers that woodland management lacked long-term viability as a commercial enterprise. The inherently uneconomic options of the SRDP, low market price, confidence in the quality of the product and better use for the land were arguments that support this Lochaber manager. “For a lot of my life [forestry management] hasn’t been commercial, it costs so much to get it out and when you’ve paid for the restocking there was nothing commercial about it... I barely make £11/tonne” (Glen Dessary). The grant system and drivers behind the current SRDP appear to be a large component of this problem, indicating that production forestry is an inferior management aim. “Yeah, I mean most of the options that would get SRDP approval inherently are uneconomic. The grant is worth getting but the end product wouldn’t have any value, there’s just not enough incentive” (Borrobol).

**Obstacle 5 – Inappropriate grant system**

The SRDP and woodland grant scheme has mixed reviews from land managers and most express frustration with the current system. The woodland grant system, which stems from the EU Common Agriculture Policy, is perceived as having many flaws. “What they tried to do, right or wrong, typical bureaucrats... is try to squish a funding system for forestry into an agriculture scheme, without providing any flexibility... The system now costs you more money, and is written by bureaucrats for bureaucrats, not managers.” (Invercauld). This highlighted the inaccessibility, time drain and financial cost of applications, which deter many land managers from pursuing a greater number of grants.

It is clear from conversations with the land managers across the case study areas that the current grant system does not function as efficiently as it could, and creates a barrier to greater woodland expansion and ease of management on sporting estates, rather than a
driver. “That schedule B treatment for tax was enormously valuable, promoting expansion of forestry responsibly... that was a better incentive than having highly technical grant systems, which give you grants for doing things in certain..... It is incredibly complex.” (Invermark). Flexibility and tailoring grants to the needs of the land managers emerges as an important factor in removing current deterrents. Mismatches within horizontal sector cooperation and gaps between policy, planning and implementation and land managers is the root of many potential conflicts, which can undermine adaptive decision-making and change (Nijnik & Oskam, 2004; Haughton & Allmendinger, 2011). An ecosystem approach that has strong links to individual managers and operates over multiple scales to translate land use implications and markets from local to national governance could help alleviate these conflicts (Sugden, et al., 2012; Muñoz-Rojas, et al., 2015).

**Obstacle 6 – Loss of forestry expertise**

The forestry sector in Scotland, and more specifically the Highlands has had a reduction in rural employment and a dramatic drop in remote and rurally based professionals over the latter half of the twentieth century (Oosthoek, 2013). This trend demonstrates that most forestry expertise has been devolved to central offices and agencies (i.e. within Forestry Commission Scotland and/or land agents). “There are 17 keepers, 1 gillie.....1 forester......there used to be 11 and we used to do everything in house now it's down to me, all I basically do is contract manage. It's now cheaper to contract than employ, which has left little forestry expertise on estates” (Invercauld). Figure 8.9 shows recently abandoned facilities on one of the Cairngorms estates that was once the site of extensive in-house forestry management and processing operations managed by a team of on-site foresters.
The keepers at both Kingie estate in Lochaber and Achentoul estate in East Sutherland noted that their woodland planning was entirely devolved to Scottish Woodlands and felt that their approach lacked thorough or valuable consultation with the estate manager. “They never consult with us and keep offering us options that we don’t want, plus there is never any management after the planting” (Achentoul). From their point of view this constituted a lack of foresight, inclusion, local knowledge or collaborative planning as well as after care to help manage the woodlands beyond establishment. “There is no forestry expertise on the estate, there is a forestry plan but nothing gets done as the professionals are remote and don’t get too involved with the estate” (Inverinate). This emphasises a common trend found across the case study areas wherein woodland continually loses value due to the absence of management intervention and collaborative action from the planning stage through multiple-aged rotations. Dandy (2016) observes that managers often lack a specific knowledge about woodland and the potential they possess for the land resulting in neglect. This is supported by the link to absenteeism, ownership change and a general
distance from the forest culture that over time can deeply embed a regionally specific knowledge deficit in the forestry sector (Nijnik & Mather, 2008; Dandy, 2016).

**Obstacle 7 – Boundary trade-offs and overlapping policies**

Land for sporting uses and grazing is the central driver for estate management (Higgins, et al., 2002; Davies & White, 2012). Land managers are concerned that woodland expansion will take valuable land away from deer and sheep grazing, and be detrimental to the profitability of the estate. “I could plant native woodland but there would be no money and all that does is take-up space that could be used for deer and sheep…. Yeah I mean I planted a birch and scots pine wood about five years ago…it had significant effect on deer movement.” (Borrobol). Furthermore many managers view woodland expansion policy as an aggressive strategy to control deer numbers (MacMillan & Leitch, 2008), “[Woodland expansion strategy] I think a lot of pressure and damage to deer numbers has stemmed from the 25% target…and standing in the way are 2 things, sheep and deer.” (Kingie).

![Grouse moors dominate the Cairngorm landscape, creating boundaries through habitat management and multiple sporting syndicates](image)

Grouse moors are a significant land use in the Cairngorm case study area, and sporting leases form smaller areas of management for recreational sporting use, which reduces the ability of the estate to implement short to medium-term plans due to increasing boundary formation (*Figure 8.10 shows a Grouse moor in the Cairngorms*) (McMorran, et al., 2014;
Wightman, 2015). “Forestry is expanding into potential grouse zones, there’s always quite heated dialogue as everyone’s always fighting for their own little piece land and way of doing things.” (Invercauld). The combination of multiple restrictions including deer stalking, grouse management and high altitudes increases land use pressure and competition of land (decreases woodland planting opportunities). In the case of Invercauld estate, “Over ninety percent of land is under some sort of conservation or heritage designation”. Land managers in East Sutherland are reluctant to consider woodland planting as peatland and bird habitats are conservation priorities (Peatland Partnership, 2016). “The RSPB are very sensitive about woodland taking land away from wetlands and bird habitats, we have to be careful due to peatlands too” (Borrobol).

The largest restriction upon woodland expansion is deer activity, as land managers are resistant to changing land cover due to the unpredictable effects upon deer populations, which supports stalking activities and the estate’s main profit centre (MacMillan, et al., 2010). Consequently land suitable for woodland expansion for diverse species establishment and use is maintained for deer grazing and feeding sites. The deer predictably visit these areas of the estate regularly (Figure 8.11 shows a young stag on an
improved pasture used for feeding, ideal for woodland). “We wouldn’t want to plant up too much it would interfere with the deer’s wintering grounds and change their movement, any land planted up will automatically be taken away from deer for at least twenty years” (Attadale).

8.3 Outlining potential woodland expansion
This section presents areas of new woodland that land managers are willing to plant on their estate. The areas and species of woodland planting are broken down by case study area, which formulates an overview of the potential woodland cover scenario to the Highlands and Scotland.

8.3.1 Potential impact of estate woodland planning
This section presents the results from the estate woodland planning exercise carried out for each estate in the case study areas. These areas represent opportunity for woodland expansion, planned to minimize conflict with other land management practices, improve the landscape aesthetic and create a platform for productive woodland objectives. In sections 8.3.3 - 8.3.6, planned woodland areas are displayed as maps and tables, including species and area composition for each case study area. The following section provides an overview of the land cover change (hectares and percentages) over the case study areas and their significance for Highland and national coverage, as well as national expansion targets.

Box 8.1 and 8.2 compares the land cover of the case study areas with the Highland region, and presents the cumulative estate woodland plantings over the case study areas and the subsequent woodland expansion.
Box 8.1 – Land cover of case study areas

<table>
<thead>
<tr>
<th>Geographical area</th>
<th>Total area of estates in case studies</th>
<th>Percentage of total Highland area</th>
</tr>
</thead>
<tbody>
<tr>
<td>4,050,000 hectares (including Deeside)</td>
<td>192,376.58 hectares</td>
<td>(4.75%)</td>
</tr>
</tbody>
</table>

- **Wester Ross**: 43,162.31 hectares
- **Lochaber**: 38,943.52 hectares
- **Cairngorms**: 76,091.45 hectares (17% of CNPA)
- **East Sutherland**: 34,179.46 hectares

Box 8.2 – Woodland expansion over case study areas

<table>
<thead>
<tr>
<th>New planting area</th>
<th>Woodland expansion area</th>
<th>Percentage of current Scottish woodland</th>
</tr>
</thead>
<tbody>
<tr>
<td>7,421.01 hectares</td>
<td>6,935 hectares</td>
<td>0.52%</td>
</tr>
</tbody>
</table>

- **Conifer**: 1,631.48 – 22%
- **Broadleaf**: 1,153.67 – 15.5%
- **Mixed**: 4,635.86 – 62.5%
- **Restructured from current woodland**: 486.77 (6.5% of planting)

**Box 8.3** shows the potential woodland expansion over the Highlands and Scotland, if private estates increased their woodland cover by an average of 3.6%, the same as the estates over the case study areas.


**Box 8.3 – Woodland expansion and land cover change**

<table>
<thead>
<tr>
<th>Relative/potential woodland expansion area and woodland cover change</th>
</tr>
</thead>
<tbody>
<tr>
<td>- 1,741,500 hectares of private sporting estates in the Highlands (43% of Highland area)</td>
</tr>
<tr>
<td>- 62,694 hectares of potential woodland expansion area in the Highlands (on the assumption of 3.6% average expansion on private sporting estates)</td>
</tr>
<tr>
<td>- 17.9% increase of woodland cover in the Highlands</td>
</tr>
<tr>
<td>- 4.7% increase of national coverage (Increase to 21.7% cover in Scotland)</td>
</tr>
<tr>
<td>- 119,350.8 hectares potential woodland increase (3.6%) in Scotland (Taking 43% as a figure for ownership of estates 4,000 ha and above for Scotland, 30% is held by 103 with 9,000 ha+, and 50% held by 343 owners (Warren, 2009)).</td>
</tr>
<tr>
<td>- 8.9% increase in national coverage (raising woodland cover in Scotland beyond the 25% target to 26.9%)</td>
</tr>
</tbody>
</table>

*Box 8.3* demonstrates the important role private estates could play in the Scottish woodland expansion strategy, as careful identification of practical woodland expansion areas that are compatible with individual estate aims could contribute significantly to the 25% woodland cover target.

**8.3.2 Woodland expansion on estate clusters**

This section shows the newly planned woodland for each case study area. Each case study area includes a Table of area and species composition, as well as a map showing the woodland cover. These areas were revisited during the land manager feedback and discussion sessions (Chapter 6.2.6) after the production of the land use reports. Questions were posed to the land managers about the practicality of their original choices and whether they would keep to the same planting areas or species mix. The majority of land managers reconsidered and reduced the coverage of planting areas often referring to
incompatibility of site or interference with current management objectives. Joint planning woodland estate areas effectively identifies land suitable for planting, which does not interfere with main management activities. However, revisiting the planned areas and viewing them from multiple-perspective, over the landscape (spatial) and in following sessions (temporal) is a vital process, as land managers often modify their choices concerning location, size and species selection (CBD EA Principles: 3, 5, 7 and 8. See following section 8.3.3-8.3.6). Detailed soil maps of each estate could have improved the species selection process, as well as increasing land manager confidence by linking soil types to a range of species options (Chapter 2.8 see (Brown, et al., 2012; Brown & Castellazzi, 2014)). Using this as a starting point may increase their overall confidence in decision-making and scientifically connect personal knowledge of woodland planting to specific estate areas. Additionally, land manager experiences and insights into planting, woodland management and local conditions should be incorporated into future estate plans to encourage collaborative actions (Chapter 9), further investment and legitimacy from the view of the land manager (CBD EA Principle 11 – incorporating local knowledge and science (UNEP, 2000)).

8.3.3 Wester Ross

Proposed woodland expansion

*Figure 8.12* (A3 maps available in Appendix H) shows woodland expansion areas, which were identified as areas of unproductive land, close to internal and external infrastructure for ease of harvesting and extraction, and unhealthy woodland in need of restructure (Inverinate old Forestry Commission blocks). Land managers frequently stated that land would be considered, if it did not interfere with deer management (Corries for wintering, feeding areas, and known migratory routes). Rivers and small lochans were popular sites for planting small lines of broadleaf species. Additionally, a current plan for a new bypass through Attadale estate increased the opportunity for woodland access and management activities.
Species planting and selection trends (See chapter 5.2.4 for species choice and rationale)

Land managers demonstrated a preference for planting small areas of broadleaves (sycamore, aspen) along lochans and rivers. Larger areas of conifers were dominated by Scot pine mixes, Douglas fir and Sitka spruce, which were considered as the best species for productive woodlands by the land managers (Table 8.1). Increased diversification of species composition was seen as desirable but most managers were sceptical of the suitability of most broadleaf species. Restructuring unhealthy Sitka spruce and lodgepole pine areas was viewed as a priority but difficult to realise due to the operational difficulties and low timber value. Land managers always showed preference for native species over all non-native options, despite the potential productive capacity of Sitka
spruce and Douglas fir. For the most part land managers followed the advice of their land agents and deferred to their professional expertise on planting matters.

Table 8.1 – Wester Ross species break-down

<table>
<thead>
<tr>
<th>Species</th>
<th>Area (Ha)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scots pine</td>
<td>65.73</td>
<td>4.3</td>
</tr>
<tr>
<td>Birch</td>
<td>123.15</td>
<td>8.1</td>
</tr>
<tr>
<td>Poplar</td>
<td>7.82</td>
<td>0.5</td>
</tr>
<tr>
<td>Sycamore</td>
<td>133.8</td>
<td>8.8</td>
</tr>
<tr>
<td>Hybrid aspen</td>
<td>91.46</td>
<td>6.0</td>
</tr>
<tr>
<td>Hybrid larch</td>
<td>92.58</td>
<td>6.1</td>
</tr>
<tr>
<td>Douglas fir</td>
<td>131.4</td>
<td>8.6</td>
</tr>
<tr>
<td>Sitka spruce</td>
<td>102.52</td>
<td>6.7</td>
</tr>
<tr>
<td>Scots pine/Birch</td>
<td>576.87</td>
<td>37.9</td>
</tr>
<tr>
<td>Scots pine/Hybrid aspen</td>
<td>165.46</td>
<td>10.9</td>
</tr>
<tr>
<td>Scots pine/Poplar</td>
<td>10.44</td>
<td>0.7</td>
</tr>
<tr>
<td>Poplar/Sycamore</td>
<td>165.87</td>
<td>14.3</td>
</tr>
<tr>
<td>Hybrid aspen/Sycamore</td>
<td>12.19</td>
<td>0.8</td>
</tr>
<tr>
<td>Birch/poplar</td>
<td>9.03</td>
<td>0.6</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1,522.45</strong></td>
<td><strong>100</strong></td>
</tr>
<tr>
<td><strong>Restructured</strong></td>
<td><strong>109.12</strong></td>
<td><strong>7.2</strong></td>
</tr>
</tbody>
</table>

**Practical planting areas**

Large areas of Scots pine/Birch expansion covering high altitudes (above 400 metres) was reconsidered by the Glencarron land manager (*Figure 8.12*), as the area was viewed as inappropriate for the estate landscape and an obstacle for deer stalking activities. Two long areas of Birch and Scots pine/Hybrid aspen on the southern boundary of Attadale estate (*Figure 8.12*) would be split into smaller areas to ease access and movement for deer over the estate.

**8.3.4 Lochaber woodland expansion**

**Proposed woodland expansion**
Figure 8.13 shows that proposed woodland expansion would be driven by connecting current areas of woodland, especially alongside Loch Arkaig (middle of Achnacarry) with fenced rides alongside the stands to aid deer access and movement around the estates. Also common grazing was seen as very promising for woodland, taking advantage of the ‘Woodlands In and Around Towns’ (WIAT) grants due to the proximity of rural population centres. Restructuring of Sitka spruce and lodgepole pine stands (Kingie) was a desired aim, however access made this difficult. Land that surrounded current harvesting operations on Glen Dessary was viewed as potentially promising, as was establishing additional phases of planting to extend the woodland cover, thus creating a multiple-aged woodland structure (See Appendix H for Glen Dessary restocking map). Upgraded roads that enable current and ongoing operations provide further support to the case for increased woodland establishment in the future.

Figure 8.13 – Lochaber new planting areas
**Species planting and selection strategy**

Native woodland (Scots pine mixes) dominated expansion (50% - *Table 8.2*) on the estates. Poplar was chosen to complement riparian and loch areas (21.2%). A few areas of Sitka spruce and Douglas fir were planned for potential production (around 20% explicitly productive land); these recommendations were the result of consultation with the estate’s land agent.

*Table 8.2 – Lochaber species break-down*

<table>
<thead>
<tr>
<th>Species</th>
<th>Area (Ha)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scots pine</td>
<td>365.5</td>
<td>17.2</td>
</tr>
<tr>
<td>Poplar</td>
<td>450.84</td>
<td>21.2</td>
</tr>
<tr>
<td>Sycamore</td>
<td>63.02</td>
<td>3</td>
</tr>
<tr>
<td>Douglas fir</td>
<td>193.04</td>
<td>9.1</td>
</tr>
<tr>
<td>Scots pine/Birch</td>
<td>302.79</td>
<td>14.3</td>
</tr>
<tr>
<td>Scots pine/Douglas fir</td>
<td>448.45</td>
<td>21.1</td>
</tr>
<tr>
<td>Poplar/Sycamore</td>
<td>16.09</td>
<td>0.8</td>
</tr>
<tr>
<td>Birch/poplar</td>
<td>100.17</td>
<td>4.7</td>
</tr>
<tr>
<td>Sitka spruce/Scots pine/Douglas fir</td>
<td>183.94</td>
<td>8.7</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>2,124.24</strong></td>
<td><strong>100</strong></td>
</tr>
<tr>
<td><strong>Restructured</strong></td>
<td><strong>188.37</strong></td>
<td><strong>8.9</strong></td>
</tr>
</tbody>
</table>

**Practical planting areas**

The common grazing land under crofting agreements was the only area of planned woodland planting that was reconsidered due to the difficulty of securing cooperation from multiple crofters. (*Figure 8.13*, five stands planned at the south-eastern area of Achnacarry).

### 8.3.5 Cairngorms (Deeside) woodland expansion

**Proposed woodland expansion**
Figure 8.14 Shows that the Cairngorms has a larger proportion of woodland than the other case study areas, which run through both Invercauld and Balmoral, close to estate borders running alongside main roads (one of the expansion drivers). Other drivers included planting alongside rivers to stabilise banks and regulate temperate and food sources for the fish (seen on all three estates). Former livestock grazing areas were viewed as a possibility, as long as other grazing animals were not rotated into the area or the land was not converted to grouse moor. Grouse moorland was out of bounds for woodland expansion (See Appendix H for Invermark Grouse management map), which ruled out significant areas on Invermark and Invercauld estates. Natural corridors for woodland expansion developed from the current resource, which was planted at lower altitudes, close to roads (below 550 metres, seen on Invercauld and Balmoral estate). Other areas of native woodland (Scots pine mixes) were created to enhance amenity and shelterbelt areas.

Figure 8.14 – Cairngorms new planting areas
Species planting and selection strategy

Expansion of the current Scots pine forests (Caledonian pinewoods) (65% monoculture and mixes, Table 8.3) dominated species selection. Again poplar was planted along riparian areas and in close proximity to rural populations for potential woodfuel market (20% monoculture and mixes). Douglas fir was planted as a productive conifer forest and to cultivate areas of visually impressive long-term growth (20% monocultures and mixes).

Table 8.3 – Cairngorms species break-down

<table>
<thead>
<tr>
<th>Species</th>
<th>Area (Ha)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scots pine</td>
<td>158.75</td>
<td>6</td>
</tr>
<tr>
<td>Poplar</td>
<td>110.52</td>
<td>4.2</td>
</tr>
<tr>
<td>Sycamore</td>
<td>15.91</td>
<td>0.6</td>
</tr>
<tr>
<td>Douglas fir</td>
<td>282.6</td>
<td>10.7</td>
</tr>
<tr>
<td>Scots pine/Birch</td>
<td>894.43</td>
<td>34</td>
</tr>
<tr>
<td>Scots pine/Douglas fir</td>
<td>441.42</td>
<td>16.8</td>
</tr>
<tr>
<td>Scots pine/Poplar</td>
<td>212.32</td>
<td>8.1</td>
</tr>
<tr>
<td>Scots pine/Birch/Poplar</td>
<td>199.92</td>
<td>7.6</td>
</tr>
<tr>
<td>Poplar/Sycamore</td>
<td>77.73</td>
<td>3</td>
</tr>
<tr>
<td>Birch/Poplar</td>
<td>240.62</td>
<td>9.1</td>
</tr>
<tr>
<td>Sitka spruce/Scots pine/Douglas fir</td>
<td>183.94</td>
<td>8.7</td>
</tr>
<tr>
<td>Total</td>
<td>2,634.22</td>
<td>100</td>
</tr>
</tbody>
</table>

| Restructured             | 0         | 0          |

Practical planting areas

A few proposed planting areas on grazing sites (in transition) were reconsidered as the land manager favoured to maintain the area for potential livestock or ponies (Figure 8.14 Balmoral northern most end of estate). Areas that proposed woodland planting on areas that had over 0.5 metre of peat depth, which extended out from current woodland
(western Balmoral) were reconsidered due to the potential conservation restrictions. Another consideration for all land managers was the impact of increased woodland cover on grouse moors, which are important to the regions landscape character and tradition.

8.3.6 East Sutherland woodland expansion

Proposed woodland expansion

*Figure 8.15* shows the woodland expansion areas for East Sutherland. As in other case study areas, the planting of broadleaf species around riparian areas was favoured by land managers, as an increase of broadleaf woodland was desired for edge areas surrounding the farms. The woodland resource on all estates has been damaged due to substantial windthrow, so extensive restructuring of plantation areas was deemed necessary by the land managers, so some benefit could be taken from the woodland. In the north of Badanloch estate neighbouring woodlands timber is contracted to a biomass plant in Wick, which could increase the opportunity for Badanloch to grow productive and potential profitable woodland, the land manager recognises that the supply chain already exists that could benefit the estate. Achentoul has a stand of woodland close to the main road that could be suitable for harvesting and restructuring. East Sutherland possessed a few substantial areas of improved pastures that were vacant and ideal for broadleaf planting but the land manager prefers to limit conversion of agricultural land. However, all land managers are aware of peatland conservation status and continue to be resistant to planting woodland due to the natural heritage designations. A few stands of productive broadleaves for woodfuel were planned close to the rail line where Achentoul and Borrobol converge.
Species planting and selection strategy
Native species such as Scots pine were favoured by most land managers (45% Table 8.4). Restructured Lodgepole pine stands were replaced by Scots pine and Douglas fir for a productive species with increased landscape aesthetic. Poplar and Sycamore were planned around riparian areas and roads for easy access to productive woodland (woodfuel), other areas of broadleaves were placed in improved pasture and grassland (14%). Douglas fir was planted as the main productive species (20%), as both Sitka spruce and Lodgepole pine were considered ineffective and troublesome as larger productive areas.
Practical planting areas

One land manager (Borrobol) was sceptical of Douglas fir suitability for the area and the impact it would have on the landscape and thought it would be better to plant Sitka spruce for production purposes. Through several follow-up discussions with the researcher (providing only options and not guiding the manager’s decision-making) the land manager decided upon a different strategy and species mix. These changes replaced the Douglas fir and Sycamore areas with stands of mixed native broadleaves (Rowan, Birch, scrubby willows), interspersed with Scots pine or Sitka for productive purposes.

Alder was considered to be an option along with or in place of poplar planting areas. The land manager from Borrobol also noted that the soil and tree vigour of his lodgepole pine Christmas tree plantation improved with every rotation. Other suggestions included better soil mapping and species matching for the estates as well as drainage to improve planting applicability, however this was acknowledged as contravening the Water
Framework Directive (EU WFD, 2002). The Badanloch manager was concerned that increased planting would compromise the wild rolling landscape valued by the owners.

8.4 Forest energy compatibility & economics

This section evaluates the potential of forest energy markets for individual estates and regional case studies to analyse the capacity of micro-regional clusters to form localized market structures. Table 6.4 (Chapter 6.2.5) showed the criteria for short rotation forestry and productive compatibility level along with the woodland type suited for those areas (Data presented in Table 8.5). This broke down into five categories ranging from ‘Compatible’ to ‘Very incompatible’, which were defined through discussion with the land managers taking into account environment, structural (topographical), economic and cultural factors and values. After this the land manager identified the areas, which corresponded in their opinion to these categories and then the researcher applied these defined areas to each estate through manual mapping in Arcmap (Case study maps of productive woodland compatibility can be found in Appendix H).

As Table 8.5 indicates there was an average of 8% of compatible land for woodland across the case studies, which could support short rotation forestry and longer rotation productive woodland. However, land managers required a certain amount of economic security and increased investment confidence before they planted more woodland.

Table 8.5 – Break-down of short rotation forestry compatible land for the four case study areas

<table>
<thead>
<tr>
<th></th>
<th>Compatible</th>
<th>Compatible but with constraints</th>
<th>Moderately compatible</th>
<th>Incompatible</th>
<th>Very incompatible</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Attadale</td>
<td>644</td>
<td>1,675</td>
<td>1,675</td>
<td>3,607</td>
<td>5,281</td>
</tr>
<tr>
<td>2) Inverinate</td>
<td>939</td>
<td>1,002</td>
<td>5,896</td>
<td>2,779</td>
<td>15,016</td>
</tr>
<tr>
<td>3) Glencarron</td>
<td>122</td>
<td>481</td>
<td>776</td>
<td>946</td>
<td>2,325</td>
</tr>
<tr>
<td><strong>Wester Ross</strong></td>
<td><strong>1,706</strong></td>
<td><strong>3,157</strong></td>
<td><strong>8,346</strong></td>
<td><strong>7,332</strong></td>
<td><strong>22,622</strong></td>
</tr>
<tr>
<td><strong>Percentage</strong></td>
<td><strong>4%</strong></td>
<td><strong>7%</strong></td>
<td><strong>19%</strong></td>
<td><strong>17%</strong></td>
<td><strong>52%</strong></td>
</tr>
<tr>
<td>1) Kingie</td>
<td>706</td>
<td>338</td>
<td>1,010</td>
<td>1,628</td>
<td>2,806</td>
</tr>
<tr>
<td>2) Glen Dessary</td>
<td>624</td>
<td>1,406</td>
<td>579</td>
<td>1,617</td>
<td>2,808</td>
</tr>
<tr>
<td>3) Achnacarry</td>
<td>3,406</td>
<td>2,094</td>
<td>2,622</td>
<td>5,273</td>
<td>12,025</td>
</tr>
<tr>
<td><strong>Lochaber</strong></td>
<td><strong>4,737</strong></td>
<td><strong>3,839</strong></td>
<td><strong>4,211</strong></td>
<td><strong>8,517</strong></td>
<td><strong>17,640</strong></td>
</tr>
<tr>
<td>Percentage</td>
<td>12%</td>
<td>10%</td>
<td>11%</td>
<td>22%</td>
<td>45%</td>
</tr>
<tr>
<td>------------</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>1) Invermark</td>
<td>850</td>
<td>2,862</td>
<td>1,867</td>
<td>2,658</td>
<td>11,001</td>
</tr>
<tr>
<td>2) Invercauld</td>
<td>1,740</td>
<td>5,259</td>
<td>9,782</td>
<td>7,715</td>
<td>16,037</td>
</tr>
<tr>
<td>3) Balmoral</td>
<td>1,296</td>
<td>2,732</td>
<td>2,173</td>
<td>2,597</td>
<td>7,524</td>
</tr>
<tr>
<td>Cairngorms</td>
<td>3,886</td>
<td>10,852</td>
<td>13,821</td>
<td>12,970</td>
<td>34,562</td>
</tr>
<tr>
<td>Percentage</td>
<td>5%</td>
<td>14%</td>
<td>18%</td>
<td>17%</td>
<td>45%</td>
</tr>
<tr>
<td>1) Badanloch</td>
<td>2,617</td>
<td>1,401</td>
<td>3,130</td>
<td>3,483</td>
<td>3,736</td>
</tr>
<tr>
<td>2) Borrobol</td>
<td>645</td>
<td>1,107</td>
<td>1,352</td>
<td>2,097</td>
<td>4,198</td>
</tr>
<tr>
<td>3) Achentoul</td>
<td>845</td>
<td>1,779</td>
<td>2,007</td>
<td>2,230</td>
<td>3,552</td>
</tr>
<tr>
<td>East Sutherland</td>
<td>4,106</td>
<td>4,287</td>
<td>6,489</td>
<td>7,810</td>
<td>11,487</td>
</tr>
<tr>
<td>Percentage</td>
<td>12%</td>
<td>13%</td>
<td>19%</td>
<td>23%</td>
<td>34%</td>
</tr>
<tr>
<td>Total</td>
<td>14,435</td>
<td>22,135</td>
<td>32,868</td>
<td>36,629</td>
<td>86,310</td>
</tr>
<tr>
<td>Percentage</td>
<td>8%</td>
<td>12%</td>
<td>17%</td>
<td>19%</td>
<td>45%</td>
</tr>
</tbody>
</table>

‘Compatible but with constraints’ and ‘Moderately compatible’ classifications have the potential to release a further 29% of land (across the case studies) mainly for amenity woodland, although some productive woodland would fall under this category. In the ‘Compatible but with constraints’ classification there were large areas of woodland that should have been harvested and restructured, as well as agricultural grazing land, improved grasslands and deer feeding sites.

Based upon the case study areas the Highlands has a 36% upper limit of woodland expansion, which currently stands at 18%. Reaching the 30% mark would put the highlands on the same level as countries such as France and Germany, which possess significantly larger forestry sectors and markets than the UK (37% - Average EU forest cover) (Bunce, et al., 2014). The Scottish Natural Heritage native woodland model suggests that 50% of land in Scotland could support woodland but only 4% is covered by semi-natural woodland (SNH, 2014). Overall the combined ‘Compatible-Moderately compatible’ classifications range from 30 - 44% and on average 36% of the land is suitable for a range of woodland types.
### 8.4.1 Economics and outputs of the Forest energy Tool (Testing commercial viability)

*Table 8.6* shows the value of potential woodland expansion through the potential forest energy (biomass) market. The figures are based upon current markets, sector costs and woodfuel prices. However, this represents the ideal scenario for estates serving a local market, processing in-house and selling the timber from a local hub at £70+/m$^3$ for forest energy timber. Local market demand exists but the Highland forestry sector, especially private estates, require greater infrastructure, continual management expertise and the confidence to be involved during the development of an emerging market, which could result in the scenario represented in *Table 8.6*. This scenario could be realised in the next forty years, however a change in perception, capital investment (the calculating of the costs were outside the remit of this study) and support mechanisms need to occur.

*Table 8.6* – Short rotation forestry energy production and market value for estate (20-25 year rotations)

<table>
<thead>
<tr>
<th>Estate</th>
<th>Thinned (%)</th>
<th>Area (ha)</th>
<th>Timber volume (m$^3$)</th>
<th>Calorific value (Mwh)</th>
<th>Market value (£)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Attadale</td>
<td>30</td>
<td>188</td>
<td>24,925</td>
<td>36,744</td>
<td>1,865,020</td>
</tr>
<tr>
<td>2) Inverinate</td>
<td>36</td>
<td>144</td>
<td>19,103</td>
<td>27,398</td>
<td>1,785,411</td>
</tr>
<tr>
<td>3) Glencarron</td>
<td>47</td>
<td>235</td>
<td>20,450</td>
<td>27,915</td>
<td>1,779,019</td>
</tr>
<tr>
<td><strong>Wester Ross</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4) Kingie</td>
<td>33</td>
<td>96</td>
<td>12,687</td>
<td>16,974</td>
<td>887,795</td>
</tr>
<tr>
<td>5) Glen Dessary</td>
<td>31</td>
<td>82</td>
<td>11,526</td>
<td>15,684</td>
<td>1,086,148</td>
</tr>
<tr>
<td>6) Achnacarry</td>
<td>31</td>
<td>481</td>
<td>72,029</td>
<td>114,343</td>
<td>4,321,734</td>
</tr>
<tr>
<td><strong>Lochaber</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7) Invermark</td>
<td>37</td>
<td>195</td>
<td>26,433</td>
<td>34,804</td>
<td>1,333,306</td>
</tr>
<tr>
<td>8) Invercauld</td>
<td>22</td>
<td>317</td>
<td>26,197</td>
<td>35,827</td>
<td>2,977,820</td>
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<tr>
<td>9) Balmoral</td>
<td>33</td>
<td>227</td>
<td>20,627</td>
<td>30,980</td>
<td>2,127,588</td>
</tr>
<tr>
<td><strong>Cairngorms</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10) Badanloch</td>
<td>31</td>
<td>163</td>
<td>18,689</td>
<td>28,524</td>
<td>1,711,902</td>
</tr>
<tr>
<td>11) Borrobol</td>
<td>33</td>
<td>95</td>
<td>12,785</td>
<td>18,631</td>
<td>1,002,909</td>
</tr>
<tr>
<td>12) Achentoul</td>
<td>30</td>
<td>107</td>
<td>13,738</td>
<td>19,629</td>
<td>1,432,698</td>
</tr>
<tr>
<td><strong>East Sutherland</strong></td>
<td>32</td>
<td>365</td>
<td>45,211</td>
<td>66,785</td>
<td>4,147,509</td>
</tr>
</tbody>
</table>
If estates sold the timber (standing or harvested) to third parties the price per m³ would be significantly less. According to numerous land managers, improved management and production of better quality timber would push the resource away from the biomass market in the current climate. “Our roundwood this year will be selling to Norbord. Whereas we’ve talked to a local company that is a brand leader up here in wood energy heating systems and they’re not matching prices... I can’t give you exact details but it’s a fraction of the price, not at all relevant for market competition...looking for the lowest value wood lying around” (Glen Dessary). Röser et al., (2011) propose that Roundwood could be a viable source for a woodfuel market in the north of Scotland due to the uncompetitive nature of the market. In the same study figures of €22-30+/MWh were presented as achievable profits for the woodfuel producer, which is more in comparison with Finland, as they use smaller diameter trees. However they also note the difficulty of introducing forest energy business models into countries with weak timber harvesting and usage traditions and that supply chains should be tailored to local conditions.

Even if the estates timber volume was reduced by 35% to account for varying yield classes and the market price was halved it would still produce a combined profit of £7,251,188, unevenly spread over the case study areas. For many land managers even the lower figure would appear overly optimistic, believing that profit in short rotation forestry is unlikely and if there is potential, “why aren’t we doing it?” Below comparative energy costs and potential land manager profit (based on the Forest Energy Tool outputs in Table 8.6) are presented.

**Energy costs** (Ireland, et al., 2006) ²

<table>
<thead>
<tr>
<th>Total</th>
<th>33</th>
<th>2,327</th>
<th>279,189</th>
<th>40,7453</th>
<th>22,311,350</th>
</tr>
</thead>
</table>

---

² Energy cost comparison table used in report in conjunction with current prices per unit. Oil: £0.40/litre; Coal: £284/tonne; Gas £1.21/therm; Woodfuel (HW): £75/m³; Woodfuel (SW): £69/m³.
• Oil: £17/GJ
• Coal: £17/GJ
• Gas: £19.6/GJ
• Woodfuel (Hardwood): £12/GJ
• Woodfuel (Softwood): £13/GJ

Landowner profit

• Optimum forest energy estimate (£72/m$^3$): £14.4/GJ
• Reduced yield forest energy estimate: £9.36/GJ
• Conservative forest energy estimate (reduced yield & £36/m$^3$): £7.4/GJ

Since 1990 timber prices have declined, which has produced a downturn in the forest production sector; softwood prices have declined by approximately 30% £66/ha at 2011 prices and hardwoods prices have declined by over 90% in some case £7-25/ha at 2011 prices (Edwards, et al., 2009). This is due to a combination of factors including a shift away from timber production towards more conservation and ecosystem services based management, low import prices and less suitable products to meet market demands (Edwards, et al., 2009). Additionally, the role of deer stalking not only marginalizes forest management but also significantly harms the current growing woodland stock. White et al., (2004) provides an estimate of deer impact upon woodlands and suggests annual impact of deer browsing of approximately £60/ha, which leads to part of the harvest downgrading from green logs to pulpwood. Although hardwoods are less prone to browsing damage suggesting that an increase in broadleaf species production might prove a more resilience strategy for the Highlands (White, et al., 2004; Cavers & Cortrell, 2015).

This demonstrates that deer stalking culture is detrimental to the development of forestry in three respects the tradition and drive of sporting estates, suppression of natural regeneration and browsing upon timber stocks. In 2009 a Forestry Commission estate
spent £7/ha (before revenue) by combining deer culling and venison production, which is substantially offset by the potential loss (Edwards, et al., 2009). In the same report deer stalking and venison production are valued at £3 and 2/ha, and net carbon sequestration of woodland as £239/ha. This clearly demonstrates the value for money stalking has compared to the amount of land set aside for its use, as well as non-timber benefits and potential markets of woodland. Woodfuel market is viewed by many as a legitimate way to stimulate the production forestry and expand markets (CEBR, 2010; Roser, et al., 2011).

Forest energy is both a source of cheaper energy for estates and for potential profit centres (See above for comparative energy costs); these combined factors would significantly reduce their cumulative carbon footprint. According to the Glen Dessary land manager £40/tonne profit would be the point at which productive forestry would become a worthwhile profit centre to invest in sustained rotations. This translates to £55/m³, which is lower than the optimum forest energy estimate but higher than the conservative forest energy estimate, discounting capital costs and infrastructure upgrades.

8.5 Woodland landscapes – suitability and connectivity

This section presents the results from the multi-criteria spatial analysis that determined multifunctional woodland corridors in the landscape:

1) Forest energy (SRF)
2) Commercial (Longer rotation)
3) Amenity (conifer broadleaf native mixture dependent upon location)
4) Montane scrub (Dwarf species including juniper and wych elm)

Areas were defined through the productive woodland compatibility analysis performed jointly with the land managers (Chapter 6.2.5, Table 6.4).
8.5.1 Wester Ross woodland corridors

*Figure 8.16* shows the potential woodland use over the case study landscape. Only 2% (*Figure 8.17*) of the land is viable for SRF, which is mostly situated on Attadale with some peripheral areas on the other estates.

![Wester Ross woodland landscape corridors](image)

*Figure 8.16* – Wester Ross woodland landscape corridors

However, another 13% of the area is available for longer rotation productive woodland, including mixed broadleaf/conifer stands that could be Silva-pastoral systems. The majority of land was suitable for amenity woodland (32%) and at higher elevations montane scrub (46%).
The montane and amenity areas cover significant parts of the estate important for deer habitat, whereas the SRF and commercial areas (15% - Table 8.17) occupy former livestock land and areas close to good infrastructure, which includes widely visible landscape areas. Combining the three main (SRF, Commercial and Amenity) corridors types would give Wester Ross 47% potential woodland cover.

8.5.2 Lochaber woodland corridors

Lochaber has potential for woodland corridors that could connect all three estates. Figure 8.18 shows that Glen Dessary and Achnacarry have the strongest potential links following the B8004 and internal forest roads along Loch Arkaig, which would connect with current woodland. Corridors of productive woodland could run for several kilometres through connecting glens creating a continuous cover of sustainable timber production in the area. SRF shows greatest potential on the crofting ground, close to water, rail and road links as well as urban areas at the south-eastern tip of Achnacarry. The remaining commercial woodland fans out from the SRF sites and would create greater links between current woodland, providing a more sustainable base from which to work.
Table 8.19 shows that 23% of the estate cluster is viable for productive woodland and higher elevations are dominated by montane scrub woodland suitability (44%). Lochaber has the greatest potential for woodland cover increase of all the case study areas and could, combined with the amenity corridors hold 51% woodland cover.
8.5.3 Cairngorms woodland corridors

The Cairngorms case study area (Figure 8.20) has the greatest potential for woodland corridors in regard to connectivity and area but less overall percentage woodland cover than Lochaber. Connectivity between Invercauld and Balmoral is high due to a main road (A93), pre-existing woodland and potentially convertible grazing land. However, potential corridors for amenity woodland expand into Grouse moors on Invercauld and Invermark. This could be managed through careful planning of smaller woodland incorporated into land between the edges of current grouse management areas (See Appendix H for Invermark Grouse management map). This would cause minimal disruption to the burning cycles or integrity of the grouse habitat. Productive woodlands could cover 15% of the area, only 4% viable for SRF (Figure 8.21). These areas have good infrastructure, which could be used in productive forestry operations to meet the high demand for woodfuel in the area (Invercauld Forestry manager).
Figure 8.20 – Cairngorms woodland landscape corridors

Figure 8.20 demonstrates the isolation and low potential for connectivity between Invermark from the other two estates, as shown by the large area of montane woodland and open land suitability (50% of the region). Invermark estate would have the advantage of clustered woodland resources close to access points, but smaller roads would restrict the amount of timber transported, therefore costs might be higher. New woodland would need to be integrated with the objectives and rotations of pre-existing woodland (Scots pine, Larch and Douglas fir) despite the current absence of thinning in the area for a significant proportion of potentially productive woodland. The Cairngorms estate cluster could support 46% woodland cover (Table 8.21).
8.5.4 East Sutherland woodland corridor

This region (Figure 8.22) has the highest potential for SRF (9% - See Figure 8.23) out of the four case study areas. Stronger corridor links exist due to a combination of factors including the railway line running along two estate borders, easier access (low slope gradients and low elevations), and areas of improved pasture and recently harvested woodland suitable for planting. Some areas of SRF land on the north-west part of Badanloch have potential, as woodland on the neighbouring estate is contracted for woodfuel supply by Balcas. The extent of other productive woodland is also significant (28%) and amenity woodland could cover 50% of the estate cluster. However, the peatland conservation and restoration priorities would most likely limit the expansion of SRF and productive corridors (See Appendix H for maps including peat depth restrictions).
The remainder of the land would be maintained for deer stalking, as well as preserving the wild rolling landscape valued by the land managers (Chapter 7.4.5). Considering these factors East Sutherland could possess an upper range of 39% woodland cover (Table 8.23).
8.6 Woodland expansion trends

In the UK but more notably on Highland estates a culture and practice of woodland neglect has been cultivated by years of ownership and sporting use dominance that has caused a cumulative decline of woodland health, use and perception of production capacity (Dandy, 2016). This is supported by the earlier drivers and obstacles section of this chapter that demonstrate some pluralistic tendencies in land managers perceptions and interactions with woodland management culture (Robbins & Fraser, 2003). For example woodland is deemed beneficial for amenity, shelterbelts and landscape value but simultaneously are cited as being eyesores on the landscape, referring to plantation woodland attached to earlier woodland policy – this is difficult to reconcile for a sector still caught the shadow of past decisions. Woodland grants are viewed as attractive due to native woodland amenity aims yet complex, inflexible and bureaucratic, deterring many land managers from establishing sustainable management schemes on their estates.

Both passion and legacy are terms commonly associated with trees by land managers but this seems to disappear as trees become woodland and the inherent implications of management and policy threaten the status quo of current estate structure. Low level knowledge and understanding drives this distancing from accepting woodland

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**Figure 8.23** – Chart of East Sutherland woodland corridors percentage break-down

East Sutherland - woodland corridors

- SRF: 11%
- Commercial woodland: 28%
- Amenity woodland: 50%
- Montane scrub: 11%
- Open ground: 11%
management as an integrated part of estate priorities. However, managers with greater contact and engagement with their estate have an increased propensity for considering and planning for woodland management and expansion (Chapter 7.2 and 8.2). Long rotations in general are perceived as being incompatible with shorter term aims of estate management lacking regular direct revenue to support estate operations. Such a disparity could be mitigated by connecting woodland to carbon and ecosystem services markets, which account and pay for woodland benefits cumulated over time that are distributed to the wider landscape (Deal, et al., 2012; FC, 2014). Land managers also identify that productive woodland requires timely unison of stable timber prices alongside development of targeted infrastructure networks and appropriate incentives. Highlighting the importance of both horizontal and vertical scalar cooperation (Nijnik & Mather, 2008), which continues to be a challenge for individual managers but also an opportunity for constructing an effective and meaningful ecosystem approach that taps into key gaps hindering local rural development.

Section 8.4 clearly demonstrates the potential benefit of woodfuel to both stimulate and kick start productive woodland management and markets (Dandy, 2016). Estates have suitable land available (Chapter 8.4) but a shift from exclusion to integration thinking about sporting management boundaries needs to occur by bridging common goals and outcomes of normally singular management regimes (Wightman, 2015). As identified in Chapter 7 most estates are unable to operate as a single entity and increasingly rely on partnership approaches (Glass, et al., 2013; Hindle, et al., 2014), woodfuel growers, processors and users would greatly benefit from an approach that plugs into a wider ecosystem system management structure, providing multiple layers of support.

There is a clear disparity between the willingness of land managers to plant and the potential for suitable woodland corridor areas. Figure 8.24 presents those differences (in hectares) for the case study areas by comparing estate expansion (8.3.3-8.3.6), and the woodland corridors areas (8.5 - SRF and commercial areas). This shows a difference of approximately 75% (90% in East Sutherland) between the land manager perspective on feasible woodland planting and suitable woodland corridors over the case study areas. This emphasises the influence of main management objectives (sporting use) and other
spatial restrictions (designations, landscape aesthetics and grazing maintained for posterity), which are driven by powerful cultural estate management narratives (tradition, legacy and preference), accounting for the 75% of suitable productive woodland areas.

Figure 8.24 – Estate woodland planting comparison with woodland corridors analysis

If the 75% margin is applied to the estate expansion figure to represent the difference between land manager woodland planning exercises (8.3.3-8.3.6) and actual plantings in the future, then woodland expansion area would decrease to 1,650 hectares over the four case study areas. In light of this figure, the onus of finding another 5% of woodland cover falls to public agency land, NGO estates, smaller private holdings and community ownership (See bullets points below for woodland expansion impact). If woodland expansion is to reach the policy target of 25% coverage (WEAG, 2012) then enabling land managers to plant the areas they planned in section 8.3 is vital, and in doing so policymakers and professionals will need to address the drivers and obstacles examined in section 8.2.
Based on the results displayed in section 8.3.

- **Case study woodland increase**: 0.86%
- **Increase of current Highland woodland resource**: 0.47%
- **Increase of the current Scottish woodland resource**: 0.12%
- **Scottish woodland increase, if trend extends to all Highland sporting estates**: 1.1%
- **Scottish woodland increase, if trend extends to all sporting estates**: 2.2%

Additionally, if peatland soil restrictions were to be incorporated into the analysis, including soils with half a metre or more peat depth (where planting is likely to be restricted by policy measures) then woodland expansion areas would be reduced even further, especially in East Sutherland. Woodland landscape corridor maps with policy relevant peatland soil depth extent can be seen in Appendix H, which demonstrates both spatial and policy impact of peatland conservation in the Highlands. Strong policy leaning toward peat conservation has inhibited woodland expansion efforts and precautionary approaches to planting woodland on peat soils are being followed. Greater coordination between woodland expansion strategies, the forestry sector and peatland management may be a pivotal partnership for landscape management in the Highlands.

Land managers show a strong preference for planting Scots pine mixtures as the dominant woodland component, and poplars along riparian areas. The few areas planted with productive objectives favoured Sitka spruce, Douglas fir and at times Larch. SRF could provide an alternative and profitable regional market for sporting estates; once established and in rotation, woodlands would increase their value through silvicultural treatments and use of first thinnings as woodfuel. Woodland management aims could benefit from strengthened links to climate change mitigation, incorporating carbon sequestration and market participation as a means to increase woodland value. This development would be aided by parallel investment in greater management of woodland
areas and infrastructure improvements, which would diminish profit over the first rotation period (20-25 years).

The woodland corridor maps (8.5) evidenced that the case study areas possessed greater potential for woodland connectivity and use of estate land (15-23%) with further areas available for amenity (native mixed woodlands) and montane scrub woodlands. A potential woodland cover ceiling of 20-40% is supported, which will be dependent upon planting incentives, capital investment and land managers’ understanding and interpretation of woodland in their landscape. The combination cultural factors, economic feasibility of forest energy, practical planting scenarios and potential woodland landscape corridors can be used to build a comprehensive picture of potential strategies and practice to provide estate management structures with routes to strengthened resilience.
Chapter 9

Aligning carbon management through landscape collaboration

9.1 Connecting estates to the wider landscape

Throughout the world ecosystem services are emerging as a central consideration of environmental management, and their measurement, valuation and translation into practice is vital to climate change policy decision-making (Stern 2007). In this chapter, the role of carbon sequestration and landscape partnerships in the Highlands and specifically for private estates will be examined as a gateway to greater ecosystem approaches and practice. Key to understanding the future functioning of ecosystem services in the landscape is the evaluation of land managers’ perceptions of the concept, communication of its utility and its relationship with other land uses. As demonstrated in Chapter 2, 3, 7 and 8 cooperation, partnerships and networks are becoming increasingly important to land use practice and developing ecosystem approaches. The review of the earlier literature influenced the methodological design by emphasizing the importance of transboundary and cross ownership cooperation as tenants of an ecosystem approach. Whereas Chapters 7 and 8 identified the increasing tendency of private estate land managers to seek out partnerships through leases and development opportunities, which are proving vital to ongoing sustainability and strengthened rural resilience.

This research has identified (Chapters 2 and 8.4) carbon sequestration as a gateway ecosystem service strongly associated with woodland management due to the progress of management, measurement and valuation in comparison to other services (Gómez-Baggethun, et al. 2010, Nijnik, Pajot, et al. 2013). Carbon functions and fields (tonnes sequestered per m³ for different species and yield classes, economic and social price) are incorporated into the Forest Energy Tool (Chapter 6.2.5, Appendix D), linking woodland expansion and energy markets to a potential carbon contribution from each estate. In Section 9.2 the value of carbon sequestration from each case study’s woodland planning
is compared, demonstrating how this might impact timber prices for land managers and potential management considerations. In section 9.3 the current relationship and understanding of land managers regarding the ecosystem services concept (and its practical implementation) are displayed to position ecosystem services (carbon focus) within the current mindset and priorities of land managers. In Section 9.4 cross boundary collaboration activities have been identified collectively by the case study areas, which are then presented as a potential focus or action plans as part of a localised ecosystem approach. This culminated in regional maps (constructed during feedback periods and collaborative discussions, see Chapter 6.3), which are used to identify barriers and opportunities for transboundary and multiple party collaboration. The final section (9.5) presents six areas of potential partnership that underlie land manager acceptance and requirements to operation on a regional scale. These partnerships have been triangulated through the collective synthesis of field interviews, feedback sessions and collaborative discussions.

9.2 Carbon value from woodland expansion

One of the outcomes from the Forest Energy Tool (Chapter 6.2.4) is the quantity (m$^3$ tonnes) of carbon sequestered from planned woodland expansion (FC 2014) and the potential economic value from new woodland planting and management. Along with the current economic value, the social value of carbon provides an indication of the value added to the land beyond tangible measurements (Valatin 2011). Nijnik, Slee & Pajot (2010) suggest that carbon offsetting has great potential in Scotland through forestry activities due to favourable biophysical, institutional and economic aspects. Table 9.1 displays the carbon value accrued by new woodland planting on the case study estates (derived from the Forest Energy Tool, Chapter 6.2.4). These figures are dependent upon the lifecycle of the timber and would require site restocking to maintain the increased carbon balance.

Table 9.1 shows carbon sequestered by new plantings on estates, which demonstrates the potential of carbon to contribute significantly to climate change mitigation but also to the regional rural economy (Nijnik, Slee and Pajot 2010, Markantoni and Woolvin 2013).
Even at the modest price of £5.11/tonne (Economist 2013) the income could create a subsidy for land uses that (in certain situations) no longer sustain themselves (forestry & agriculture). The carbon trading price is expected to rise in 2015 to £18/tonne (HM Revenue & Customs 2014) on the UK trading floor, which would make carbon management a serious consideration for landowners. Common difficulties are encountered in connecting local carbon sequestration to revenue generating markets (international). Effective supply chains and bridging organisations may prove valuable in mobilising the value of this core ecosystem service.

Table 9.1 – Value of carbon from planned woodland on case study estates (Forest Energy Tool, Chapter 5.2.4)

<table>
<thead>
<tr>
<th>Estate</th>
<th>Timber volume (m³)</th>
<th>Carbon (tonnes)</th>
<th>Economic carbon £ (20-25 years)</th>
<th>Social carbon £ (20-25 years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attadale</td>
<td>24,925</td>
<td>137,854</td>
<td>704,433</td>
<td>7,168,402</td>
</tr>
<tr>
<td>Inverinate</td>
<td>19,103</td>
<td>74,726</td>
<td>381,847</td>
<td>3,885,727</td>
</tr>
<tr>
<td>Glencarron</td>
<td>20,450</td>
<td>77,547</td>
<td>396,265</td>
<td>4,032,438</td>
</tr>
<tr>
<td>Wester Ross</td>
<td>64,478</td>
<td>290,126</td>
<td>1,482,545</td>
<td>15,086,568</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Estate</th>
<th>Timber volume (m³)</th>
<th>Carbon (tonnes)</th>
<th>Economic carbon £ (20-25 years)</th>
<th>Social carbon £ (20-25 years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kingie</td>
<td>12,687</td>
<td>58,193</td>
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<td>3,026,032</td>
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<td>Glen Dessary</td>
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<td>58,699</td>
<td>299,953</td>
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</tr>
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<td>Achnacarry</td>
<td>72,029</td>
<td>300,086</td>
<td>2,957,803</td>
<td>15,604,465</td>
</tr>
<tr>
<td>Lochaber</td>
<td>96,242</td>
<td>416,978</td>
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<td>21,682,852</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Estate</th>
<th>Timber volume (m³)</th>
<th>Carbon (tonnes)</th>
<th>Economic carbon £ (20-25 years)</th>
<th>Social carbon £ (20-25 years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Invermark</td>
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<td>107,943</td>
<td>551,591</td>
<td>5,613,056</td>
</tr>
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<td>Balmoral</td>
<td>20,627</td>
<td>128,848</td>
<td>658,415</td>
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</tr>
<tr>
<td>Invercauld</td>
<td>26,197</td>
<td>244,777</td>
<td>1,250,808</td>
<td>12,728,382</td>
</tr>
<tr>
<td>Cairngorms</td>
<td>73,258</td>
<td>481,568</td>
<td>2,460,814</td>
<td>25,041,552</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Estate</th>
<th>Timber volume (m³)</th>
<th>Carbon (tonnes)</th>
<th>Economic carbon £ (20-25 years)</th>
<th>Social carbon £ (20-25 years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Badanloch</td>
<td>18,689</td>
<td>99,947</td>
<td>510,730</td>
<td>5,197,253</td>
</tr>
<tr>
<td>Borrobol</td>
<td>12,785</td>
<td>63,797</td>
<td>326,003</td>
<td>3,317,451</td>
</tr>
<tr>
<td>Achentoul</td>
<td>13,738</td>
<td>67,756</td>
<td>346,233</td>
<td>3,523,311</td>
</tr>
<tr>
<td>East Sutherland</td>
<td>45,211</td>
<td>231,500</td>
<td>1,182,967</td>
<td>12,038,015</td>
</tr>
</tbody>
</table>

| Total          | 279,189            | 1,420,173      | 8,755,789                       | 73,848,987                    |

Such organisation exist already, which contribute to the social landscape through cooperative mechanisms. The Forestry Commission woodland carbon code provides the institutional and policy framework (FC, 2015), bridging organisations like Forest Carbon
UK facilitate and arrange the partnerships, and organisations such as Green Insurance, Nationwide and Ecopoint establish programmes to buy the carbon sequestered to offset their carbon footprint (FCUK, 2016). Private land owners and community groups benefit from such an arrangement as new woodlands, management and markets are supported and maintained. Buccleuch estates formed a carbon partnership (group scheme) under the woodland carbon code where Marks and Spencer bought out most of the carbon rights (FC, 2015). This scheme has enabled more land to become available for woodland creation, supported diverse woodland management and products, as well as opening up the carbon code to smaller managers that alone would not be able to access the scheme. Many of these initiatives are based upon climate change mitigation, creating woodfuel sources for local economies and communities and restoring marginal land to woodland. Several partnerships up and running in the Highlands including Alladale estate and Ardochy, part of Dell estate in the Highlands, both of these schemes are in partnership with Green Insurance (FCUK, 2016).

In 2014 sporting land uses were worth £200 million (GVA) a year (much of it located in the Highlands) to Scotland (PACEC 2014), whereas Scottish forestry was worth nearly £1 billion (direct GVA) and £649 million (indirect GVA), which reflects the value of woodlands to the economy, landscape and the people (SFTT 2014). Carbon sequestration can be seen to boost the woodland income by 30% per hectare economically (based upon Forest energy outputs in ‘Estate land use reports’) and add a significantly more valuable contribution through the social benefits (recreation/Health and well-being) (MEA 2005, FC 2015). Mechanisms and frameworks are in place for these estates to join such schemes and benefit from unlocking land, increasing woodland creation and management, as well as receiving an income connected to climate change mitigation. Similarly these carbon schemes can plant trees for flooding control, habitat restoration (grouse) and productive woodlands of all types. Estates may benefit from approaching the woodland carbon code as a group (i.e. within their case study clusters or DMG), this would reduce risk, facilitate knowledge exchange and strengthen landscape management in the region.
9.2.1 Carbon potential on case study regions

The case study areas were for the most part equal in their spread of carbon capture, with the exception of Lochaber (depending upon woodland planting and size of case study area), which had two of the smallest estates. These have the lowest potential by area for planting. The infrastructure of Kingie was considered very limited, but woodland operations were underway in Glen Dessary.

Achnacarry has the largest land cover in Lochaber, which gives more scope for woodland planning. East Sutherland, the smallest region, could sequester the least carbon through woodland planting, however most carbon is in the peatlands that the land managers and agencies strive to conserve. Although the Cairngorms region could potentially sequester more carbon from woodlands due to the size of the estates, a focus on grouse management limits this goal. However, grouse moors represent a long term carbon store, especially when they coincide with peatland soils (Grant, et al., 2012).

On average, at the current price, carbon sequestration could be worth £100,000/year to each case study area and £1 million/year based upon social carbon value (Social value equates the entire set of benefits delivered by sequestration that cannot be accounted for by conventional measurements, see Chapter 6.2.4 and (Valatin 2011)). This could provide a cumulative pot for estate repairs and improvements that would benefit the region. Other points to consider are the timing of payments for carbon sequestration and the conditions placed on management and production. These could all become either deterrents or incentives for planting more woodland and potentially joining a regional carbon scheme.

Shorter rotation lengths will produce lower yields and therefore the cost of sequestering carbon will increase (McKenney, et al. 2014). Nijnik et al (2013) compare various timber yields from afforestation sites on poor livestock land in Scotland and resulting in production costs of General Yield Class (GYC) 12 = £16.60; GYC 24 = £6.80 per tonne. Such costs do not cover the current carbon price. The best projected price only marginally covers the costs and in the Highlands reduced yield can be expected due to increased
biophysical constraints and higher frequency of windblow. Management costs need to decrease, the price of carbon needs to increase and additional support and approaches are required before carbon sequestration becomes a strongly viable market option.

The costs of carbon management need to be incorporated into a pre-existing suite of wider management costs that integrates carbon capture as a beneficial management addition. Greater investment in infrastructure and diverse silvicultural approaches for the forestry industry and Highland woodland sector would aid this development, as well as increasing timber quality and management that encourages productive woodlands (orientated towards multiple deliverables). Any system for trading carbon or woodland management would benefit from scaling-up, sharing resources, reducing transaction costs and wielding more power as a larger economic platform than individual estates would have alone. A multi-rotation system (distinct timber product rotations, climax forest, active thinnings for the forest energy market, based on a multi-age structure – discussed in Chapter 10.2) that is increasingly resilient to diverse influences could be one approach to encourage regional stability and corporation.

Trust between actors that implement new rural developments (Camagni 1991) and links between industry, state and research provide impetus for innovation. This has the potential to improve land use management relationships (Etzkowitz and Leydesdorff 2000, Kemps and Martins 2007). A transformative effect is reliant upon networks tapping into the array of rural development opportunities (Pettenella and Maso 2009).

9.3 Land manager perspectives on ecosystem services

Across the case study areas, common views are held by land managers on the subject of ecosystem services. Through the field interviews (Chapter 6.2.2), feedback session and collaborative discussions (Chapter 6.3) four clear themes emerged surrounding carbon management and (to a lesser extent) other ecosystem services.
9.3.1 Theme 1 – Unrecognised contributions and estate management portrayal

A position that resonates with the majority of land managers was that ecosystem service management is both apparent and inherent in their current efforts, and these inputs and costs often go unnoticed and unappreciated. “A lot of what we put into the land goes unrecognised, we don’t see any of that input and it’s often at our own cost...and then we become the villains that hoard the land” (Attadale). A number of managers believe that business as usual and refining those practices is the best way to improve the environment of the estate, “I believe we already do a lot of things connected to ecosystem services and integrated land use, and we have done for a long time now, it just goes unrecognised...so we will just try and improve some of our practices and that should in turn enhance the services that we produce” (Invermark). Some managers were offended by the term ecosystem services, as it implied that the estate was not being managed effectively or conscientiously, “We have lots of things going on that add to what they are calling ecosystem services, it’s what has always been done” (Balmoral).

9.3.2 Theme 2 – Jargon inhibiting awareness

Estate managers believe that ecosystem services, integrated land use, and multifunctionality are essentially a rebranding of the management they have been practicing for centuries. “Don’t know much about ecosystem services and carbon that’s a global issue that we can’t do anything about locally, nothing to do with us or the management of the estate” (Attadale/Kingie)....“Not sure whether there is much to be done on that level around here” (Inverinate). A reluctance to engage with the subject was apparent, as the jargon of ecosystem services often appears to question their experience and expertise.

Another land manager relayed an example of incorrect information about ecosystem services he had be given by a local agent relating to practical estate management. “I’ve pressed those that are supposed to know to tell me why the carbon absorption value of heather collapses if you burn it and I haven’t had any answers and I don’t think its correct...You know the ecology trend to letting everything look after itself” (Borrobol). After a brief discussion it became clear that the information had been misinterpreted by the
land manager due to the inaccessible manner in which the information had been delivered. In general, poor communication, little connection to operations and current practices, and the prospect of tackling another layer of convoluted land management concepts does not encourage land manager engagement or confidence.

9.3.3 Theme 3 – Applicability and implementation
The everyday significance of carbon working as a market and daily management consideration is confusing for most land managers, “I have no idea how it would work...” (Borrobol). Additionally land managers have difficulty viewing the globally significant intangible concept on a local scale that fits in with estate management priorities. “I don’t know anything about carbon markets or ecosystem services and how it would relate to my estate...” (Glen Dessary).

The absence of a clear route between understanding, application and management implementation caused some managers to place carbon management and wider ecosystem services outside the scope of future estate plans. “The estate is doing some carbon footprint stuff but we’re not looking explicitly to pursue that avenue... I’m not convinced really of the applicability right now” (Balmoral). Other managers believe carbon management is adding conservation goals to their current management regime, “I guess our role in enhancing ecosystem services for the estate and region is to conserve the peatlands, plant some hardwood trees and maintain the health of the deer populations” (Achentoul). During the interviews, it became apparent that the management benefits and potential influence of ecosystem services on an estate level was not well understood and those that possessed a higher level of knowledge still did not know how to begin incorporating them into the estates objectives.

9.3.4 Theme 4 – Interest in carbon market
There is strong interest in the potential of carbon markets complementing the estates’ functions, especially with regard to woodlands, but land managers could not identify clear access to information or an easy avenue to explore their options. “I would be very
interested in learning about it [carbon market] and exploring opportunities if there are any...but as I said I have no knowledge of this” (Glen Dessary). One land manager was very enthusiastic about the prospect of receiving extra payments for planting woodland and management. “Is there a possibility of making something from carbon when planting? I would certainly pursue that if it would support the financial return of woodland and timber management” (Achnacarry). Organisations such as Forest Carbon, knowledge of the FC woodland carbon code and the working of these schemes have not reached these land managers. This identifies a lack of effectiveness in raising awareness of this potential for the majority of land managers that do not actively seek out ways to innovate their estate practice. Greater connection and buy-in from traditional and absentee managers needs to be sought for wider landscape impact.

All case study area land managers express interest in carbon management, which results in extra income, local climate change strategies and a ‘green stamp/certification' acknowledging their contribution. “If I could gain some accreditation for my activities and be able to say the estate is carbon or ecosystem friendly that would be an attractive option, especially with the addition of increased economic value to woodlands” (Borrobol/Glen Dessary/Achnacarry/Glencarron – several similar quotes from different land managers pulled together to show the common theme of their separate statements).

9.4 Cross boundary collaboration in the case study areas
This section covers the potential willingness and capacity of case study areas to benefit from collaborative activities and partnerships, relating to management activities covered in chapters 7, 8 and 9. Estate cluster maps were developed through the collaborative discussion groups and feedback sessions (Chapter 6.3). Land managers pointed out particular areas of the estate that were inaccessible, potentially productive, and possess an opportunity for development. This exercise aims to identify land that could be potentially unlocked by infrastructure upgrade, habitat connection or operational networks. These are indicated on the maps in the following sub-sections, which show the three estates in each case study area as a regional cluster. Following the collaborative
discussions, it became clear that collaborative activities were restricted to three, spatially focused actions that would potentially unlock increased activity and benefits:

| Ideal locations for common hubs/yards to store, sell and transport woodfuel and other grade timber products |
| Prime spots for infrastructure upgrades that would facilitate access to areas of the estate |
| Deer landscape enhancement corridors that would improve connectivity of woodlands and deer habitat for the region |

This section shows each case study’s collaborative landscape map, which includes current infrastructure (road and rail), current woodland, rivers and lochs as well as individual estate boundaries. During the discussions, it became clear that the jointly constructed regional cluster maps (infrastructure upgrades, woodfuel hubs and deer landscape enhancement) represented an optimistic viewpoint. Most land managers agreed the economic and management shifts mentioned in this chapter (as well as Chapters 7 and 8) would be necessary to motivate such change, requiring an organisational hub to manage stakeholders and regional business interests.
9.4.1 Wester Ross

**Figure 9.1 – Wester Ross landscape collaboration maps**

**Constraints**

The main obstacles in Wester Ross stem from a lack of infrastructure to service particular areas of the estates. Forestry operations are viewed as a cost due to the remoteness of harvesting operations and processing points, as well as the frequent need to use sky line extraction methods, as trees grow on inaccessible areas with high gradients. The Highland Council has impeded economically significant harvesting activities for Inverinate estate by restricting the weight of timber Lorries can transport to 100 tonnes a year due to potential damage to the roads. Even simple road maintenance was said to be prohibitively expensive, therefore new infrastructure was almost unthinkable without generous grants.
Opportunities

Figure 9.1 shows the collaborative map that identifies two woodfuel/timber hubs that could be used to benefit all three estates, if not more. Figure 9.2 shows an area suitable for SRF that could be serviced by regional timber hubs. In Figure 9.1 the turquoise line identifies the most beneficial infrastructure upgrades. These would to aid access and further operational capacity to the estates and support development of forest roads and hydro connections, as the road upgrade on the west side of Attadale is based upon future plans for hydro grid connection and a bypass.

All land managers are interested in the potential for short rotation forestry (SRF) but are unwilling to take the first step without any type of guarantee. Hydro-schemes are being developed and the land managers unanimously agree that once in place, they will open up
opportunities for additional estate activities, which indicates future capacity and development toward ecosystem services management.

Explicit collaboration is viewed as unlikely, as the geography and location of estates prevent significant activities. Hills, ridges and rivers are used as examples of restrictive geography that devalue operational or management potential.

9.4.2 Lochaber

Constraints
Lochaber land managers do not possess strong inclination to collaborate or collectively discuss land use issues. As they all refused to meet with one another or compromise on potential locations for a group discussion, they were content to remain separated. All three estates agree that there is little chance for spatially explicit collaboration beyond the deer management count. However, two land managers are in favour of creating smaller blocks of native woodland across the landscape to link shelterbelts and improve the quality of the timber resource. Planning of woodland and timber resources is still considered a single estate approach with no need for larger planning consideration or landscape scale thinking. This demonstrates that these estates still, for the most part, operate within silos that focus inwardly on single estate management in spite of opinions and statements that reflect otherwise.
Opportunities

The importance of upgrading and increasing the capacity of grid connections and infrastructure was stated as key step to unlocking the land's potential. Hydro is viewed as the only new land use profitable enough to develop and dedicate estate funds to in the immediate future. Each land manager is waiting for the development, installation and payback of hydro schemes before considering other activities. The majority of hydro-schemes are being developed in partnership with private utility companies or the Forestry Commission. Achnacarry is in the process of converting land to Forestry Crofts, which are being converted into residential properties that will manage and utilise the timber resource in cooperation with other members of the Forest crofting community. The land manager is finding it difficult to make a decision regarding charging the community a tariff or concession for extraction and road usage, as he wants to encourage
the community objectives and active forest management yet wants a fair income from the use of estate facilities.

![Image](image1.png)

**Figure 9.4** – Lochside timber resources in Lochaber, no access for management

Deer counts are acknowledged as the sole area of existing collaboration; however land managers also conceded that marginal savings from woodland management could occur if planting and harvesting regimes were aligned across several estates. In Figure 9.3 landscape development through woodland corridors is positioned along estate boundaries and the prominent lochs. If these woodlands are to be considered productive in any way, the proposed infrastructure upgrades would need to be built to open up access across multiple estates. The three timber hubs are positioned by A-roads or potential infrastructure upgrades, which would serve multiple estates close to timber resources (Figure 9.4 shows inaccessible timber resources).

Carbon interested two of the land managers, who were intrigued by the value carbon could accrue through management, and acknowledged it could subsidise woodland investment and operations. However, both were clearly confused as to what this could mean for the estate and how they could enter this new sector.
Suggestions for collaboration beyond explicit spatial operations include further integration of the public sector, “there needs to be more agreements and two-way support mechanism with the public sector to support the common landscape” (Glen Dessary) and the formation of more relevant and specific policies, which could be supported and implemented by collective action from multiple estate cooperatives. “Estate resources and potential for greater diversification would be helped, if several estates banded to together to access greater funds through collective action” (Achnacarry).

9.4.3 Cairngorms (Deeside)

Constraints
According to the three Cairngorm land managers, the Highlands are not suitable for collaboration due to remoteness and less intensive use compared to other areas. The management and identity of the Cairngorm estates are spoken about as standalone entities [more so than the other case studies] due to their size and significance to the tourism sector, which was described by one land manager as an ongoing issue, “we need to distance ourselves from landowners viewing their estates as private kingdoms and increase engagement with the communities and land management approaches enable to improve the estate” (Invermark).
Figure 9.5 – Cairngorms landscape collaboration maps

Opportunities

*Figure 9.5* demonstrates the impact of roads accessible by multiple estates on woodland development, as woodlands cover the border areas of Invermark and Balmoral whereas in other case study areas border regions have minimal land use. Due to the size of the estates, more infrastructure upgrades are needed to make management viable in locked-up areas, increasing the connectivity of areas applicable for land use development. Potential timber hubs are positioned at A-roads where at least two estate borders meet to maximise the range and catchment of the hubs.
Current collaborative activities include deer counting, firefighting efforts (if grouse moorlands caught fire) a woodland planting scheme along the Banochbuie and a cross boundary planting with Mar Lodge estate. One manager did express concern that a lot of money was being wasted due to estates’ venison transport and marketing policies (Figure 9.6 – venison products), which could be improved if neighbouring or regional estates coordinated with one another (Licensing and policies affect these activities). “There’s money being wasted all the time in regard to transport of venison products across the country – this could be coordinated by estates, if they were willing” (Invermark).

**Figure 9.6** – Venison products being processed and prepared for shipping to London and markets in China
9.4.4 East Sutherland

Constraints
Carbon in this area is viewed largely through the peatlands. The estate cluster borders the RSPB Forsinard reserve, which has become a peatland conservation centre and dominates land use focus. “A lot of the time when submitting proposals the RSPB veto the planning as they say it will interfere with bird habitat or the integrity of the peatlands” (Borrobol). Hydro schemes are less of an incentive in this area as there was a reduced capacity compared to the rest of the Highlands. So the estates are not relying on hydro related opportunities to bolster estate finances and therefore focus on developing the hunting lodges or farming areas. The overriding constraint on developing woodland resources and production in the area is the peatland conservation profile and increased focus on livestock grazing. This is heightened by the contrast of one very active land
manager who runs the estate as a personal business and two neighbouring absentee managers. This decreases the potential for effective land use partnerships.

**Opportunities**

*Figure 9.7* shows that the East Sutherland estate cluster is dissected by both an A road and a rail line, which gives the area multiple options for transport and accessibility. The railway option provides the strongest potential for collaboration between the estates and surrounding area. This would encourage greater timber extraction as well as use and clearance of windblown timber. The timber resources could be transported at a reduced cost, especially if multiple estates signed up for use of this option. “*It’s a shame as it’s right there and was a logical solution for a big problem*” (Achentoul). Reduced transport costs and operations would make the timber more profitable and enable the estates to restructure and consider further investment. However, the low potential for collective action by land managers has affected the realisation of potential cost cutting activities such as the use of the rail line for timber transport.

![Agriculture land and woodland in close proximity to a railway tracks (potential transport)](image)

*Figure 9.8 – Agriculture land and woodland in close proximity to a railway tracks (potential transport)*
The stalkers regularly help one another with deer counts and machinery problems and hold fishing and shooting competitions between the estates and community. It was suggested that creating a joint in-house estate operations team might be beneficial but this would require formal agreements and flexibility amongst the estates concerned. East Sutherland could be one of the most cost-efficient case study areas for woodland management/woodfuel production due to the current transport costs caused by remoteness, proximity of the rail line and clear internal extraction routes for the estates (See Figure 9.8 for an example of such land).

9.5 Potential ‘Landscape partnerships’
Several areas of converging interests have been identified during the feedback and collaborative discussion sessions (Chapter 6.2.7). These show the most promising outlets for cooperation between estates. They are a mixture of spatial, administrative and financial mechanisms that may aid the development of a more localised interpretation of an ecosystem approach (Collier, 2015), representing CBD EA principles 2, 3, 4, 5, 7 and 11 and Operational guidelines 1-5 (UNEP, 2014).

9.5.1 Carbon marketing partnership
Many of the estate owners and their managers are aware of carbon sequestration as a mechanism or justification for woodland expansion and peatland conservation. However, there was little knowledge about the potential market and the fact that the work they performed could qualify for carbon trading schemes. Additionally, there is little willingness to enter into a market that has no visibility or familiarity. The majority of land managers believe that carbon capture had no benefit beyond mitigating climate change. Bridging the scales between carbon markets to include a wide scope of individual land managers or groups by a capacity building organisation could reduce trading costs and administrative accessibility. “If carbon could provide sound financial support or incentive for woodland management, especially upfront, then that might change a few decisions” (Achnacarry). The newly established Peatland Code is a voluntary mechanism that enables businesses to help fund peatland restoration projects for their carbon benefits,
ensuring environmental credibility, carbon emission reduction that meet social corporate responsibility targets (IUCN, 2016). This mechanism provides financial incentives to land managers for peatland restoration where there was none before enhancing community, water and biodiversity benefits. Two voluntary mechanisms exist to connect land managers to carbon markets, which focus on natural resources important to Scotland’s landscape.

9.5.2 Venison marketing partnership
The disparity and disjointed arrangements for selling venison in national and foreign markets were well-acknowledged by land managers. There is huge demand for Highland venison and the associated imagery the product creates for the consumer but much of the meat is distributed to community members and friends, and the remainder is sold onto Highland Game or at times individual restaurants. Despite stalking and shooting seasons being the same across all estates, there has been no provision for joint transport or organisation of regional venison trade to reduce costs and create a more recognised and saleable regional product. Additionally as voluntary standards for deer management and most notably failure to achieve culling quotas market incentives for the production to venison have been suggested to resolve some of the conflicts between sporting management and other land uses (Macmillan & Phillips, 2010). However, this approach might be considered limiting as the majority of the target group is extremely wealthy and not entirely motivated by profit maximisation. As demonstrated in Chapter 7.2 sporting management are main priorities and considered to be part of a Highland wildland aesthetic and increasing culls would diminish stalking capacity.

9.5.3 Timber and woodfuel hubs partnership (Locations and use)
The largest costs for woodland management are transport, extraction and harvesting operations. Estates communicate very little, especially about plans and operations that are outside of deer management, so coordinating thinnings or harvesting has been difficult due to inadequate communication streams, misaligned agendas and timescales. If long term forest plans and shorter rotations are to be implemented over specific
landscape defined areas, smaller regions would be in a position to coordinate harvesting/thinning operations and designate common staging areas for extraction routes, storage and transport. A practical prospect for future woodland planning and management requires cost reduction, developing infrastructure around potential expansion areas and identifying a woodfuel catchment area upon which to base a local market. Machinery Rings currently operate over various regions in Scotland to optimise use of farm machinery against rising costs of owning and operating in-house machines (MR, 2016). The Ring is a coordinate process that aims to create savings for the individual through group action, such as purchasing of supplies, use of machinery, labour costs and insurance. A similar operational set-up subscribe to by estate manager membership could work for forestry machinery, labour and even markets.

9.5.4 Hydro grid connection partnership
Waiting for hydro-schemes connections to the grid has caused many estates to lose ground on their hydro-schemes and therefore lose increasing amounts of potential revenue. Hydro-schemes are viewed as important to economic and energy futures (Chapter 3.4, 7 and 8) but with only a single estate pushing or lobbying for new grid connections, priority for improving the grid connection in that area will be low. Estates would clearly benefit from forming small coalitions that lobby for vital grid connections that could service multiple operations and needs over several estates. “A lot of hydro potential is being lost, which is costing us [the estates]. If strategic grid connections could be installed to benefit multiple parties, the gain over time would be great, however waiting around helps no one” (Glen Dessary).

9.5.5 Infrastructure upgrades partnership
The majority of respondents describe their estates as remote, isolated and inaccessible (Chapter 7 and 8). Harvesting routes, extraction points and roads are inadequate to consider management operations in the majority of woodlands. Internal tracks are on the periphery of estates, which increasingly turn into dirt tracks that can barely support 4x4 vehicles or quad bikes. A few estates (Glencarron & East Sutherland) are fortunate
enough to have railway lines or A-roads running along their borders, however large segments of estates remain inaccessible to operations and restoration due to inadequate infrastructure. A few land managers suggest that intelligent infrastructure upgrades could connect several estate roads increasing accessibility for multiple estates. Additionally, use of the rail line in East Sutherland for timber extraction and transport remains unutilised due to lack of will and coordination of the neighbouring estates. Reorganising and acting on such opportunities could play an important part in restructuring and reorienting the forestry sector. “Inaccessibility and lack of prior consideration for woodland management needs causes problems down the line when attempting to thin, roads and lack of extraction ability are large barriers to active woodland management” (Invercauld).

9.5.6 Woodland planning partnership (Deer landscape)
The only joint woodland planning operation is in the Cairngorm case study area (Chapter 7.6), which relates to the transboundary woodland development between Invercauld and Mar Lodge estate (National Trust Scotland). There is consensus from land managers that joint operations, plantings and planning, much like the machinery ring could benefit estates overall, but the concept of shared responsibility, costs and possible revenue from commercial enterprise is complex and unattractive. This highlights the fear that loss of autonomy, traditional landscapes and management approaches may support increased woodland expansion and production that directly conflicts with main estate priorities (sporting use). Without this cooperative mentality in place, not only will planning and planting be unlikely but also the formation and implementation of regional woodfuel hubs would be challenging. This can be associated in part to the disconnect of land managers from woodland management in their everyday routine that has been embedded over generations, this is also compounded by the expectation and comparison with other land use practice, such as agriculture and deer stalking (Dandy, 2016). Re-emergence of woodland markets and management through woodfuel, which could potentially reframe practice and generate new approaches.
9.5.7 Mobilising effective partnerships through practice

Landscape partnerships would give estates, in part, the recognition they have lacked for their land management services, as it will provide an outward looking profile of their multiple contributions to the landscape. Additionally, they could provide opportunities to share resources, enhance estate capacity, and reduce transport and transaction costs. However, land manager mind-sets would need to shift considerably and new channels of communication and collaboration will have to be forged, if this is to be achieved. Before this shift occurs the right set of tools and incentives need to be available including:

- Grants (Collective, flexible that tie-in carbon sequestration)
- Revenue potential
- Connecting infrastructure
- Operational capacity
- Cooperation (based on micro-regional agreements)
- Confidence (increased by supportive and facilitative networks)
- Administrative support (personal, organisational, financial and virtual)
- Adoption and support of ecosystem approaches

Most of the partnerships mentioned already in this chapter operate as single mechanisms often voluntary and driven by the private markets, the buy-in is driven by economic incentives and targets innovative land managers and companies. Landscape scale partnerships that coordinate multiple land uses and planning will require novel institutional architecture that creates a hybrid institution that mixes both government and private management (Hodge & Adams, 2012). Evolving partnerships will involve a mix of governance tools, markets mechanisms, management structures, and novel forms of engagement to shift social practice that is both sensitive and tailored to local conditions (Buscher, 2012; MacDonald & Corson, 2012). In the case of potential partnerships in the Highlands that involve private sporting estates tradition and cultural are integral to the regional identity and management (Chapters 1-8), a core consideration in an interpretation of a local ecosystem approach (Collier, 2015). Spatial coordination and planning that works across sectors (CBD EA principles) and connects scales, which align
efforts and makes the best use of available resources is consistent challenge (Adams, et al., 2014). Tackling the interface of spatial planning including joined up thinking about production and regional markets between various stakeholders and different owners is important to the overall effectiveness of landscape scale partnerships.

9.6 Summary

Carbon has an increasingly important role to play in land management but for many land managers in the case study areas the prospect of incorporating carbon into ongoing management is either inconceivable or inaccessible. Economic carbon is most suited as a complementary integrated management objective for woodland expansion and peatland restoration, which is currently emerging through voluntary private market mechanisms in the form of the Woodland Carbon and Peatland Codes. Linking estate management to the intrinsic benefits of carbon sequestration and wider ecosystem services requires recognition, certification or an ‘Ecosystem management’ standard in the view of land managers. Both Carbon and Peatland Codes can fulfil this role yet they need to be placed within a larger ecosystem approach to aid planning, practice and generation of social benefits. A notable gap exists between the value of economic and social carbon, worth ten times more (as shown in section 9.2), which arguably, represents the unrecognised/unquantifiable management inputs and benefits provided by estate management. The £47 per tonne difference between the economic and social price of carbon represents (from the land manager perspective) the work, inputs and costs fed into the estate for the enjoyment and benefit of others.

Integrating ecosystem services in line with the priorities of the managers producing landscape wide benefits is central to an EA, which means aligning the CBD EA principles with culture and tradition at a local level to mobilise an effective local interpretation. This means that an EA and subsequent partnerships in the Highlands must accommodate the deep seated traditions of sporting use and upland agriculture (Glass, et al., 2013). An EA would also aim restore woodland management culture by supporting entry into diverse markets, implementation of alternative silviculture approaches and creating an interdependency of productive outcomes from core land uses. Strengthening the socio-
economic resilience through land management partnerships and networks will aid ecological resilience by enhancing regional cooperation, best practice and the rural economy. However, finding ways to unlock land is an important first step, which could be aided by the landscape resilience, woodland planning and collaboration maps presented in Chapters 7, 8 and 9.4. Across the case study areas land managers view little possibility for collaborative activities due to the restrictions of the landscape. Without improving communication and in some cases strengthening relationships between neighbouring estates, the prospect of collaboration is seen as unfeasible and impractical. Targeted extension and improvement of infrastructure to provide multiple benefits to the region is considered vital by land managers for releasing locked-up potential in remote areas. Greater connectivity is not only required across land uses but also between the people who own and manage the land.

Establishing an effective partnership structure has raised several concerns that are not currently addressed by current schemes (Carbon and Peatland) and collaborative structures such DMG. These include the issue of ‘trust’, as many voluntary standards such as deer culling quotas and plans have been unsuccessful, which undermines connected land use practices (i.e. woodland regeneration and planting) but are seen as ill-informed and unfair to the land managers; leading to mistrust of government led initiatives in spite of many managers still desiring the stability of government involvement (Macmillan & Phillips, 2010). This suggests that horizontal and vertical cooperation is required to support ecosystem approaches (Muñoz-Rojas, et al., 2015). These current schemes do not account for integrated spatial planning that connects individual and regional priorities in a considered manner, incorporating progressive short and long-term plans are important to improving ecosystem function and management (UNEP, 2014). Targeting more traditional land managers less prone to pursue innovative approaches is recommended in order to capture wide ranging landscape impacts; forming strategies to engage absentee and disconnected owners will be important in these efforts (Glass, et al., 2013). As section 9.3 demonstrates land managers have very little knowledge and awareness of the mechanisms available to them for incorporating innovative management approaches that enhance estate operations and income. Therefore greater communication and
awareness is required to incorporate ecosystem services language and knowledge into practical and daily management routines (Dandy, 2016).

Land managers are more likely to adopt Landscape partnership that encompass administrative, organisational and financial aspects in order to reduce costs and improve profit margins. These partnerships could increase operational capacity and investment in multiple regions providing a forum for ecosystem services and associated management to be understood and valued. In this way Landscape partnerships, which are already occurring from a landscape conservation perspective, could shape and guide practices that in turn could begin to define a useable and transferable ecosystem approach that is accessible to land managers. In practice, carbon sequestration would play a more significant role in woodland expansion and management, if the revenue generated from planting could be rerouted to the investment stage, giving land managers greater impetus to establish good management regimes from the beginning. Creating strong ties between woodland culture, deer management, energy and carbon sequestration appears to be a potential base for a local ecosystem approach, finding stability through hydro schemes and increased venison marketing. Such an approach would rely on (Infrastructure, timber hubs and shelterbelts) a key organisation to coordinate spatial planning resource use and partnership structures.
Chapter 10

Interpreting a private estate ecosystem approach – Application of woodland, energy and resilience management

This chapter synthesises the results and outcomes of the previous three chapters allowing for cross-comparison of shared relationships, common practices and potentially convergent management activities. This analysis aims to pinpoint specific characteristics that could form core elements of a feasible ecosystem approach to land management in the Highlands.

10.1 Synthesis of results

Individual and collective land manager perceptions and views on land use, woodland and landscape management have been captured and analysed in order to generate meaningful interpretations of local ecosystem approaches. Private ownership history in the Highlands greatly influences land use decision-making and practice (Warren, 2009; Macmillan, et al., 2010), which consistently supresses development of woodland culture (Lawrence & Edwards, 2013; Dandy, 2016). For instance manager preferences and personal landscape narratives are identified as central components of estate management, which construct current views on what is considered resilient and important to the wider landscape. These views create abundant dichotomies and contradictions that disturb potential integration and cooperation. Such divides include history, tradition, personal views and wealth clashing against emerging markets, policy, public interest, shifting management approaches and changing ownership structures. For example tradition and private wealth are acknowledged to be significant shields against adaptive responses and diversification that would normally be in line with sustainable business models (chapter 7.3-4). This barrier of tradition has the ability to preserve historical trends of land use and reduce or nullify the usual drivers for change, such as societal levers, market fluctuations and policy (Everard, et al., 2014).
Although a common phenomenon over the case study areas, land managers increasingly acknowledge the need to improve connectivity between estates in the form of social networks to structurally unlock land use access and potential. This demonstrates a significant shift towards ecosystem approach thinking and planning, which is currently undermined by a lack of investment, knowledge and understanding of landscape management issues (chapters 7-9). Two broad manager types describe the case study ownership divide, idealists and pragmatists. This factor is compounded by the dichotomies mentioned above, which strongly links to the schizophrenia identified in chapter 8 that has led to a distancing from woodland management culture and divergent attitudes towards woodland grants (Robbins & Fraser, 2003). This relates to land manager contact time with the estate and in turn a level of understanding of woodland as a key service and benefit provider to the local environment; and can be further eroded by the impact of history and tradition of sporting interests that virtually exclude management and suppress natural regeneration (Bunce, et al., 2014). This is supported by the majority of woodland in chapter 7.5 being classed as static within the landscape resilience maps.

A strong inclination toward a single land use mentality still persists throughout the landscape both within the estates and across the region, resulting in land managers dividing the Highlands up into regions responsible for singular land uses, which in their view absolves other regions of these responsibilities (Chapter 7.4.6). Such perceptions influence land use natural range, habitat suitability and cultural resistance impeding the development of ecosystem approaches (Wightman, 2015; Warren, et al., 2016), as clear boundaries are drawn over the landscape, between uses and people. Smaller estates show greater capacity and inclination toward diversification and sustainable land practices (chapter 7) in spite of the majority of literature on this subject citing larger estates as more sustainable with greater capacity to diversify due to the scales of economy (Warren, 2009; Glass, et al., 2013; Hindle, et al., 2014). In this study the fragmentation of larger estates into smaller estates attracted new owners that demonstrate a propensity for innovation and diversification. However, one estate in Wester Ross consists of three former estates consolidated under one owner, and subsequently removed from pursuing productive activities, such an approach is facilitated by immense private wealth, which
further supports the argument that larger estates have increasingly less correlation with diversification.

Some estates lack of diversification is due to remoteness and lack of infrastructure, which creates and reinforces the isolation and inaccessibility that limits connectivity of land, practices and managers. Importance of remoteness to a potential EA is highlighted by the continual reference to this factor throughout the result chapters with infrastructure upgrades being identified as one of three spatial collaboration activities by estate clusters (Chapter 6.3 and 9.5.5). Similarly the landscape resilience maps in Chapter 7.4 provide insights for both decision and policy-makers, emphasising values and rationale for estate management, which could identify priority areas for development, such as infrastructure for rural development (Moffat, et al., 2014). Targeting areas suitable for development, expansion or change while maintaining traditional use and work could formulate acceptable adaptation strategies, in this way land managers can individually develop and implement relevant government policy aims that are compatible with estate management.

Woodland expansion planning in chapter 8.3 indicates that estate land exists that does not infringe upon main priorities. The subsequent analysis identified the potential to increase woodland cover in the Highlands by 2.2% and Scotland by 1.1%, applying this approach across all estates Scotland holds significant benefit for expansion targets with an average increase of 3.6% woodland cover over case study estates, which could potentially mean an 8.9% cover increase for Scotland, if all private estates over 2,000 hectares contributed to this wide scale effort. An average of 8% of estate land is considered suitable for SRF and prime production woodland (8.4) across the case studies, showing willingness to entertain alternative woodland products and rotations. However, Chapter 8 also recognises land managers tend to reconsider woodland planting decisions, as woodland expansion often means limiting land use potential and benefit for sporting and agriculture use.

Figure 8.24 demonstrates the disparity between suitable ranges, productive woodland capacity and land managers view of woodland capacity (productive and unproductive). Despite the Highland woodland cover average of 18%, the estate average in this study is
approximately 6%, and woodland range for the estates has a top ceiling of 42% cover (Referring to chapter 8.4-5). Although forest energy is an emerging market with potential to reinvigorate woodland management and markets, further supported by chapter 8.4 results land managers are unconvinced by the ecological feasibility and lack confidence to invest or take a risk (CEBR, 2010; Roser, et al., 2011). Combining insights from the land manager perceptions of woodland (chapter 8.2), planting maps and woodland corridor maps could aid development of woodland culture in the Highlands, as well as improving resilience of woodland for the region and individual land managers (chapter 10.3 and Figure 10.1).

Integration of carbon sequestration markets have the potential to strengthen woodland culture and resilience by creating revenue and raising awareness of its wider benefits and impact, which are explicitly linked to practical management actions (Tullus, et al., 2013; Grace, et al., 2014). Integrating carbon sequestration addresses land managers concern that many management inputs go unrecognised by wider society, and integration of climate friendly action could reduce the criticism they receive for single management focus (Higgins, et al., 2000; MacMillan & Leitch, 2008). Such steps are central in realising an ecosystem approach; Carbon and Peatland Codes provide mechanisms through which lofty policy aspirations can be aligned and reconciled with practical and local management responses (IUCN, 2016; FC, 2015).

Significant gaps in knowledge, understanding and distribution of these schemes exist, as not a single land manager in this study is aware of these schemes (Chapter 9); therefore associating such options with popular zeitgeist of estate management would aid the potential contribution toward ecosystem approach practice (Pelling, et al., 2015). This in part demonstrates the need to incorporate deep seated traditions within an ecosystem approach in the Highlands, rather than attempting to overcome them. Deep commitment to sporting and recreational use is apparent in all case study areas, however, a culture of partnerships is increasing on Highland estates with demonstrated precedent of sporting syndicates, tenant farmers, Crofts and DMG (Warren, 2009; Glass, et al., 2013). This trend continues with hydro schemes being developed in partnership or land leased to private organisations for scheme development. Other land managers have leased out stalking and pheasant shooting businesses, leased land to the Forestry Commission to for woodland
expansion, and to community groups for Forest Crofts. Connecting and working with other people and forming networks is a clear strategy adaptation and diversification (Adger, et al., 2013; Horlings, 2016).

Chapter 9 identifies key collaborative actions and partnerships that could develop regional connectivity on structural and social levels. Land managers identify infrastructure upgrades, local timber hubs and linking woodland planning to spatial design of enhanced deer shelterbelts to increase landscape value of woodland management and culture. Energy and economic stability offered by hydro schemes along with development of venison and carbon sequestration markets could strengthen regional economies, if offset by financial and administration services provided by a trusted bridging organisation, which connects both horizontal (sectors, managers and supply chains) and vertical (markets, regional priorities and policy) scales.

### 10.2 Private estate resilience

In chapter 2.6 a clear need to translate, provide guidance and practical application for resilience to land managers and wider stakeholders was identified. An integral part of EA is to provide meaning and direction to concepts such as resilience and ecosystem services (Fee, et al., 2009; UNEP, 2014). This has been done for Highland estates through contextualising within the literature review, a novel methodological design that focuses on land manager interpretation of EA, leading to the mapping of resilience on a spatial scale in chapter 7. Combining this has produced a framework of private estate resilience, which also includes triangulation of interview data (chapter 7-9), landscape woodland connectivity (chapter 8), and regional collaboration (chapter 9). Articulating land manager interpretation, resulted in two tables (10.1 and 10.2) that identified both High and Low resilience factors, which were in turn scored by land managers in each case study and averaged out to reflect the EA relevance to the region as a whole.
10.2.1 Connecting resilience to an Ecosystem approach – a private estate perspective

Land managers view resilience in terms of the success and robustness of their sporting resources, this is unsurprising considering that ‘Sporting’ is the raison d’être of these estates, which over time has created a permanency for sporting use resistant to management shifts (Wightman, et al., 2002; MacMillan & Leitch, 2008). As indicated in chapter 7.2, 8.2 and 10.1 (ownership), interest in sporting use can, for some managers, cultivate an ephemeral connection as contact with the estate is short-term and irregular. Factors such as distance and infrequent visits are responsible for the low personal connection, which causes low interest in developing diverse land uses (such as woodland management). In some cases land managers have great personal interest in the estate but may have no interest in forestry whatsoever, which can create a very powerful resilience sub-culture that counters the wider societal interpretation.

As evidenced by chapters 7 and 8.2 estates have a contrasting profiles: The accessible landscape, which is open, visible and connected through fluidic shared landscape resources, and the management and business that support the internal estate aims, which for the most part remain isolated and detached from the neighbouring area (counter to CBD EA Principle 3). This introspective tendency contradicts underlying principles of a common landscape and resource, especially when applying an ecosystem approach, which encourages integration, transparency and departure from traditional boundaries (Pujadas Botev, et al., 2014). This contradiction persists at the core of estate management, raising the question of whether estates have the capacity to modify current practices to match ecosystem approach aims or whether they need to adopt new frameworks that guide integration toward the ‘common good’ (Elliot, et al., 2014), which may erode some measure of private ownership and boundaries.
Table 10.1 - Highland sporting estates link between high resilience and Ecosystem Approach

<table>
<thead>
<tr>
<th>Rank</th>
<th>High Resilience (landowner confidence)</th>
<th>Reason</th>
<th>Ecosystem Approach significance</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Economic</td>
</tr>
<tr>
<td>1</td>
<td>Sporting uses (grazing areas)</td>
<td>Private wealth (Tradition, economic and recreation)</td>
<td>***</td>
</tr>
<tr>
<td>2</td>
<td>Landscape views (no large woodland presence)</td>
<td>Private wealth and public interest (Private wealth, tradition and preservation)</td>
<td>*</td>
</tr>
<tr>
<td>3</td>
<td>Rental properties</td>
<td>Private wealth (economic and recreation)</td>
<td>***</td>
</tr>
<tr>
<td>4</td>
<td>Personal investment in livestock management</td>
<td>Private wealth (Personal preference and tradition)</td>
<td>*</td>
</tr>
<tr>
<td>5</td>
<td>Designated heritage areas (historical)</td>
<td>Public interest and support, regional significance (Preservation)</td>
<td>*</td>
</tr>
<tr>
<td>6</td>
<td>Grouse moors, sporting syndicates</td>
<td>Private wealth (economic, tradition and recreation)</td>
<td>***</td>
</tr>
<tr>
<td>7</td>
<td>Peatlands conservation efforts</td>
<td>Public interest and global significance (carbon/avian wildlife)</td>
<td>**</td>
</tr>
<tr>
<td>8</td>
<td>Riparian areas</td>
<td>Private wealth and public sector (Conservation, economic, recreation, renewable energy)</td>
<td>***</td>
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</table>

Private wealth, tradition and personal preferences drive much of the estates highly resilient areas and land uses (as shown in Table 10.1 and chapter 7). This makes the adaptation of private estates to new uses, change and inclusion of more publicly driven motives a challenge. Both peatlands and heritage sites restrict activity due to their environmental and social value, which encroaches upon the land managers’ decision-making scope, and is symptomatic of the disjointed relationship between planning and practice (Scott & Shannon, 2007). Land managers frequently state (see chapter 7.2 page 141-2) that estates are consistently under pressure as multiple stakeholders (RSPB, FC, SNH) have land use priorities that are incompatible with the estate’s aims (Munton, 2009).
In this form, diverse aims support single objective land management due numerous individual agendas being pursued by multiple organisations to the point that cooperation is often viewed more as coercion (Davies & White, 2012; Maffey, et al., 2013). Such a trend demonstrates the vulnerability of overarching top-down estate management approaches (Redpath, et al., 2013), which are often susceptible to the dominance of economic drivers over the social and environmental aspects of sustainability (Quine, et al., 2013). However, in this case, economic drivers are reinforced by land manager motivations (Wagstaff, 2014). This current platform highlights the difficulty of cross scale cooperation, especially for managers seeking to innovate but lacking the necessary knowledge or tools.

Implementing a management approach that integrates multiple socio-ecological aims runs the risk of becoming overly concerned with valuation systems (Daily & Matson, 2008; Carpenter, et al., 2014). As the creation of tangible and measurable outputs for ecosystem services aim to convince land managers seeking greater revenue and management recognition (Chapter 7 and Chapter 9.4 in reference to ecosystem services and unaccountable management inputs) (Fontaine, et al., 2014). Such approaches may shift focus away from areas of the estate that possess low resilience and have potential for longer-term development. Based on the analysis of landscape resilience in Chapter 7.5 and the cultural drivers in Chapter 7.2 - 7.3, Table 10.2 (below) highlights the areas of low resilience on estates (lack of adaptation and low confidence). These areas have been characterised as possessing low resilience due to the lack of immediate return and measurable short-term outcomes and unstable states that do not inspire confidence.

Table 10.2 – Highland sporting estate areas of low confidence which exhibit low resilience and an Ecosystem Approach

<table>
<thead>
<tr>
<th>Rank</th>
<th>Low Resilience</th>
<th>Reason</th>
<th>Economic</th>
<th>Ecological</th>
<th>Social</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Unmanaged and windblown woodland</td>
<td>Lack of ability to be converted or restructured, seen as a deficit and will remain</td>
<td>-</td>
<td>*</td>
<td>-</td>
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As demonstrated throughout the result chapters (7-9), and evidenced in Table 10.2, land managers have low confidence in woodlands (Lawrence & Dandy, 2014). This is further supported by their response to plantation woodland, planted for productive objectives. Commercial forestry is given a low priority amongst management options due to: i) the lack of grants incentivising production goals; ii) confusion amongst land managers in understanding various silvicultural approaches; and iii) underestimating the impact of woodland services and benefits, as a key ecosystem regulator for the landscape. Many of the low resilience areas are acknowledged by managers as being vital for encouraging ecosystem approaches in the Highlands (integration, employment and emerging markets) but appear to become low priorities with the prospect of management intervention. This

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<tbody>
<tr>
<td>2</td>
<td>Commercial woodland</td>
<td>Lack of confidence, policies and intermediate return</td>
</tr>
<tr>
<td></td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>3</td>
<td>Mixing uses or creating useful transitional (fringe) areas</td>
<td>Management costs, unbeneificial to main land uses, resistance to change</td>
</tr>
<tr>
<td></td>
<td></td>
<td>***</td>
</tr>
<tr>
<td>4</td>
<td>Utilising vacant land</td>
<td>LFA grants more appealing than encouraging new land use. Land capacity is viewed as unproductive – often around boundaries</td>
</tr>
<tr>
<td></td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>5</td>
<td>Emerging regional markets</td>
<td>No proven track record, lack of encouragement, unwilling to take risks</td>
</tr>
<tr>
<td></td>
<td></td>
<td>***</td>
</tr>
<tr>
<td>6</td>
<td>Rural knowledge and skillsets</td>
<td>Lack of work, community deterioration, centralisation of agencies</td>
</tr>
<tr>
<td></td>
<td></td>
<td>**</td>
</tr>
<tr>
<td>7</td>
<td>Conventional rural employment</td>
<td>Changing structure of environmental sector and ability of estates to employ permanent and diverse staff</td>
</tr>
<tr>
<td></td>
<td></td>
<td>***</td>
</tr>
<tr>
<td>8</td>
<td>In-migration/Out-migration</td>
<td>Lack of work (diversification of rural economy), lack of community infrastructure, centralisation of urban areas</td>
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</table>
gap between concept and action transmits to most of the case study estates, resulting in limited engagement and interaction with the broader landscape (Glass, et al., 2013).

An ecosystem approach to management requires a level of understanding and knowledge about the medium/long-term trade-offs and the interaction between low and high priority land uses (Raudsepp-Hearne, et al., 2010; Quieroz, et al., 2015). Woodland planning and management on private estates continue to operate on a disjointed short-term cycle without purposeful longer-term planning (as evidenced throughout chapters 7-9). A landscape dominated by private estates would encounter difficulty interpreting and implementing ecosystem approaches to management (Elliot, et al., 2014; Olsson, et al., 2015), as diverse timeframes and planning periods are required to work in unison. The main focus of estate cycles are on sporting resources seasons that occur annually, including rental property, even the grouse shooting syndicates’ cycle every fifteen years (Chapter 7 and 8). These periods are incompatible with conventional woodland planning and outputs, which are currently frustrated by slow plan formation, communication with agents and lack of flexibility (Chapter 8). An EA could align these two separate streams of management planning into a dynamic estate plan designed to enhance the benefits from multiple services (Batt, et al., 2013).

Tables 10.1 and 10.2 inform the development of a practical ecosystem approach (EA) in which woodland management is a focal point, assessing the level of EA readiness and potential indicators. Table 10.3 presents connections between main resilience factors and their influence upon increased resilience strategies, to potential practices and operational development. Connecting resilience to practice is the next stage of designing management strategies that aim to develop an applied ecosystem approach. This could be described as science in transition, drawing upon social-ecological systems to formulate practical responses to new landscape management challenges (Seastedt, et al., 2013; Collier, 2015).

10.2.2 Linking resilience with practice

Table 10.3 shows the progression from estate resilience (interpreted and defined by the land managers incorporated with established concepts) to operational components of a
specific ecosystem approach applicable to Highland private estates. Chapter 2 identified the need for operational guidance and regional specific targets for resilience practice (SG, 2015), as well as collaborative structures and spatial planning playing a pivotal role in resilience over large landscapes (Cumming, 2011; Curtin, 2014). Chapter 7 developed insights into cultural land use drivers that influenced practice and landscape implications of land use management on a spatial scale. A range of indicative practices have been developed by combining the analyses of woodland expansion areas, forest energy compatibility, and collaborative discussions (Chapters 8 and 9).

Table 10.3 – Impact of resilience on ecosystem approach processes and potential practice for Highland sporting estates

<table>
<thead>
<tr>
<th>Resilience practice</th>
<th>Main development need</th>
<th>Key operations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Management responsive to land use timescales (planning and mixed use)</td>
<td>Integrating sporting and woodland plans with shorter aims and outcomes</td>
<td>➢ Quicker production of adaptive plans to mitigate slow management response and action</td>
</tr>
<tr>
<td>Adding value to woodland resource</td>
<td>Mixed silviculture approaches (multi-aged, species and production)</td>
<td>➢ Carbon market integration; greater awareness and support for increased woodland resource production</td>
</tr>
<tr>
<td>Landscape scale approaches for ecosystem connectivity</td>
<td>Collaborative and administrative management</td>
<td>➢ Key administrator organisation to connect landowners, networks and agencies; agency support and involvement; ➢ Buy-in packages and regional zones</td>
</tr>
<tr>
<td>Ownership interaction and support</td>
<td>Utilising diverse agendas to increase engagement, as well as management capacity</td>
<td>➢ Provide supportive environment to facilitate alignment of mixed ownership priorities; ➢ Expand DMG’s remit; ➢ Focus on core conflicts across ownership boundaries</td>
</tr>
<tr>
<td>Appropriate grant design</td>
<td>Accessibility, flexibility and utility of grants for specific and mixed land use goals</td>
<td>➢ Regional, collective, Energy, Ecosystem, multi-silvicultural grants; ➢ Adaptive to spatial and temporal requirements; ➢ Support emerging markets (energy and carbon)</td>
</tr>
<tr>
<td>Sustainable communities</td>
<td>Integration of communities in rural economy and increased economic, environment and social links</td>
<td>➢ Stronger links between estates and community groups; Involvement in LP’s; ➢ Forest Crofts and syndicates; ➢ Increase community participation and investment in landscape management; ➢ Synergy between renewable diverse renewable energy</td>
</tr>
</tbody>
</table>
Sasaki et al., (2015) suggest ecosystem resilience could be based in scientific evidence by first identifying key ecosystem functions that confer ecosystem resilience, such as species and diversity within localised context. Secondly ecological appropriate thresholds need to be identified, establishing ecosystem health indicators that can shift management from precautionary to more practical action to cope with uncertainties (Naeem, et al., 2012). In Scotland or more specifically on Highland estates Red deer could be used as an indicator in relation to woodland and natural regeneration. Most estates carried between 12-14 deer/km², which most estates agreed is a good number despite a few managers favouring an increase in numbers (Interview transcripts and estate land use reports). However, for natural regeneration to be successful in the Highlands around 4 deer/km² is recommendation (Bunce, et al., 2014). A balance between the ecological and the socio-economic threshold would need to be established and tested for ecosystem resilience. Regional woodland production capacity could be another indicator for a healthy forestry sector providing baselines for demand, capacity of transport routes and infrastructure development; additionally forest energy market could be a more specific indicator of regional energy sustainability. A whole range of indicators could be established and used by land managers, DMG’s and other managers in partnership with a trusted organisation, such as a National Park to further ecosystem resilience management. Landscape resilience (chapter 7.6) and collaboration maps (chapter 9.4) could aid in the identification of key ecosystem functions (Cumming, 2011; Sasaki, et al., 2015) and developed with greater detail in concert with regionally relevant landscape partnerships.
The proposed Landscape partnerships (Chapter 9.5) could be central to establishing a network for increased resilience. Their operational scope and organisational structure would be vital in guiding and informing a local EA, which attempts to bridge the knowledge-action, theory-implementation and science-policy/management gaps that continually undermine coordinated practice (Roux, et al., 2006; Gaffey, 2008; Arlettaz, et al., 2010; Cook, et al., 2013; Swilling, 2014). This highlights the shifting focus to resilience design and the departure from conventional planning, stemming from collaborative processes, interpretation, knowledge development and dynamic approaches that integrate individuals and organisations in the long-term to effect change (Curtin, 2014).

Results from Chapters 7-9 inform the operational and development column in Table 10.3 through triangulation of land use drivers, planning and engagement with land managers, and potential organisational support. Practical approaches developed by active managers are important to bridge the policy-practice divide (Walker & Salt, 2012). Table 10.3 highlights the necessity of local level analysis to underpin regionally appropriate adaptive processes by distilling the results and themes from chapters 7-9, which unpack the key processes of an applied ecosystem approach. Identifying resilience attributes could organise an explicit understanding and utility of the local environment, which could be incorporated into effective landscape management practices, beneficial to multiple land managers.

Glass et al., (2013) developed a sustainability toolkit based upon consensus building of seventeen Scottish upland estates under mixed ownership. This created a framework of five principles (Adaptive management, Broadening options, Linking into social fabric, Ecosystem thinking and Thinking beyond the estate) and twelve actions indicative of operational practice and gives multiple parties the ability to assess an estate’s progress on delivering a series of practical management actions. This research goes a step further in three ways firstly by basing the research on two scale of land manager and groups of contiguous land manager, secondly through the iterative one-on-one interaction with the land managers while traveling through their estate and daily routines and thirdly by spatially mapping targeted land manager action and ecosystem thinking. Providing ecosystem management indicators, such as woodland planning, infrastructure networks,
timber hubs that could be incorporated into estate and regional management plans. However, a tool that can evaluate estate’s progress toward sustainable practices from multiple ownership perspectives is valuable for a more comprehensive view of interconnected land use. Cockburn et al., (2015) emphasise the importance of building collaborative capacity and social capital in science-action partnerships that rely on the process of transdisciplinary research to produce more applicable science, management and policy objectives, which bridge the conceptual and practical.

Tracing multiple functions of scale within resilience is important to understand the collaborative links between individuals, groups, regions and other subsets of scale (Hegney, et al., 2008; de Groot, et al., 2010). Rural growth and stabilisation of local economies require strong networks and partnerships to manage landscape management interests (Adams, et al., 2014). Through greater administrative powers (collective action, reduced transaction costs and more efficient management approaches) over smaller, but increasingly connected regions, partnerships could bridge scales and align private estates more closely with public interests and create an operational management framework over a larger landscape scale (Curtin, 2014). A lack of connectivity could account for land managers’ tendency to act singularly, emphasising the importance of geography in isolation, as well as long standing relationships and norms of communication.

The appropriate operational scope of landscape scale management is an uncertainty for many practitioners and land managers and requires the flexibility and explorative function of adaptive capacity to negotiate effective working relationships over multiple scales. Finding common opinions during the case study area discussion groups (5.2.7 and 9.5) was not difficult; however, drawing out potential agreements on spatial planning and practice over three estates was extremely challenging. In practice, the prospect of trialling concepts and different approaches quickly disappear when commitment from land managers and estate resources are required.

Widely understood levels of governance will be crucial for improving management of landscapes, particularly in addressing transaction costs and overcoming barriers
Composition (individuals, agencies, sub-groups) of partnership agreements will impact the interpretation of ecosystem management in different regions. Mekenzie et al., (2013) suggests that top-down collaborative agreements (government led) could benefit local-scale feedback, facilitating local scale collaborative structures and increasing connectivity between landscape scales. However, the type of structure described by Mekenzie et al., can be seen within the proposed Landscape partnerships (9.5), but these agreements rely on hybrid organisation that is supported by the government but not answerable to them. Reflecting more a bridging/enabling body as opposed to a regulator. Many land managers are dissatisfied with current top-down government programs, which threaten to shift from voluntary to mandatory structures (such as joint development of Deer plans) and are more willing to place their trust in a less traditional organisation. Such an organisation could channel grants and direct actions of mutual benefit to the region, as well as establishing additional beneficial structures, such as carbon trading platforms. It would operate under partnership agreements that focus on an administrative structure driven by common goals. Flexibility would be necessary to alleviate pressures on spatial planning (singular land use, infrastructure) and timescales (as described in chapter 8.1) in order to support the grant structures that encourage greater engagement with working landscapes (Lawrence & Edwards, 2013).

Research on resilience and rural economies has generated a significant body of papers, strategies and position documents (SG(a), 2010; Steiner & Markantoni, 2013; Folke, et al., 2010; Gunderson, 2000; Haines-Young & Potschin, 2010; Raudsepp-Hearne, et al., 2010; Redpath, et al., 2013; Skerrat, 2011; McMorran, et al., 2014). However, the challenge remains to translate resilience into meaningful rural landscape practice (Carpenter, et al., 2009; De Groot, et al., 2010; SLUS, 2011). Table 10.3 identifies a strong potential synergy between diverse renewable energies (Hydro, forest energy and solar) and joint complementary use on estates and over case study areas. Upgrading grid connections that take into account potential growth and other inputs are key to such development. Forest energy and hydro schemes were identified by land managers as compatible joint energy and landscape priorities for estates (Chapter 8 and 9). Cultural acceptance for
these joint energy developments is necessary for creating impetus over diverse landscapes (Warren, et al., 2016). The unequivocal acceptance of hydro-schemes is evident, whereas wind energy is unanimously unpopular over the case study areas, as they are viewed as damaging to the land and landscape (Slee, 2015). Land managers convey the importance of confidence throughout the process, indicating that the impediment (establishment, economic returns, maintenance and lack of interference with other land uses) of hydro-schemes may affect future willingness to adopt further renewable schemes or collaborative ventures. This point underlines the impact of new areas of social and community resilience that examine the role of character and infrastructure of place, which shape adaptive responses (Lyon, 2014). Establishing practice and tailoring interest to local stakeholders may influence the effectiveness of renewable energy ability to mitigate such issues as fuel poverty over multiple regions (Atterton, et al., 2011).

Diminishing forestry knowledge and the need for ecosystem management practitioners are emerging, highlighting the need to foster rural expertise (Oosthoek, 2013; Dandy, 2016). This could be supported by the administrative structures of LP’s (Chapter 9.5), which would coordinate and organise a network of skills across regions. Restructured grants to support rural skillsets and employment, as well as influencing fundamental changes in education and training could help to address the decreasing primary sector employment and community migration in rural areas.

Sustainable communities are not a substantial concern for many estates, especially to ongoing management, which is emphasised by the high response of communities to the buy-outs (Rennie & Billing, 2015; McHarg, 2016). However, one land manager increasingly relied on local community enterprise to support their land use businesses, including sporting leases and forestry crofts (chapter 7.4.2). Without the community buy-in this land manager would be unable to benefit from the management and business potential of the estate. Reliance upon government-led efforts to bridge the gap between stakeholders over the landscape can lack the immediacy and adaptive capacity of the private sector working together with community investment (SG(b), 2010; SG, 2015).
Increased stakeholder involvement and diversity of business opportunities may provide a measure of alleviation to the ‘low confidence’ driver that has undermined woodland expansion, integrated land use and rural development efforts on estates (See chapter 8 – re-engaging people with the forestry sector) (SG, 2011; WEAG, 2012). Partnerships that spread the risk and improve the rate of return (security) could offer potential to produce greater regional resilience through a sense of stability, connection and confidence (SCDC, 2011). Glass et al (2013) recognised that more inclusive representation across sectors and scales was necessary for effective partnerships and upland estates will be one component of these partnerships. Establishing effective areas and projects that recognise and promote the practical components of landscape scale management would validate the approach and build local land manager confidence (SG, 2011; Hamilton-Peach & Townsley, 2004), which could add value to woodland resources and enhance landscape connectivity. Woodland management and landscape approaches are also strongly connected to longer timescales (chapter 8.2) (Nijnik, et al., 2016), which highlight the land managers viewpoint that time is a restrictive element for production, influenced by annual income, bureaucracy and personal outlook (many land managers acknowledge not looking beyond the next 15-20 years due to life expectancy).

A major concern and restriction for land managers is the slow production of management plans by external agencies, which affect implementation and adaptive response of estates to develop wider impacting plans. Responsive plans that operate on shorter term goals within longer timeframes could lead to increased integration of land uses, developed by greater communication and dialogue between managers and agencies (Chapter 7.2, 8.2 and 9.4). A short term productive land use plan would complement long-term planning as adaptive practices would turn land use “…from a waiting game to a doing game” (Balmoral).

The level of ownership interaction and support (Table 10.3, Chapter 7.2) affects land management potential, which will influence capacity and inclusiveness of landscape-scale partnerships (Glass, et al., 2013). Tapping into the passions that drive ownership
(Chapter 7.2) is key to connecting land use to investment, which will represent diverse, marginalised and neglected uses over the landscape (Warren, et al., 2016). Contrasting land ownership patterns across boundaries is identified in Chapter 8.6 as a necessary component for building greater partnership capacity. Although mismatched agendas have hindered land use agreements (Chapter 7 and 8) (Morgan-Davies, et al., 2015), they can also increase engagement and resolve core regional issues through innovative approaches (Fiorini, et al., 2011; Cockburn, et al., 2015).

### 10.2.3 Woodland resilience

Research and policy relating to improving the resilience of forestry in Scotland primarily focuses upon resistance against pests and pathogens, as well as adaptation of species to climate change (Cavers & Cortrell, 2015). This strategy promotes the use of native species, high quality genetic stock from locally adapted provenance rather than imported stock from Eastern Europe or exported nursery stock to the continent where species phenotypes are adapted to different conditions (Neale & Kremer, 2011; Gilligan, et al., 2013). Forestry Commission Scotland promotes local provenances as local stock has greater adaptive ability to cope with climate change (FCS, 2008; FCS, 2009; FCS, 2015). However, planting schemes have been impeded by limited supply of local seed stock for the majority of species, as well as poor and fragmented knowledge of genetic distribution, location and suitability (Cavers & Cortrell, 2015). Land managers advocate the enhancement of local genetic stock to produce higher quality timber (Chapter 8.2) but highlight the low availability of such stock in their areas. The degradation of genetic resources and local provenances [land manager view] is the cause of investment in exotic species, unsuitable planting strategies and deterioration of silvicultural practices.

As chapter 2.6 identifies land managers view woodland resilience through a socio-economic lens, which includes protection of river banks, shelterbelts and small-scale amenity woodland, as they support sporting objectives (chapter 8.2). Whereas timber production is generally classed as a low priority (Stated by land manager on every estate). The threat of pests and pathogens and the uncertainty this created for management is a deterrent for future planting. Compounding this issue is existing woodland that continues
to undermine future forestry prospects, as unmanaged and damaged woodland are
diminishing the potential value of the estate (Chapter 8.2 – Eyesores). The inability to
restructure or extract timber cost-effectively has increased the resilience of existing
estate activities and uses, creating resistance to change/adaptation, even if beneficial.
Static areas such as these are strongly linked with practical management difficulties
(Chapter 7, section 7.5) and lock estates into cycles that perpetuate more segregated and
traditional uses. This is an example of wicked environmental problems afflicting Scotland
and the forestry sector (Duckett, et al., 2016).

Land managers view development of productive woodlands as detracting from sporting
resources and therefore weakening the resilience of the estate. Sitka spruce is considered
the only practical option for timber production due to high yields [Land manager –
Chapter 8.2]. However, continued timber production in monocultures may cause further
vulnerability to pests, pathogens and climate change (See chapter 8.2 and (Cavers &
Cortrell, 2015; Wainhouse & Inward, 2016)). Although greater species diversity in
productive woodlands is likely to increase resilience (O’Hara, 2014), this approach
counteracts the traditional view of viable production [land managers, see chapter 8.2] and
would appear more risky to managers, despite grants for native broadleaf planting.

Clonal forestry is considered one avenue for improving the quality and production of
timber in Britain (Park, 2002), which would be beneficial to short rotation forestry for
woodfuel, as the diameter and uniformity of the timber could increase by 60%, which
could impact the markets and increase carbon sequestration rates (Lee, 2009). Historically, less work has been done on breeding and selection of hardwoods due to
lower economic returns compared to conifers. Cavers and Cortrell (2015) highlight
practical barriers to enhancing and diversifying tree populations, including poor
generational turnover (disruption) caused by overgrazing, habitat loss and fire
prevention measures. This emphasises the disruption of woodland development and
adaptive capacity over an extended period of time in the Highlands, which requires
management strategies to recover and re-establish consistent and uninterrupted
woodland successions within diversified species-structures (Chapter 8.2 – persistence of
unhealthy woodland structures) (Mason & Connolly, 2013). These actions would increase resistance to future pests and pathogen vectors, and therefore enhance the resilience of woodland structures within estate objectives and planning.

A landscape framework that places productive woodland and increased species diversity as a priority connecting to carbon trading and hydro schemes in balance with sporting use could be beneficial to estates’ long-term resilience (Progressively described through chapters 2.8, 7-9). Short rotation forestry (SRF) or regional energy woodland may kick-start further productive aims and increase the importance of healthy woodland and quality timber in the view of land managers and the Highland landscape (Chapter 8.4) (Roser, et al., 2011; SFTT, 2014; Dandy, 2016). Frameworks and strategies such as Flexible Adaptation Programs (FAP’s), which deal with a set of small but clearly defined goals (Moss & Martin, 2012) could develop of SRF plans in parallel with longer productive rotations. FAP’s may provide a short-term solution for managers experiencing planning and implementation difficulties by gathering important data, aiding cooperation between stakeholders and identifying areas for immediate action and further adaptive management response (Moffat, et al., 2014). Wise et al (2014) argue that the environmental management sector expends too much time and effort on identifying impacts and vulnerabilities of practice rather than interconnecting a range of alternative policy options with natural and social management approaches. Generating impetus through management lessons and action has greater chance of influencing social change for land managers than uncertain and transient policies (Plieninger & Bieling, 2013; Lawrence & Ambrose-Oji, 2015).

Slee et al. (2014) refer to the ‘squeezed middle’ where competing land pressure is highest for agricultural land, woodlands and sporting resources in Scotland. These areas are resistant to change, dedicated mostly to agriculture and sporting use with little room for woodland expansion, which is corroborated by chapters 7-9. Results chapters also provide evidence that these areas of competitive land are often protected by the shield of tradition but continue to remain vacant. In the case study areas managers would only entertain utilising these areas, if multiple objectives and products could be produced over
varying timescales. The Scottish Land Use Strategy (2011) and other similar instruments are designed to be pathways to transform this middle area to a more resilient area, able to adapt to change and competing agendas (Slee, et al., 2014). These documents should broker knowledge into management actions for land managers in tandem with other organisations that are tackling resilience issues (Chapter 2.6 e.g. Sniffer). The ‘squeezed middle’ represents a limited but important percentage of the land in the case study areas (Chapter 6, 7.5, 8.3-6 and 9.4), including improved grassland, pastures and lowland grazing areas, the remainder considered unproductive for forestry and fertile grazing areas (according to the LCA) (Bibby, et al., 1991). For the case study estates these areas (designated most suitable for agriculture) are free vacant; however, planting woodland is viewed as a waste of the land’s productive capacity. Although land managers identify improved grasslands, declining agricultural grazing and old deer feeding sites as suitable for SRF (Chapter 7.5), they remain safeguarded, as integrated approaches or greater woodland cover as are considered damaging. A partnership approach would be able to facilitate management knowledge, expertise and planning to the individual, closing the gap between the forestry/agricultural divide, by providing incentives though market opportunity, support and networks, reorientating social perceptions of land use in the region (Deal, et al., 2012; Curtin, 2014).

10.3 Re-interpreting woodlands
Knowledge based upon historical assumptions, inherent management difficulties of upland areas and increased transport costs explains land managers’ tendency to overlook the potential of productive forestry in the Highlands (Hobbs, 2009; Lawrence & Dandy, 2014). This section revaluates the role of woodland and productive forestry for the private estates in the Highlands. These are key factors in understanding and mobilising an ecosystem approach through woodland improvement whereby management and production could become an important driver. Misconceptions of woodland capacity in the Highlands has marginalised a once strong component of the rural economy (Oosthoek, 2013), which has since been reduced to a mostly recreational feature with a narrow physical range and species structure, a deteriorating provenance, and public profile (Mason & Connolly, 2013).
Past management has a profound effect on the biodiversity of Scottish woodlands (Tipping, 1991; Smout, 1997; Smith, 1998). Substantial loss of woodland resource occurs as felling (or fragmenting) for sporting and agricultural results in reduction of species range and habitat complexity. Woodland structure and composition has been dramatically simplified over the years by a single systems approach (Lindsay, 1975; Cavers & Cortrell, 2015). Additionally, overgrazing by deer (*Cervus elaphus*) and the absence of successional timber resources has had a deleterious effect on habitat quality, old growth trees and timber production (Bunce, et al., 2014). Increasingly, woodland and land use is being looked at from an integrated and landscape perspective, which has become embedded in national policy. Such approaches continue to require greater development and practical implementation (Mason, et al., 1999; SG, 2006; SG, 2011).

These strategies have led to Forest Habitat Network (FHN) concepts, which implement landscape scale planning, emphasise core forest areas, corridors and links between woodlands (Peterken, 2003; Plantlife, 2011; SG, 2006; SG, 2011; WEAG, 2012). However, clear FHN concepts focus on biodiversity enhancement at landscape scale and do not link the drivers affecting individual land managers to regional scale factors. Central to this consideration, especially in a Highland context, is the balance between wooded areas and open ground (SNH, 2000). This dichotomy is core to the woodland expansion issue and the policy stance ‘that more woodland is better’ and isolated patches should be connected to improve regional land use (Humphrey & Quine, 2006; Bunce, et al., 2014) is seen as a threat by some land managers.

A finite amount of land was considered suitable for woodlands by land managers in this study (See chapter 8.3, *Figures 8.2 - 8.5*). Expansion was limited by biophysical, economic and landscape factors but dominant sporting use priorities and negative perceptions of woodland obstructed greater consideration. These factors have progressively altered land manager perception of woodland range and woodland capacity, highlighting the powerful influence of landscape narratives and personal preference on the composition of the landscape (Schama, 1996; Antrop, 2005; Taylor, et al., 2015). Such influences have
the power to perpetuate management practices across regions and generations, creating layers of inherited values and local knowledge that may work against innovative woodland management (Robbins & Fraser, 2003; Dandy, 2016).

Figure 10.1 – Fostering knowledge and innovation for a sustainable woodland economy
Figure 10.1 summarises feedback from land managers, presenting interconnected themes and approaches that could develop an enhanced and integrated woodland management culture. Few land uses could be separated from sporting management over the case study areas (land managers’ perspective). Therefore in planning new woodland areas the first priority is to deer feeding sites and shelterbelt design; woodland size is restricted by the potentially disruptive effect of larger stands on deer movement.

Figure 10.1 will be referred to throughout Section 10.2, highlighting the manner in which woodland can benefit estate practices. For higher cultural value to be placed upon woodland by land managers a clear link needs to be established between increased woodland (management) and sporting use (e.g. reduced deer mortality, increased health (weight) and reduction of parasites). Such links will require support from grant systems, carbon management and intelligent forest design to convince land managers of overall benefit for the estates. To cultivate awareness of the potential benefit of woodland investment to the economic, ecological and cultural aspects of estates, woodland management needs to be recognised as a core component. In a public policy context this research can inform the efforts of the Woodland Expansion Advisory Group by providing regionally specific data about land manager motivations, challenges and areas for potential planting to aid the government’s expansion targets. Several policy recommendations emerged from the research to encourage increased woodland management and production:

➔ Restructuring current woodland as a gateway for further expansion and healthy landscape corridors (Improve woodland, unlock the land for replanting, feed spruce and pine stands into forest energy market. Allowing land managers to convert stands that are inhibiting their activities into potentially useful areas)

➔ More appropriate timescales and management margins for woodland establishment and productive rotations to support regional and national markets

➔ Collective and collaborative grants (Including Deer landscape enhancement, multiple parties for joint transboundary projects, infrastructure upgrades and grid connections)
Forest energy grants (As part of a silvicultural treatment for improved woodland health and supply chain development)

Integrating woodland management with carbon sequestration aims and payments

Ecosystems management grant scheme (a collective suite of cumulative grant actions resulting in certification, which could include the Energyscapes concept and Landscape partnerships)

Productive broadleaves with identified species mixes and stand rotation aims

Multi-aged woodland

Training and expertise grants (capacity building and education)

Peat depth guidance flexibility for suitable planting areas (Using a 0.5 metre marker through landscape-scale mapping severely limits woodland expansion potential, which overlooks more localised areas suitable for planting with less than 0.5 metres of peat)

10.3.1 Knowledge, perspectives and awareness

A reoccurring issue raised by land managers is the lack of local knowledge incorporated into external management decision-making, resulting in disjointed planning. The absence of such processes on some estates, creates an aversion to agency support and advice for some land managers. Blennow, et al., (2014) describe this as ‘knowledge risk’ in which management priorities and experience of a manager can override logical actions, such as remedial thinning or structural design to reduce windthrow risk. Development of effective communication streams that convey technical expertise to land managers (Carpenter, et al., 2009) is a persistent barrier for woodland expansion. In theory, management plans and agents are the means of communicating expertise and knowledge to estate land managers. However, the timing of consultations and production of plans sometimes fail to meet land managers’ expectations (Figure 10.1 - Cross agency cooperation).

Information platforms, such as user-friendly computer based support tools (Forest Energy Tool, Chapters 6.2.5 and 8) can be used to support decision-making. These handle large datasets and account for complex interactions whilst providing accessible options
for local level woodland planning (Humphrey & Quine, 2006). Such tools may provide a more direct and practical guide for managers to assess management options. Land managers responded positively to the Forest Energy Tool, surprised by the potential profitability of woodfuel markets and carbon sequestration but are concerned over the extent of investment and timescales for returns (Chapter 7.1 Profit centres and 8.2 land manager deterrents). A further advancement of the tool could incorporate capital investment rates and multiple production aims.

Most land managers admit that declining forestry-related expertise prevents regional and national forestry sector from competing with other European forest industries (Cameron, 2011). This is partially due to the heavy reliance upon imported timber and the shortfall of domestic timber markets in the Highlands and across the UK (FC, 2011). UK imports account for 80% of all wood (production + import) in 2013, all grades of imported wood products have increased from 2012-2013 with the exception of a 3% decrease in paper and pulp imports (FC, 2013). However, wood pellets imports have increased by 128% (FC, 2013), which highlights the emerging importance of forest energy markets and the potential for increased supply of woodfuel and timber products (Figure 10.1 Species diversity and multiple rotations for diverse products). The areas identified in chapter 8.3-8.5 could guide an expansion strategy across regions for private estates.

10.3.2 Encouraging quality woodlands
Land managers generally agree that forestry needs to be more appealing to compete for greater consideration (spatially and management-wise) on estates. Primarily, this notion refers to greater economic benefits but increasingly evidence is needed that woodlands are capable of enhancing the value of the estate in a similar way to sporting management and hydro schemes. Ongoing discussions on the value of ecosystem services to society presents forest management with the challenge to describe, assess and deliver the benefits of forest ecosystems (Mason & Mencuccini, 2014). A forest ecosystem that includes productive objectives will need to demonstrate more frequent economic returns alongside increased environmental status, which is then recognised and supported through grants and public support (Figure 10.1 Adaptive grants).
Several suggestions came out of the discussions to improve management approaches (Figure 10.1 Mixed rotations and Diversify species) such as individual tree management (Horticultural approach), improvement of genetic stock (see section 10.1.2), diversifying species (native broadleaves and some potentially productive non-natives), and encouragement of a more complex woodland age structure (Bunce, et al., 2014; O’Hara, 2014). Investing more time in management to create multiple productive rotations is viewed as being a desirable scenario but implementation of new practices prevents change. The crucial issue remains, ‘the buy-in’ factor or package, which is challenging to sell as reduced costs, increased profits, greater management support and security for long-term investments requires time and organisational structures (Reed, et al., 2014; Austin, et al., 2016). This could take the form of financial incentives, such as the carbon code, partnerships or enhancement of public profiles.

Land managers unanimously advocate better approaches to the integration of woodland management, deer management and agriculture but refer to, “managing the woodland sympathetically”, reducing the importance of woodland in comparison to primary land uses. The Invermark manager refers to the efficiency of systems used in Scandinavia and on the continent, which focusses on single-tree management and produces higher quality timber (Horticultural approaches Figure 10.1). O’Hara (2014) states that plantation forestry (even-aged) and new approaches that diversify forest structures (multi-aged) use common tools and procedures, and therefore choosing a different silviculture option may not be such a dramatic change as initially envisioned by many of the land managers.

10.3.3 The role of Sitka spruce and woodland mixtures

Land managers consider Sitka spruce (Picea stitchensis) as the only viable option for productive woodland due to the rate of growth and high yields (Chapter 8.2/8.4). Sitka spruce elicits ambivalent responses from other land managers as it has the status of being the most commercially valuable species (Mather, 2003), yet is viewed as a cause of native woodland deterioration and unattractive landscape views (8.2) (Nijnik & Slee, 2008). Supporting the position of the Land and Deer Taskforce that, “the Highlands is dominated
by coniferous plantations in a landscape once dominated by a greater complexity of habitat mosaics” (LDT, 2013).

Sitka spruce is likely to continue to dominate productive woodland in Britain and particularly Scotland. Mason and Mencuccini (2014) suggest that Sitka spruce has not been used to its full potential in the Scottish landscape, and as a commercially valuable species may provide greater contributions to ecosystem services than originally acknowledged. Woodland strategies aiming to encourage expansion of productive forestry would be remiss, if Sitka spruce was not given a central role as the most profitable species (producing the highest yields in the shortest time) (Cameron, 2011). In recent years there has been growing interest in Britain in producing mixed species stands to address the ecosystem services remit and facilitate adaptation to the diverse suite of demands on today’s forests (Quine, et al., 2011). However the majority of land managers in the case study areas narrowly define mixed woodland as Scots pine and birch with amenity objectives (chapter 7 and 8). Scotland aspires to increase its planted woodland diversity, which includes different silvicultural approaches and a broader range of species used in plantation structures (Grant, et al., 2012). Sitka spruce and other traditional plantation species are viewed by estates as best managed as monocultures and considering integration of traditional plantation species with multiple structure/objective woodland is a difficult change to accept (7.2 and 8.2/8.4). However social attitudes are aligning strongly with conservation based objectives, which favours native woodlands, finding strategies and practice to integrate Sitka spruce with native woodland and increased diversity will be a crucial foundation for a healthy Scottish forestry sector (Nijnik, et al., 2016).

In spite of interest in cultivating mixed stands to increase woodland resilience to climate change (Mason, 2006; Bolte, et al., 2009; O’Hara, 2014), mixed stand creation in Britain is low, so it is difficult for practitioners to understand and implement the best species mixes on suitable sites (Mason & Connolly, 2013). Further research and integration of these factors into decision-making, especially in Highland areas, will help to identify potentially resilient areas suitable for producing enhanced ecosystem management. Planting small areas of hardwoods on certain estates (chapters 8.2 and 9.3) is viewed as a positive move.
toward ecosystem management; however, more extensive areas and hardwood production objectives are not beneficial to overall estate management according to land managers. This emphasises the lack of silvicultural understanding on the case study estates and a deeper cultural aversion to productive woodland management that uses mixed species and produces multiple products.

Differences between first and second rotations (Chapter 8.3) are important to stand development, as the role of complementarity over time shows that benefits have increased and persisted over decades, enhancing factors that may not be evident in the establishment phase or initial rotations (Binkley, 2005; Pretzsch, 2009; Zhang, et al., 2012). Mixtures of conifers and oaks have proved beneficial over long periods of time in upland Britain, as benefits are often unidentifiable until stands mature (Gabriel, et al., 2005). This signifies that the benefit of species mixes and the resultant quality of the rotations depends on facilitation, complementarity, provenance and site suitability, as well as the functional interactions over time, wherein various species dynamics and enhancement may not emerge until advanced stages of stand development. This also affects the flow of ecosystem services into the local environment (Lavorel, 2013). These sets of interacting components underlines the long-term investment needed to produce diverse and productive woodlands, which does not match the shorter timescales of estate management and planning (Chapter 7.2/7.4/5 and 8). This represents significant investment for estates in woodland that currently does not exist and an understanding of stand dynamics, generational succession and specific product cultivation that may take time, finances and new infrastructures to develop.

Clearly temporal dynamics of mixed species stand development is poorly understood by the many practitioners and professionals, as there is a shortage of current and recent history evidence in the landscape to support this notion (Chapter 8.2/7). The time delay and unpredictability of complementarity effects in stands does not build a convincing case for land managers who want immediate results within short timeframes and unequivocal proof of benefits channelled into their estates. The increased use of silvicultural practices such as partial cutting, thinnings and shortening of rotations have proven to create more
diverse and complex forest structures with more valuable timber crops (Deal, et al., 2014). Consequently the absence of thinning regimes on most estates has produced dense and unhealthy woodlands (Chapter 7.2/8.2), which have been damaging biodiversity, cultural and economic values for the last 30-50 years (Quine, et al., 2013). The persistence of these practices continues to counteract the potential of ecosystem services in these regions and detrimentally affect other landscape provisions, services and benefits (Nijnik, et al., 2016). Dismantling the wall between entrenched past practice, current priorities and practice focused around ecosystem approaches will require coordinated effort in social mechanisms that directly tackle these preconceptions.

10.3.4 Forest energy – enhancing rural markets and silvicultural practice in the Highlands

Chapter 8 demonstrates that short rotation forestry (SRF) is considered a promising option for private estates, in theory, but most land managers are unconvinced about the practical commitments and feasibility for profit. The joint woodland expansion planning process (Chapter 6 and Chapter 8.4) shows that land managers have both the space and inclination to include sustainable short-term forestry practices within their estate plans. This could help meet rural energy needs and woodland management diversification, as well as aiding delivery of national climate change targets, adoption of renewable energies and supporting ecosystem based management (SG, 2010; SG(b), 2010; SG, 2011). Balmoral estate has a small woodfuel set-up (chips) but only produces a small amount for houses on the estate. Other estates have performed feasibility studies with help from private renewable energy companies but the rates of return and investment required are not attractive enough to warrant a change in energy use (Chapter 8.2). In contrast Balmoral’s neighbouring estate Invercauld sells woodfuel and cannot meet local demand. In fact, the manager regularly buys timber from neighbouring regions to meet demand, demonstrating clear need for woodfuel market development. Joint planning in cluster and using coop timber hubs that takes advantage of beneficial infrastructure (chapter 9) could be a great boost to market development.
Energy independence and the increasing abandonment of agriculture have provided a niche opportunity for SRF to move into currently unproductive land (Aosaar, et al., 2012; Tullus, et al., 2012). Most of the case study of estates possess abandoned agricultural areas due to the decline in profitability, including pastures and improved grassland with no plans for future development (SRUC, 2011). Economic and ecological uncertainty is a clear concern for SRF development, yet many land managers view it as a future consideration to be developed in partnership. Trade-offs for biodiversity and soil carbon stocks need further evaluation, however Keith, et al. (2014) conclude that in the UK there is little change in soil carbon stocks for SRF, in fact some planted mixed stands show evidence of increased stocks. In comparison with currently unmanaged plantations on estates SRF offers potential to improve silvicultural practices, as well as soil health and carbon stocks. As in countries such as Finland, Denmark and Austria SRF provides a sustainable market, as well as an early management treatment for further products and the woodland structure (Roser, et al., 2011; Dandy, 2016). A multi-aged woodland structure provides more diversity and potential habitats than current stands in poor health, therefore broadleaf/coniferous mixes would increase biodiversity and wider ecosystem services (Keith, et al., 2014; Mason & Connolly, 2013; O’Hara, 2014).

SRF offers considerable potential to develop productive silvicultural systems and support regional energy markets. This research demonstrates that integration of forest energy systems into mixed woodlands (structure, rotation and objectives) could provide land managers with significant profit and alternatives for generating energy (Chapter 8.2 and Appendix G, example estate land use report). However, in light of undeveloped supply chains, grant payment delays and lack of immediate return land managers are in general reticent to be market pioneers (CEBR, 2010). Currently the investment is not worth the risk in spite of the promise and the potential environmental improvements. Most land managers’ focus is on mobilising hydro-schemes, which have an immediate return, larger energy generation capacity and minimal landscape impact (Bracken, et al., 2014). These schemes are in partnership with government agencies or private sector in which cost, upgrades and profits are shared and therefore low risk to the land manager (Sample, et al., 2015). This is an opportunity for woodland schemes to be integrated with hydro-
schemes as a regional and national wide strategy for increased ecosystem and energy planning.

Many land managers do not possess the practical expertise or knowledge on woodland management (See Chapter 8.2). Creating a new management stream for the estate is a long-term project, many of the land managers will not live to see the result, and previous woodland planting does not inspire confidence that a different result will be achieved (Chapter 7 and 8 lodgepole pine and Sitka plantings in the 60/70’s). According to the case study areas infrastructure creation to support woodland management will be incompatible with maximising profits from sporting management. Tullus et al., (2013) state that poplar woodlands offer potential benefits both in terms of energy crops and carbon sequestration but may impact on biodiversity, if planted in large uniform areas. Land managers are open to planting poplar as native species suitable for riparian areas, which already grow and naturally regenerate in the landscape (Woodland planning areas Chapter 8.4). Alder is also acceptable due to their native status. Benefits for riparian areas and their historical presence as Highland woodlands can be traced through Gaelic names of various estate areas (Alt Fearn – Hill of the Alder) (Chapter 8.4). Additionally, alder has nitrogen fixing properties, which can enhance afforestation on contaminated soils due to their ameliorating effects on heavy metals (Tullus, et al., 2013). These SRF areas would be compatible to smaller-scale, broadleaf areas that are continually mentioned by managers on accessible land close to extraction points.

Short rotation forestry fits all the requirements of an ecosystem approach. In spite of a focus on fast growing broadleaf species (poplar, hybrid aspen, alder and willows), there is potentially greater benefit from mixed broadleaf and coniferous woodlands that provide a wider range of ecosystem services (Tullus, et al., 2013; Keith, et al., 2014). As mentioned in Section 10.2.5 Sitka spruce, Norway spruce and Scots pine all produce greater yields in mixed stands, which emphasises the underestimated potential of major coniferous species to forest energy (Mason & Connolly, 2013; Nijnik, et al., 2016). A few land managers are open to other broadleaf species mixes (dwarf birches, elm, oak and
cherry) with productive conifers. This could create a market for coniferous SRF and longer rotation species intermixed with diverse broadleaf sub-structure.

The perception of forest energy’s potential contribution to the individual estates, rural economy and larger issues, such as climate change varies over different estates and land managers (Chapter 7.2 and 8.2). The saliency of development needs for woodland management to increase value and function is obvious, which could be supported by integration with hydro-schemes that provide energy and economic stability, as well as carbon sequestration to increase the profitability and environmental value of woodland management (Chapters 7.2/8.2/9.4). In this management set-up SRF could encourage multi-aged structures, rotations and timber products, stimulating early silvicultural treatments to improve stand health and timber quality. Increased awareness, expertise and knowledge dissemination is needed (Chapter 8.2 and Figure 10.1), through a combination of greater engagement with practical knowledge and user-friendly platforms from which land managers can gain confidence and management skills (Quine, et al., 2013). In light of this the following recommendations for developing the Forest Energy tool are proposed:

Refinement of the Forest Energy Tool

- Increase the range of species choice to include Grey alder, willow and non-natives like Red oak, Western hemlock, White fir and Japanese cedar.
- Comprehensive soil mapping of the estate land to build a more accurate picture of woodland capacity and range in comparison to landscape-scale and land manager perspectives.
- Transport radius options for woodfuel and weight carrying capacity of transport routes to analyse infrastructure limitations and identify crucial road improvements for forestry sector development (plus carbon offsets).
- Clarification of carbon sequestration impact and value after woodland establishment and the effect of different management approaches
- Increase the accessibility and user-friendly interface of the Forest Energy Tool by developing an application for a website or mobile devices. This could aid decision-
making, gather more data for tool improvement and be a portal for land manager education and industry updates.

10.3.5 Carbon market – Providing additional value to woodland

Carbon is the most accessible ecosystem service (ES) and increasingly is a focal point for integrating various land uses through common management goals (FC, 2014; IUCN, 2016). In the case study areas linkages between land manager and markets are underdeveloped, resulting in separation between carbon sequestration and the land manager. For most land managers carbon represents a theoretical market, the financial mechanisms and connection to their activities is poorly understood (See Chapter 7 and chapter 9.3). Woodland expansion is considered one of the key strategies for reducing Green House Gases (GHG) as carbon sinks (SG, 2010; SG(b), 2010). In general, forestry accounts for a net reduction in GHG emissions, whereas agriculture activities increase emissions despite conditions of greening and environmental measures (EEA, 2012).

Emissions from forestry (including establishment, harvesting, road construction and transport) are small in comparison to the environmental benefits; even transport, the largest contributor to emission levels creates a marginal loss (Morison, et al., 2012). Emergence of regional partnerships could further reduce emissions by increasing efficiency of forest operations and its capacity as a carbon sink. This emphasises the importance of regional structures and subsequent efforts to cultivate an effective ecosystem approach that reduces climate change impact (Lippke, et al., 2011). Increased carbon capture from short rotation forestry systems will occur, if the harvested land is restocked with a similar mix of species (Broadmeadow & Matthews, 2003; Grace, et al., 2014). Such considerations require life-cycle analysis to highlight the wider impacts of an EA over spatial and temporal scales throughout established partnerships (Helin, et al., 2013; Gonzalez-Garcia, et al., 2013; Njakou-Djomo, et al., 2015). Carbon payments could improve economic feasibility for forestry through direct financial support and also by supporting structures that facilitate sustainable forest management with multi-rotation timber products (Chapter 8.2/9.3-5) (SG, 2009; Grace, et al., 2014). Support from carbon
payments could also create recognition for estate management’s wider role in delivering ecosystem services (Chapter 9.3). This is already occurring on a small-scale as mentioned in Chapter 3 through the Woodland Carbon Code and bridging organisations and companies willing to support projects for carbon credits.

Incorporating market mechanisms into organisational frameworks could usher in dramatic change for environmental management (Chapter 7.2-3) (Grace, et al., 2014). Such frameworks could develop woodland management economic viability and improve land use integration (Chapter 9.3-5), as well as managing old growth forests alongside SRF and carbon sequestration (Chapter 7.3-4). This research demonstrates (chapters 7-9) the difficulties in mobilising collaborative activities for woodland expansion (Read, et al., 2009) despite the broad benefits and acknowledgement of forestry as one of the most cost-effective methods for sequestrating carbon (Chapter 7.6 and 9.5-6) (Grace, et al., 2014). Coupling carbon payments with forestry activity represents a first step into a rapidly developing ecosystem approach framework (Daily, et al., 2009), which will require the support and commitment of private estates as they represent a significant segment of managed land in the Highlands (Warren, 2009). Potential exists for bridging organisation to approach and work with DMG’s or vice versa and form a significant carbon partnership for large areas of land, this would give DMG greater stability and credibility as a partnership and present a financial route to re-engage with neglected woodland.

10.3.6 Development of sporting uses and improved woodland resources
Chapter 9.2 highlights the disparity between sporting use and forestry and chapter 3 emphasised the strength and tradition of the sporting estate supported by private wealth. The sporting sector generates a GVA of £200 million (PACEC, 2014), whereas the forestry sector generates £1 billion (direct) and £649 million (indirect) GVA (SFTT, 2014). Despite the perceived strength that sporting use provides the rural economy forestry far outstrips sporting use for its direct and broader impacts to the economy but not always to the individual. Yet many land managers view sporting management to be the centre of Scotland’s rural economy while forestry is consistently undervalued (Chapter 7.2 and 8.2)
(Wightman, 2015). Landed estates own 91% of all non-Forestry Commission forests in Scotland (approximately 61% of Scottish woodland) (Wightman, 2012), which is often in poor health, unmanaged, and considered unproductive land for estates (Macmillan & Phillips, 2010). This again supports the argument to strengthen links between sporting use and productive woodlands.

As most land managers consider forestry a low priority vast areas of estate land has been locked away that could be suitable for planting and increasing the production of timber resources (chapter 7.6 landscape resilience). Watts et al., (2009) argue that sporting tourism can be unsustainable as it becomes isolated from rural realities through traditional practices and susceptibility to distorted public perception. The key challenges facing integration of sporting and woodland management are discussed in chapters 7.1-5 and 8.1-2; including economic uncertainty and emerging markets, unsuitable grants, fencing issues, isolation of management approaches, owner engagement and low value of forestry to the estate. Ostensibly woodland has been marginalised both spatially and culturally due to the distortion and dominance of sporting use in the Highlands. Furthermore land managers (Chapter 7.2 – page 196-7) view woodland expansion equating to reduction in deer and grouse numbers, as well as heightened regulation upon sporting management (mandatory deer management plans and culling quotas), which continue to erode control over land rights and privacy (Austin, et al., 2014). These factors increase land managers’ scepticism and sensitivity to woodland expansion and management, which has become embedded in estate practices (Dandy, 2016).

In practice, forestry should either complement sporting resources, demonstrating utility beyond simple shelterbelts or aim to increase capital and product value to warrant expansion as a competitive land use in its own right. Although some decisions are less dependent on grants and value, as private wealth and personal preferences of the land manager drive management decisions (Slee, et al., 2014; Lawrence & Dandy, 2014). These normally focus upon habitat enhancement of sporting species and recreation, this is especially acute on estates with large grouse moors (Deeside). The elite nature of sporting use dominates the landscape to the detriment of other landscape components, including
woodland expansion, re-introductions, illegal raptor killings and culling of hares (Slee, et al., 2014). Estates are frequently the focus of land management issues in the Highlands, as a result they have become the centre of management debates and symbols of single-use management (Warren, 2009; Redpath, et al., 2013; Slee, et al., 2014). However, philosophies, drivers and management approaches behind the estates vary greatly (chapter 5, 7.4) yet they are regularly painted with the same brush (Hindle, et al., 2014). Landscape partnerships that promote and recognise multiple management objectives and benefits could provide both a forum and platform for estates to change their traditional and single-management image. For example Wildlife estates initiative and the carbon codes establish guidelines for best practice (FC, 2015; IUCN, 2016; WE, 2016), which could be tied into a greater suite of partnership options.

Land managers manage Highland estates for multiple reasons from wildland preservation to supporting the rural economy through sustainable land-based businesses. One Cairngorms land manager views the Highlands as (Chapter 5.2.7), “a sporting and recreational reserve for Europe”. Morgan-Davies, et al., (2015) describe this dichotomy as ‘Use of the land’ versus ‘Delight from the land’, wherein management by the many is shifting toward management for the few (Chapter 9.3), generating friction between tradition and mounting societal demands and needs. This dichotomy underscores the decline of woodland culture in the Highlands (Robbins & Fraser, 2003; Dandy, 2016) and the engendered perceptions that hermetically separate land uses and management focus.

Despite estate focus on tradition and sporting practice, management and ownership are increasingly linked to wider regional and national aims (SG(a), 2010; SG(b), 2010). Collaborative mechanisms like the DMG’s, the Deer Code and resulting management plans aim to improve ecological objectives of deer management and create a landscape scale conflict resolution forum (Fiorini, et al., 2011; SNH, 2013). Local and regional participative mechanisms are vital to making these groups cohesive and mutually effective for a range of stakeholders, evidenced by the difficulties identified in Chapter 9.5 in mobilising LP’s into a functioning framework (9.6). Again DMG across Scotland vary in their efficacy but in this study many land managers commented on their limited scope for
practical management solutions (Davies & White, 2012; Foirini, 2013) and is more a figurehead of landscape collaboration rather than driver (chapter 7, 8 and 9).

Core issues (Chapter 7.2 and 8.2) continue to hinder joint management, which require innovative approaches that motivate managers to form resilient and effective partnerships (Redpath, et al., 2013), reflecting the nuances of small regional clusters on a larger scale (Chapter 9.2-5). However, voluntary organisations such as DMG’s have limited influence on practical management (DMG) and the push for a mandatory system to meet broader public objectives including woodland expansion (WEAG, 2012) and landscape scale restoration (Bunce, et al., 2014) is strongly opposed by many land managers (Davies & White, 2012; Lawrence & Edwards, 2013; Lawrence & Dandy, 2014). Thus collaborative ventures like LP’s (Chapter 9.6) should avoid restrictive regulatory measures and create ‘buy-in’ through financial incentives and decreased management burden. Buy-in factors such as increased recognition of beneficial landscape management, increased income, collective action to improve regional infrastructure and reduce transaction costs, machinery coops, as well as advice, education and training.

10.4 Connecting Highland estate management through responsibility and cooperation

Geographical isolation of estates is a barrier to collaborative planning and operations (Chapter 7.4, 8.2 and 9.4). Chapter 9.4 presents collaborative maps (Chapter 6.2.7), which identify three spatial management activities: Woodland planning (‘Enhanced deer landscape’ – development of effective shelterbelts), woodfuel and timber hubs, and operational infrastructure. Land managers largely envision collaboration as administrative, organisational and financial functions, which could facilitate access to emerging markets, aid adaptation to new management approaches and develop management knowledge. These partnerships (Chapter 9.4 for LP’s) could be viewed as adaptive regional responses to climate change and novel ecosystem conditions (Collier, 2015), driven by land manager responsibility alongside economic incentives. Landscape partnerships can offer land managers recognition of their contribution to landscape-scale management that is often overlooked by multiple stakeholders (Chapter 7.2 and 9.3).
Glass et al., (2013) demonstrate that consensus on landscape management issues with wide implications for the rural economy and non-sporting use is possible, even between ranges of ownership types, in spite of broad scepticism at the beginning of the process. The range of ownership, conflicting management agendas and regular engagement was found to be an asset to constructing effective partnership options with practical solutions, which were designed and approved by all participant estates.

Ecosystem services bundles and payments are operating successfully for landscape management and land managers (Muradian, et al., 2010; Farley & Costanza, 2010). Many of these payment mechanisms are based on a combination of voluntary participation and market-based approaches, which operate at regional scales. Deal et al., (2012) highlight the promise of organisations such as the Willamette Partnership in Oregon, which involves a range of participants signing an agreement to uphold environmental standards while trading multiple ecosystem services (WP, 2009). Dominant single management streams of estates, which ignore the impact of interconnected management at the landscape-scale could undermine the provision of multiple ecosystem services (Salzman & Ruhl, 2000; Reed, et al., 2013). Therefore similar mechanism will provide accountability and interconnectedness over a region, which is currently lacking and undermining the willingness of land managers to participate in partnerships.

New partnerships require increased coordination and integrated approaches, if they are to have wider ranging impacts than smaller fragmented programs that mostly benefit focussed areas (Deal, et al., 2012). Bundling or stacking ecosystem services could increase the value of forests while simultaneously protecting them from conversion, or land uses that reduce ecosystem management capacity (Kline, 2006; LaRocco & Deal, 2011). However, many land managers in the Highlands prioritise sporting objectives (Higgins, et al., 2000; Macmillan, et al., 2010; Wightman, 2015), therefore Landscape partnerships/frameworks should develop agreements that centre upon integrating sporting management into the partnership structure (Chapter 9.4 Woodland planning, translated into Deer landscape enhancement). Reed et al., (2009) emphasise the need for ecosystem services zoning in order to recognise regional variants of upland areas.
(peatlands, river basin catchments, recreational areas, grazing and woodlands). These areas occur at multiple scales (Hein, et al., 2006), requiring strategies to coordinate unified national and regional priorities, which operate alongside stakeholder partnerships at the local level (de Groot, et al., 2010). These suggestions correspond with the comments of land managers in 7.4 regarding regional responsibility and such zoning would aid spatial planning but could simultaneously separate land uses. Relegating the importance of others in certain areas, which could provide a route for managers to favour some landscape options, which align with their personal interests over others that serve a wider public interest.

Deer Management Groups (DMG’s) are organisational pillars of tradition well established in the Highlands; using local knowledge to work toward common goals (Fiorini, et al., 2011; DMG, 2015). Dominant objectives and management agendas have created a core driver within these groups, hindering the potential expansion of the DMG’s collaborative development (Chapter 9.4 group composition) (Dandy, et al., 2014). These power structures enforce core traditions of estate management and reduce the potential for adaptation to multiple agendas that could encourage wider management impact (Davies & White, 2012). Although multiple agendas often polarise members, fracturing the group rather than developing adaptive management approaches (Chapters 7.2 and 8.2). Other land managers group view the power and financial influence of government agencies, such as the Forestry Commission, as complicating decision-making for members through grant approval and other incentives that could be withheld, if conflict arises (Chapter 7.2 agency influence and Chapter 9.4).

For many land managers the inclusion of diverse issues would weaken the effectiveness of the DMG (spreading the focus and interests too thin for effective resolution – Chapter 7.2 and 7.4.2). If financial incentives and payments for ecosystem services are implemented land managers may have an additional motivation to collaborate (Austin, et al., 2014). However, evidence is needed to support future landscape partnerships, requiring successful exemplars to encourage land manager commitment to broader management goals (UNEP, 2012; SG, 2011; Elliot, et al., 2014). Demonstrating diverse
sources of financial return within a supportive social network could generate sufficient confidence for land manager ‘buy-in’ numbers to achieve significant management changes over the landscape. Atwell et al., (2013) examined multifunctional agricultural partnerships in Cornbelt region of the USA and found certain initiatives have the potential to span differences between conservation and production interests by blurring the lines between protected areas and working land. However this is dependent upon two factors, first facilitation of both vertical and horizontal scales forms of social capital between social actors from different scales and perspectives (Muñoz-Rojas, et al., 2015). Second, scale appropriate mechanisms that improve the value of practices for land managers. These two points highlight the potential of partnerships to align normally mismatched scales (Blackstock, et al., 2007; McMorran, 2008) by using local managers to act as interpreters of local management needs and capacity, in concert with regional actors that act as intermediaries to macro-scale markets, technologies and policies.

Land managers tend to be resistant to top-down approaches, such as woodland expansion targets and deer management plans. Collaborative structures have greater success when stakeholders participate in developing flexible and responsive mechanisms to fit local conditions (Reed, 2008; Prager & Freese, 2009). Glass et al., (2013) co-produced a sustainability toolkit for upland estate management in Scotland, which provided a reference point for sustainable management decision-making and monitoring across a diverse ownership. As such the toolkit encouraged collaborative thinking as well as an ongoing critique of integrated land use goals on a landscape scale. The LP’s (Chapter 9.5) could utilise the toolkit to act as a guide for partnership structures, additionally the spatial planning (Chapter 7-9) and resilience mapping in this research could link the toolkit to aid the development regional landscape strategies and action plans (Atwell, et al., 2013).

Effective channels of communication between various landscape scales can be created through feedback and iterative input from local stakeholders (Prager, et al., 2012). Collaborative discussions and feedback sessions (Chapter 6 and 9) indicate that land managers prefer a set-up detached from central government control (Franks & Emery, 2013; Dandy, et al., 2014), which operates within a larger framework to deliver their
goals, so estates retain independence while benefiting from the security of a government endorsed structure. Resilience of landscapes and partnerships could be strengthened through the inclusion of different manager types (e.g. tenant farmers, collective community groups, agencies, farm owners, renewable energy partnerships, forestry groups), which would align multiple agendas through common land management priorities and networks (Reed, et al., 2009). In Denmark the dominance of intensive crop farmers distorted the ability of integrated landscape strategies to drive rural economy and landscape change. Primdahl et al., (2013) identify landscape narratives as powerful tools in building spatial strategies that involve wide ranging stakeholders. However, they also found a significant gap between those that have little stake in the dominant land use, and those few that manage production have little desire to participate in local level planning, as they are driven by important global drivers that supersede local issues (Primdahl, et al., 2013). The situation in Denmark with intensive agriculture has some parity with private sporting estates in the Highlands and reconciling these dominant areas with a wider landscape ecosystem aims will require a localised ecosystem approach that taps into larger scales.

Central to developing practical ecosystem approaches is understanding the drivers that influence policy. Makkonen et al., (2015) note that trade-offs between bioenergy and carbon sequestration policies in Finland favours bioenergy as the products are a part of a secure and valuable market. This developed as a result of Finland’s strong forest production focus in the latter half of the 20th century that absorbed and dominated more peripheral forest sector aims (Saarikoski, et al., 2012). However, in Scotland, forest policies refocused to native woodland restoration and recreation after the strategic planting of exotic species. Timber production is significantly less developed and valuable in comparison to Finland. Similarly the bioenergy market and supply chain has recently emerged as a more central objective as renewable energy commitments and rural fuel poverty have become national priorities.

In countries such as Finland divergent development and composition of forestry sector dynamics creates conditions compatible for timber production but unsuited to ecosystem
services integration. The strength of provisioning services (forest timber production and related markets), inhibits integration of ecosystem services management and wider forestry objectives. Whereas Scotland’s timber production is weak in comparison (imported timber – 68%). This may give Scotland an advantage over countries with highly developed timber production supply chains. A less developed forestry sector could allow for timber production to increase alongside coherent ecosystem services on a landscape scale. Carbon sinks and forest production (including forest energy) can be managed together to generate the greatest balance of benefits, creating rudimentary synergies to support climate change, local markets and ecosystem service strategies (Nabuurs, et al., 2007).

Translating ecosystem services management into practice is difficult as targeted policy often neglects multiple services at the expense of one, whereas broader policy has greater latitude to promote and interpret the supply and demand of numerous services but has less practical application (Nelson, et al., 2008; Makkonen, et al., 2015). Umbrella strategies such as Scottish Land use strategy (2011) has scope to steer long-term change and show policy in action through practical projects. Three pilot projects are part of the SLUS and demonstrate that innovative and inclusive approaches can be applied on a wider scale (Nilsson, et al., 2012). However, more specific localised approaches may need to be formulated to account for unique ownership structures, environmental conditions, economic and social systems. Such an approach is proposed in the next section drawing from the framing set at the end of chapter 3.5.1 that focus upon a local interpretation of an ecosystem approach linking private sporting estates to wider ecosystem concerns and landscape frameworks.

10.5 Energyscapes: Unifying estate practice with local ecosystems

In Howard et al., (2013) energyscapes is defined as: “The complex spatial and temporal combination of the supply, demand and infrastructure for energy within a landscape”. The authors propose that energy supply, demand and delivery (infrastructure) ties in with the majority of ecosystem services (provisioning and regulating) and identifies ways in which energy systems interact with characteristics of diverse regional landscapes (chapter 2.8
As chapter 2 and 3 demonstrates the most promising emerging markets and land use management potential for private estates in the Highlands are hydro schemes, forest energy production and carbon sequestration. This informed the methodological design (chapter 6) that identified the need for and developed a forest energy tool to evaluate potential value of woodfuel and carbon sequestration. Chapters 7-9 continued to identify hydro schemes, forest energy and added woodland value (carbon) as strong themes in future and potential management options.

Instead of linking energyscapes to ecosystem services through availability and demand of energy, this research views energyscapes as a practical means for interpreting and promoting greater integration of land uses, a platform for private estate ecosystem approach and greater landscape resilience. This creates a meaningful approach based upon economic, environmental and social research that bridges science-policy-community gap, thus engaging with new and novel landscapes (Musacchio, 2013; Milcu, et al., 2013; Collier, 2015). Beneficial spatial and cultural configurations (catchments, national character, estate identity, future vision) may emerge with compatible management options and practices. Franks and Emery (2013) suggest that a collaborative vein of Agri-environmental schemes in the UK is necessary for capturing and managing wider ecosystem services, as well as increasing the financial resilience of small scale farms. A similar collaborative vein could function for estate clusters in the Highlands through an energyscapes framework.

Unifying multiple interests in the Highlands is difficult, as only a few land uses dominate the landscape (Slee, et al., 2014). Despite being aware of numerous intersecting issues and considerations the majority of land manager decision-making focus on narrow objectives (See Chapter 7.2/5, 8.2, 9.4). Thinking of management as singular land uses (woodland, deer, grouse, fisheries, agriculture, wildlife conservation), which are squeezed into an ‘either/or’ decision-making framework, counteracts the core intent of ecosystem approaches and fails to capture benefits important on a landscape scale (CBD EA Principles 2, 3, 7 and 11). Kelly et al., (2015) emphasise that the key to successful resilience strategies and actions is the presence of strong networks and partnerships; additionally the presence of trained forestry professionals regularly engaging on the
ground facilitates development of trust and knowledge transfer between scales and ensuring implementation of locally specific and appropriate action plans. Sustainable practices are proven to improve regional resilience by linking social and economic domains but is countered by the economic and institutional issues operating at higher scales that undermine local practices and resilience (Bodin & Crona, 2008; Magis, 2009; Wilson, 2012). Energyscapes has the scope to develop effective cooperation and balanced interests between higher scales and local practice through land use that focuses around energy and ecosystems services (Howard, et al., 2013; Richter, et al., 2015).

Energy management has been increasingly adopted and infused into policy, strategy and now practice, from national assessment to individual use (MEA, 2005; SG, 2006; SG(b), 2010; SG, 2011). Recent instability in oil and gas prices, negative social opinion of the fossil fuels industry and concern over foreign energy dependency, has spurred development of regional initiatives to meet energy demands (SG(a), 2010; SG(b), 2010). These provide opportunities to modify current practice and integrate emerging concepts and markets (such as ES, EA, SRF and renewable energies) through bottom-up landscape initiatives (SG, 2011), which could ease tension and competition with dominant land use objectives and practice. Such approaches could incorporate wider ecosystem management goals, while maintaining the priorities and traditions important to land managers. Interpreting novel ecosystems, management practices and resilience needs will require innovative and flexible approaches to develop meaningful and pragmatic frameworks that deliver accessible and effective outcomes (SG, 2011; Collier, 2015; Sniffer, 2016).

10.5.1 Energyscapes composition and function

Energyscapes forms a specific set of aims that reflects an ecosystem approach for both individual estate operations and greater landscape management considerations. The following section explains the research’s interpretation of the energyscapes concept (Adapted from (Howard, et al., 2013)), which begins with three core objectives at estate level:
1. **Hydro power** (Hydro-schemes) could provide economic stability (meeting estate energy demands and/or selling energy to the grid), which would provide opportunities for land use diversification and longer-term planning capacity.

2. **Forest energy** (estate to regional woodfuel supply) could encourage silvicultural treatments to increase the quality of estate woodland and timber products (Dandy, 2016). SRF could introduce forest management approaches that will enhance regional supply chains and reduce negative perceptions.

3. **Carbon sequestration** (carbon management and markets) is a gateway service through which other ecosystem services can be incorporated into management responses to climate change. Additional value to woodland could improve management investment and regional timber markets.

This research shows that estates are mostly unable or unwilling to shift management approaches, they require institutional support (policies and grants), knowledge exchange and financial assistance (Chapter 7-9). Effective implementation will require collaborative activities that operate as practical extensions and facilitate the aims and objectives of energyscapes from estate to the wider landscape. Another factor that weighs heavily on the perceptions and prevalence for traditional practices is social memory, which preserves the narrative of woodland as an eyesore and negative impact upon estate management and economies (chapter 7.2 and 8.2 (Cutter, et al., 2008; Davidson, 2010)). The LP’s (Chapter 9.5) are localised practical partnerships that could provide a structure for communication and social learning pathways to strengthen regional resilience and development ecosystem approaches based upon aspiration principles, which are tied into local contexts – a core aim of numerous strategies and frameworks (*Figure 10.2*) (UNEP, 2000; Smith & Maltby, 2003; SG, 2011; Kelly, et al., 2015; Muñoz-Rojas, et al., 2015). Alone these collaborations may not be significant but together their cumulative impact could develop strong areas of practical and tangible landscape management in the Highlands. For this reason identifying appropriate collaborative-scales suitable for practical management solutions is important (*Figure 10.2* suggests LP’s operate as a step between micro-regional estate clusters and a regional level/ CBD EA Principles 2, 3, 5, 7 and 8, as well as OG’s 2 and 4).
Sustainable Livelihoods resilience framework (Chapter 7.5) involves a combination of human, natural, social, physical and financial capital to inform better ways forward (Hamilton-Peach & Townsley, 2004). Figure 10.2 is one possible better way forward for land managers in the Highlands and possesses distinct links to all five principles of the Sustainable Livelihoods Framework. The energyscapes framework also demonstrates strong links to the five ecology and context driven factors in the multidimensional resilience framework in chapter 7.5 (RRC, 2016):

- **Individual** (land manager interaction),
- **Relationship** (scales, collaboration),
- **Community** (regional estate clusters and partnerships, land manager dynamics),
- **Cultural** (interviews, identifying local contexts, cultural acceptability of woodland expansion and landscape resilience maps)
- **Physical** (woodland expansion suitability, forest energy tool, estate boundaries).

This demonstrates that energyscapes is developed from an integrated suite of established ecosystem approach and resilience frameworks. Partnership size is important factor influencing the scope and application, as all land managers view DMG’s as too large and unwieldy to implement meaningful outcomes on the ground (chapter 7 and 9 (Fiorini, et al., 2011; Dandy, et al., 2014)). Subsets of 3-6 estates similar to the micro-regional estate clusters used in this research could be a manageable and appropriate landscape unit (Chapter 5, 6.6 and 9.4/CBD EA P: 2, 3 and 8. OG: 2). Maintenance of sporting traditions will be an unnegotiable part of these partnerships, development of ecosystem approaches highlight local conditions, people and culture as core elements and tapping into the sporting culture alongside community and rural development goals needs to be addressed in any landscape management approach in the Highlands (SG(a), 2010; SG, 2011). As Figure 10.2 shows a trusted central organisation responsible for coordinating collaborative activities, as well as establishing effective networks is crucial (Davies & White, 2012; Elliot, et al., 2014; Cockburn, et al., 2015).
Similar to the study in the Marston Vale (Howard, et al., 2013) the Highland energyscapes framework focusses on smaller regional areas, defined by land use and topological boundaries. However, the authors suggest their study can be used as a microcosm for the UK as the population density in Marston Vale is similar to the national average. This assumption overlooks regions with low population density, such as the Highlands where low population densities, especially in more remote areas will create different land use dynamics. As earlier chapters (5-9) demonstrate a single case study area is not representative of the Highlands, therefore energyscapes framework represents a practical response to local nuance, as ecosystem approaches and frameworks are often viewed as too broad and insensitive to regional diversity (Fee, et al., 2009; Dick, et al., 2011; Waylen, et al., 2015). Each case study area has unique characteristics, which may affect the composition of management priorities and practices, however the energyscapes framework can provide a core network in which to operate and interpret further sensitivities to local ecosystem approaches.

The energyscapes framework (Figure 10.2) incorporates the LP’s, which are central to the organisational structure at a higher scale. Three core management objectives (Hydro, wood and carbon) could be implemented at estate level or as a micro-regional cluster, which would also support the main estate activities (enhancing traditional management priorities). Coordinating and facilitating access to markets and larger scales of activity that would be out of an individual land managers’ scope (e.g. small scale timber sales, relatively small amount of carbon sequestered or redistributed funds for strategic infrastructure upgrades) is a core remit (Chapter 9 (Vignola, et al., 2013; Schultz, et al., 2015)). The responsibility for the core organisational role, managing communication and coordination requires a trusted and present organisation in the landscape, respected for expertise in land use and social engagement, as well as a proven history of landscape scale management (Nijnik, et al., 2007; Elliot, et al., 2014; Muñoz-Rojas, et al., 2015). The suitability of external environmental management agencies and groups are explored in the next section of this chapter.
Land managers are a central to this research, therefore energyscapes framework has been crafted from practical solutions based upon their perception of collaborative management options. Insights into the composition of resilience at local scales, as well as the relationship between traditional and emerging management practices form the bridge toward a Highland estate ecosystem approach. Through study of DMG’s, Austin et al. (2014) identify four areas vital for collaborative management:

1) To consider sporting management as single component of a broader landscape management package
2) Inclusiveness
3) Provision for education and advice
4) Flexibility toward area-specific management issues.

Energyscapes incorporates these values that are often overlooked in strategic planning, offering increased capacity for engagement and building social capital on a regional-specific scale. However, most land managers fear the potential administrative burden of new schemes, “insidious process of regulatory creep, which has inhibited many promising schemes in the past”. Developing the most appropriate and acceptable structure to attract land managers will require greater social capacity and trust, as well as financial incentive to generate the necessary ‘buy-in’ motivation (Folke, et al., 2005; Berkes, 2009).
Figure 10.2 – Energyscapes in conjunction with Landscape partnerships driving and shaping an ecosystem approach
An important principle of the energyscapes framework is the supportive set of structural mechanisms that would encourage land managers to pursue personal preferences for estate management alongside aims to strengthen wider ecological integrity, contributing to the rural economy, and increasing estate financial solvency. This may result in a landscape mosaic shaped by collaborative action of a wide range of stakeholders rather than lone management actions of a single manager (Franks & Emery, 2013). Partnership identity has a powerful role to play in legitimising outcomes (chapter 7.4 – Regional variations), which represent cultural and environmental characteristics of an area, as well as the drivers and priorities of the member partners (Parks & Gowdy, 2013; Sandstrom, et al., 2014). This joint development of landscape characteristics could foster local adaptation and provide a partnership to develop area-specific strategies for core management challenges (Mills, et al., 2011; Swales, 2012).

The following actions are recommended to further develop the energyscapes framework in line with this research:

- Develop the landscape resilience map as a template for landscape planning with further input from land managers, which can produce practical management advice and options. This will transform these cultural-spatial maps into an active planning element and a visible reflection of estate resilience at higher-scales.
- Establish Energyscapes pilot areas with the support of Scottish land use strategy, Woodland Expansion Advisory Group and other relevant policies to develop demonstration sites and practical experiences.
- Document these practical experiences and development processes through real-time recording (increasing the mobile methods scope), which can sit alongside more conventional documentation but could uncover issues that can be mitigated through immediate response, therefore increasing the effectiveness and significance of adaptive management.
10.5.2 External agencies and organisations – satellites for landscape coordination

Mistrust of increased government intervention has cultivated cautious attitudes in land managers with regard to joining collaborative schemes and partnerships (Glaves, et al., 2009). Chapter 2, 3 and later 7-9 highlighted the lack of obvious leadership from an agency or organisation in driving landscape management or ecosystem approaches. In general, land managers agree that legislation lacks flexibility to address needs of local estate management, therefore integrating wider landscape aims will be challenging (Austin, et al., 2014). External agencies able to bridge the gap between land managers and larger scales of operation and practice are most likely to generate interest (Mills, et al., 2011). The Cairngorms National Park Authority (CNPA, 2015) is a centralised organisation practicing landscape management over a large region and could administer partnership agreements within the park boundaries and throughout the Highlands. Expanding the role of the CNPA, an established landscape scale manager (CNPA, 2012) could represent a credible option to land managers for overseeing partnership responsibilities (McMorran, et al., 2014; Everard, et al., 2014). All of the land managers in the Cairngorms case study respected and rated the CNPA and its staff over other land use agencies and organisations in the area, despite feeling geographically and politically separated from the main activities of the Park (Chapter 5, 7 and 8).

*Figure 10.4* demonstrates the potential catchment areas of the CNPA and other National Parks as central landscape administrators, which could coordinate regional ecosystem approaches. The CNPA is a respected by most land managers for its expertise, common management goals and diverse initiatives. However, many land managers describe the CNPA as a detached area-specific construct, which has limited impact for them (Chapter 6, 7 and 8). As a regional coordinator or leader in managing micro-regional land clusters the CNPA (*Figure 10.5*) could extend their influence to remote areas and strengthen regional landscape connectivity and resilience. This would require some expansion of the CNPA remit or creation of another management branch with staff operating over the member clusters, which could affect purposeful resilience design on a landscape scale through collaborative governance (Curtin, 2014).
The Forestry Commission’s ‘Carbon Code’, is unknown to most land managers in the case study areas but represents a progressive step towards integrating carbon sequestration into management and policy (chapter 9 (FC, 2015)). Other organisations such as the RSPB, SNH and DMG work within partnerships across the Highlands and could operate in parallel with the CNPA for a more robust management network. Administrative fatigue and over saturation of landscape partnerships could become a danger as most land managers possess varying levels of trust for particular institutions and already suffer from regulatory fatigue (Chapter 7 and 8 (Puszka, et al., 2013)). The CNPA could provide guidance upon ecosystem approaches that include ecosystem services management, strategies for strengthening resilience and explicit connections to international goals and principles (e.g. CBD EA) (Curtin, 2014).
In the Highlands land management agencies manage administrative and financial affairs for estates and working in partnership with Scottish land and Estates could be a strong option due to their collectively broad administrative expertise. Research institutions and Universities primary goal is to generate knowledge and innovative approaches, which could extend to applied management partnerships, as they possess diverse expertise and effective working relationships with diverse stakeholders in their region (Taff, 2015). Universities are eager to expand their remit to explore enterprise and entrepreneurship that can strengthen their institutional framework (Urbano & Guerrero, 2013; Wright & Fu, 2016). A recent report from the ‘Land Reform Review Group’ calls for a single body (Scottish Land and Property Commission) with the responsibility for understanding and monitoring the management and ownership of Scotland’s land (Elliot, et al., 2014). Such
an organisation with oversight on a national level could fulfill the role of deploying an energyscapes framework and multiple land use partnerships. There are numerous routes to developing ecosystem approaches, however a central organisation that operates autonomously from government structures could inspire trust and represent the interests of multiple stakeholders, including private sporting estates in the Highlands – aligning traditions with current and future management demands of the wider landscape.

10.6 Critique of methodological approach

The methodological approach of this research aims to gain insights into the links between woodland management, short rotation forestry and potential ecosystem approach on private estates in the Highlands of Scotland. Multiple-methods are used, including field interviews (mobile method – GPS tracked and mapped), joint woodland planning (Tablet and mapping app), Forest Energy Tool development (management/economic context), and estate cluster discussion groups (investigating collaborative potential). Connectivity between each component of the methodological design is important for generating a more complex and detailed account of landscape management issues from the stakeholder's perspectives (Mellqvist, et al., 2013).

Stakeholders have a highly developed sense of their local area, which establishes a strong spatial awareness of land use change and traditions (Soini, et al., 2012). In practice, land managers have strong opinions on land use for their estate and region that is tied closely to social memory, personal experiences and preferences, creating a landscape narrative. However, in the field, during the interviews, land managers’ perspectives and decisions would change from the earlier discussions around a map demonstrating the importance of stakeholder interaction with space and place (Carpiano, 2009; Evans & Jones, 2011). Area objectives or potential plans would often change, which at times contradicted earlier statements. This variation in the land managers’ decision-making process demonstrates the importance of viewing resources and management from multiple-perspectives, which highlights the importance of mobile methods and on-site planning.
Expanding the methodology to include manager movements over long periods of time (week-month) to identify hotspots and neglected areas of management activity could give valuable insight to actual versus perceived management. Assessment that considers a single scale, such as landscape or estate level can overlook the nuances and subtleties of rural dynamics wherein different processes and actors influence change across scales (Wilson, 2010). Broad societal aims do not always align with estate management as they often base decision-making upon local environmental conditions and needs. Matching the landscape resilience analysis (Chapter 7.5) alongside public stakeholder defined landscape values could develop more widely compatible area-specific resource management and conservation strategies (van Berkel & Verburg, 2014).

The woodland expansion planning advances the methods from ‘spectatorship’ (expert constructed landscapes) to one created by those that influence local management decision-making (Hawthorne, et al., 2015; Wood, 2010). This study’s decision-making process was definitively led by land managers with minimal input from the researcher. In this way the cultural drivers discussed in chapter 7-9 are an accurate representation of the cultural landscape for the case study areas. As noted in chapter 8.3.2 the woodland expansion planning method could have benefited from providing greater scientific and ecological information to the land managers before the planning or interview session. Gauging their knowledge of woodland ecology, suitability and species capacity would be valuable, informing the baseline and present expertise that exists on the estate. This could create useful comparisons of woodland compositions over the landscape correlated with knowledge base. Such tools as the Ecological Site Classification tool, readily available over the internet could guide coarser grain suitability and future suitability in line with potential climate change impact (FR, 2016; Wainhouse & Inward, 2016).

Revisiting the woodland expansion areas in the last 6 months of the research may have resulted in more changes or greater affirm of the original choices. Additionally, encouraging managers to plan how they would like the estates woodland to look fifty years into the future would be a useful exercise to guide development and inform current decision-making. The plan could work over the spatial level of the estate with cultural
justifications from the land manager perspective, defining different products and rotations of woodland succession, as well as continued expansion, amenity areas and links to the wider landscape. Incorporating this exercise would expanded the methodologies utility to ecosystem approaches, planning, climate change and resilience (CBD EA P: 2, 3, 4, 5, 7, 8, 11, and 12; OG: 2, 3, 4, and 5).

The Forest Energy Tool (FET) (Chapter 6.4 and 8.3-4) intends to match potential species with planting sites on the estates. However, after interacting with land managers and attending Woodland Expansion Advisory Group meetings, it became clear that economics is a central motivation for woodland planting. Additionally prospective woodland managers wished to gain greater benefits from woodland than simply breaking even and complying with current policy trends. In response to these factors the FET was developed to gain insight into the potential market value of short rotation forestry, sequestered carbon and calorific supply, as well as identify key areas of development. The analysis of woodland value provided by the FET demonstrates a potentially valuable market for estates. However, attractive scenarios may require a leap of faith, which could be eased by landscape partnerships or through the demonstration and mentoring of a successful pioneer estate. Species choice in the tool could have been easily expanded to include alders, willows and oaks, as chapter 8.3 shows some species were substituted in favour of others not included in the FET. A separate set of species could be included that respond to a climate change predications, offering a greater variety of non-native species that could diversify and enrich Highland woodland structure and productivity.

Life cycle analysis of carbon sequestration in relation to further woodland management would provide a more accurate estimate of long-term returns to land managers, after the initial expansion. Policy-wise there are limited grants available for SRF (coppicing and 15 year rotations) and these rotation periods would be unsuitable for the Highlands. The FET has used conventional woodland grants with SRF being extracted at 20-25 years, as first thinnings, thus encouraging a mixed rotation system based upon long-term woodland structure improvement. Developing the FET into an internet App or program could increase its impact and audience. A user-friendly interface for land managers would
support decision-making and account for ecosystem services or climate change contributions. This type of tool might appeal to a wide range of land managers over diverse landscapes. However, many tools currently exist for predicting ecosystem services value (i.e. INVEST) and an SRF/woodland planning tool could have more specific utility, for ecosystem services, providing a less complicated management scenario.

Bringing together small groups of neighbouring land managers for brief discussions was a difficult task. Largely, this is the result of mixed ownership and geographical constraints of the areas, which affect the ease, access and continuity of potentially collaborative agendas (chapters 5 and 7-9). Land manager receptiveness to participation improved with frequency of contact. Additionally, the production of a significant Land Use report demonstrated the level of commitment and time devoted to creating the reports for each estate, which increased their willingness to participate further. These reports provided a comprehensive but focussed platform from which to base the collaborative discussions. However, scheduling conflicts, absentee owners and sporting seasons were all obstacles to arranging convenient meetings. Also most land managers were unable or unwilling to travel or meet at other estates; one head stalker was not permitted to leave the estate for such activities. There is also a degree of reticence on the part of stalkers to participate alongside owners in discussions about land management issues. On some estates a hierarchy seems to exist, which maintains power structures delineated by responsibility and traditional roles. However, this was not the case on every estate, as management structures and ownership lines blurred and the repository of expertise, knowledge and decision-making is shared across the estate management structure.

Although this methodological design requires significant time investment through field interviews, planning exercises, iterative contact with land managers and group discussions clear benefits can be identified from this approach. The field interviews provided a strong spatial platform to the research integrating cultural drivers, meaningful landscape narratives and insights into planning considerations from the beginning. This data would not have been captured in a shorter, less explorative interview, as contact with both the researcher and the landscape has proven vital (Carpiano, 2009; Jones & Evans,
2012). Also the iterative contact, consultation and planning with the land manager is tantamount to forming a partnership, demonstrating the researcher’s prolonged interest and commitment to understanding the management challenges of estates. Over two years this built trust between the researcher and the land manager, which increased land manager engagement, interest and continued willingness to participate in further work. Acknowledgement of land manager perceptions and production of spatial plans played key roles in developing ecosystem approaches for private estates, which recognized their importance as landscape managers and potential for future contributions.

This study focussed on private estate ownership and case study areas within the Highland region. Despite the area-specific development of the methodological approach and outcomes, many elements of the study have wider application across diverse landscapes. Initially, this methodological approach could be used for other regions of the Highlands and Scotland not captured by this research. For example, the central belt and borders region would most likely produce different results from the Highlands. The Moray region, especially with its proximity to the Highlands but with an absence of sporting interests and propensity for agricultural activities, could inform how surrounding regions would interact with Highland areas. Identifying neighbouring estates with mixed land ownership including private, community, NGO and government agency could offer more insights into aligning multiple agendas and progress collaborative activities. Moreover aligning case study areas with marine environments and prominent river catchment areas to produce an increased understanding of coastal or river estates, could dramatically broaden the ecosystem approach interpretation and applicability of connectivity over a landscape.
Chapter 11

Conclusions

The iconic Highland landscape is famous for its natural beauty and recreation opportunities, and is affected by an array of land use issues. A unique system of private land ownership, intensive grazing and sporting management has maintained this widely recognisable landscape but in the last two decades reform has been a priority of the Scottish government. “The term ‘common good’ describes a comprehensive and complex concept which brings into its embrace questions of social justice, human rights, democracy, citizenship, stewardship and economic development.” The Land Reform Review Group (2014) considers the ‘common good’ a way to produce healthy, rounded and robust outcomes, in a sector prone to narrow interpretations that limit the value of the land. Waylen, et al., (2015) highlight the difficulty of incorporating all aspects of an ecosystem approach into management systems and suggest implementation will emerge from localised interpretations.

This thesis has presented and discussed a mixed methods research process with strong spatial planning elements, which developed the energyscapes framework; a locally relevant ecosystem approach for Highland sporting estates (chapters 3.5.1 and 10.5). Four case study areas each containing three contiguous estates and twelve land managers participated in field interviews, woodland planning and collaborative discussions over a twelve month period (chapters 5 and 6). Energyscapes provides a framework for the deploying a local ecosystem approach through three management activities and six regional partnerships, which generate domestic energy independence and profit gains, as well as enhancing overall estate management and resilience. These activities represent important emerging markets in the Highlands, which can be integrated alongside traditional sporting and agricultural uses. Hydro power, forest energy and carbon sequestration are the three estate level activities linked with estate cluster or regional partnerships (chapters 3 and 10.5) that focus on venison and carbon marketing,
infrastructure upgrades, hydro power connections, woodland planning for shelterbelts and timber hubs (chapter 9.5). These outcomes reinforce the importance of bridging scales and providing clear signposts and access to these bridges, which enable individuals to operate over a landscape (chapters 2, 3, 6, 9 and 10 (UNEP, 2000; Carmon-Torres, et al., 2011; Cumming, 2011; Curtin, 2014)). Without the inclusion of the collaborative and spatial estate cluster discussions and case study set-up (chapter 4, 5, 6 and 9) this research would have produced less significant contributions to the fields of landscape and ecosystem approaches.

As highlighted throughout this thesis, culture heavily influences land use practices on Highland sporting estates (chapters 2, 3, and 5-10 (MacMillan, et al., 2010)). This factor informed the methodological design (chapter 6), which centred upon the individual land managers’ connection to physical areas of the estate, practices and landscape scales. The use of the field interview effectively captured land manager perceptions on a spatial scale, generating insights into perceived strengths of practice, meaningful links between land use integration and scale, as well as dominant land use drivers that affect decision-making and adaptive management responses. Although the need for profit centres came through as a dominant driver, the combination of private wealth, personal preferences, and land manager perceptions constructed powerful landscape narratives that have become a central force in decision-making (chapter 7.2 (Kelly, et al., 2015; Wightman, 2015)).

High levels of ownership engagement appears to influence the propensity for managers to diversify, as does smaller scale estates, whereas low level engagement coincides with less active or progressive management (chapter 7.2). All estates are invested in leaving a legacy, which involves carefully counterbalancing future management prospects like renewable energy and business leases against culturally valued historic landscape, such as the ironically named deer forests. Land managers emphasise the dual role of agencies in shaping land use change, positively influencing change through incentives, education and support to enhance landscape management and policy; yet negatively effecting change by creating mistrust, and inadvertently causing greater isolation and separation. Physical, structural and social remoteness is a common theme amongst land managers,
which impacts land practices on regional and local levels, hindering potential partnerships and damaging social capital (chapter 7.4). Most land managers subscribe to regional management responsibilities (7.4.6), which reflects the single land use mentality that continues to pervade estate management in the Highlands. This regional mentality is tantamount to zoning regions for specific and specialised land use management (Cairngorms – Grouse moors; East Sutherland – peatland; Lochaber – woodland), which works against the core philosophy of building an effective ecosystem approach.

Landscape resilience mapping represents a novel approach, which takes an important step towards translating resilience concepts into practice over spatial scales to develop estate plans that capture cultural drivers associated with practice and use (chapter 6.2 and 7.5). This method highlights the interaction between perception and practice, forming visible connections to the subsequent shape of the landscape. Landscape resilience mapping could be an effective tool to guide and strengthen dialogue between practitioners and policy-makers, as well as identify distorted effects of both practice and policy. Resilience is an important policy and landscape goal for Scotland (SG, 2011; SG, 2015), therefore this thesis aimed to offer insights into the meaning of resilience for land managers and the estate, as well as resilient woodland management culture (chapter 2.6 and 10.2). These components demonstrate another important application for building and interpreting a locally relevant ecosystem approach.

Traditional land uses will continue to be deeply embedded in the culture of estate management in the Highlands despite the diversification of ownership and objectives (chapter 7-9). Woodland has been at the centre of this cultural divide, which has formed a professional divide (Warren, et al., 2016), and perpetuated a neglect and loss of woodland culture which has directly influenced the shortfall in planting targets, low levels of expertise, narrow silvicultural approaches and the little value placed upon woodland’s potential benefit to estate management (chapter 7-8 (Dandy, 2016)). Land managers also display pluralistic attitudes toward woodland (Robbins & Fraser, 2003), in which the questionable woodland expansion policies of the past still persist in the landscape affecting decision-making and woodland values of the present (chapter 8.2 and 10.2.3).
Many managers understand that woodland can be a valuable asset to the estate and wider landscape; however the diminished value, potential management inputs and perceived difficulty of integration with sporting use deters managers from expanding woodland cover on estates (chapter 7, 8 and 10). Despite these insights this research demonstrates land managers willingness to expand woodland cover through careful and considered planning on the estate level (chapter 8.3). This outcome, however, represents considerable time investment to build trust and relationships with the land managers, which could be integral to any future strategies attempting to unlock estate land.

This research identifies the potential for estates to make a significant contribution toward the woodland expansion target, as land managers identified over 6,000 hectares of land suitable for planting on a range of Highland estates (11% of Highland estates), creating new woodland for multiple objectives including forest energy production (chapter 8.3 and 8.4). In spite of wide spread scepticism about the validity of the forest energy market, many land managers show active interest in developing local woodfuel production capacity (chapter 7 and 8.2). The Forest Energy Tool developed for this study supported the potentially significant value of a local woodfuel market, especially as forest energy management could generate further woodland health and production through silvicultural intervention early on in the woodlands successional cycle. However, land manager confidence is a crucial factor in developing the forest energy market (Roser, et al., 2011), which requires support through education, infrastructure upgrades for stronger operational networks and increased woodland expertise in-house and locally (chapter 8.2 and 10.3). This includes considering the impacts and benefits of a wider range of species to increase both resilience and diversity of woodlands, which could align with a multiple rotation and functional woodland producing recognisable ecosystem services.

Carbon sequestration has the potential to add value to woodlands through financial markets and increasing estates’ public profiles by contributing towards climate change targets. Many estate managers are seeking for ways to offset negative public image, which in their opinion undervalues estate management’s contribution to the wider landscape
The Forest Energy Tool demonstrates the strong connection between woodland expansion and carbon sequestration value, generating interest from land managers across the case study areas (chapter 9.2). However, in spite of emerging mechanisms such as the Woodland Carbon and Peatland Codes, managers still have limited knowledge of carbon sequestration functionality and market access (chapter 9.3). Capacity building is vital in this instance, as both the landscape partnerships and energyscapes framework identify carbon sequestration as a core element in facilitating an ecosystem approach and developing wider application of ecosystem services management (chapters 2.8, 3.4.2, 3.5.1, 9.5, 10.3 and 10.5). Marshalling focused efforts to incorporate carbon sequestration marketing into woodland expansion planning and policies may be key to reigniting woodland expansion strategies and increasing the appeal of planting on less favoured, abandoned pastures and marginal deer stalking land.

In 2000 the CBD published a set of principles and operational guidelines to facilitate understanding and practical progress towards implementing successful exemplars of an ecosystem approach (chapter 2 (UNEP, 2000)). These aspirational aims proved too broad and lofty for many policy-makers and managers to understand let alone deploy over a landscape or piece of land (Fee, et al., 2009). This research provides a local and practical interpretation of an ecosystem approach (Curtin, 2014; Collier, 2015) based upon the perceptions, spatial planning and collaborative outcomes of private sporting estate land managers in the Highlands. Both the separate components and the entire energyscapes framework can be traced back to the CBD ecosystem approach, addressing the ambit of a number of principles and operational guidelines (chapters 2-4, 6-10). This supports the assertion that energyscapes is a valid interpretation of a local ecosystem approach for Highland estates and that strengthened woodland culture integrated with traditional land use is vital for creating a more resilient, culturally significant landscape that resonates with the individual land managers, as well as the wider community.
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Appendices
Appendix A – Recruitment Flyer

Field Interview: Exploring the management realities of Highland Ecosystems

Land use has been a contentious issue in the Highlands and Islands, historically and into the present day. The research being conducted as part of a PhD project is focused on the interaction between people behind the management decisions, the realities of management for emergent markets with the flexibility and thresholds of economic drivers. New Scottish Government and regional strategies are encouraging integrated use, domestic energy supply and managing land through an Ecosystem Approach. The research investigates the difficulties behind these strategies by exploring the cultural links of land management practices (interview), looking at potential for Short Rotation Forestry (SRF) (field mapping & Forest Energy Tool), and investigating the collaborative side of management that crosses boundaries (collaborative map building).

Method:

- **Field Interview**: Researcher and landowner walk/drive around land parcel discussing current and future land management practices (recorded on Dictaphone and GPS tracker).
- **Tablet with Mapping App**: To help locate features, record observations and note potential areas for forest energy.
- **Potential Forest Energy Tool**: Takes into account management and harvesting costs, local environmental conditions, local prices and timber yield classes, SRF grants and produces approximate figures for 8 tree species planted for forest energy (Potential 20 year volume, net economic return, carbon value and calorific value).
- **Micro-regional clusters**: Comprised of participating landowners/managers, discussing conflicts and opportunities for management as well as challenges for the locality.

Research Outputs:

The interview and mapping exercises will produce a series of maps for each land parcel including: current land uses; cultural-informing land practices; potential areas of SRF; SRF site compatibility and Master map (built collectively by the landowners). A short report will also detail potential SRF economic returns dependent upon species planted as well as carbon and calorific values.
Appendix B – Participation form

Participant Consent Form

Walking the Land
Examining and Ecosystem Approach through the lens of woodland expansion

Researcher: Euan Bowditch

Participant Identification for this project:

1. I confirm that I understand the scope of the project and have had the opportunity to ask questions or address any concerns.

2. I understand that my participation is voluntary and that I can withdraw at any time without giving any reason. (Contact Euan Bowditch: euan.bowditch@ghi.ac.uk if wishing to withdraw).

3. I understand my responses will be anonymised and that the land use report and other information will only be available to the participant and researcher.

4. The participant will not be referred to personally and any information will be referred to in a regional context within the thesis (e.g. Cairngorms).

5. The name of the estate may be used by the researcher for the purpose of the thesis, listed as participating estates.

__________________________                ___________________________
Name of participant and date                Signature of participant

__________________________                ___________________________
Name of researcher and date                 Signature of researcher

Copies: One copy will remain with the researcher and a second will be given to the participant.
Appendix C – Interview topic guide and transcription example

Semi-Structured interview script for land owners/managers

General

− Tell me briefly about this particular parcel of land its use and how it fits into the local area?
− What would you say is the main objective of your management practices?
− What would you say your role is?
− Do you feel any responsibility to the land certain practices?

Specific Areas & Practices

− Why do you work the land? How did you come into working there?
− How do you decide to divide the land into particular practices, what are the considerations?
− Will established practices always persist due to tradition, familiarity and uncertainty of future practices?
− With land that has no particular value for agriculture-why wouldn’t you consider diversifying into bioenergy?
− Do you see forest, wind energy and traditional practices working alongside one another in the long-term?
− What would be the short-term motivations for you to establish areas of forest energy?
− Would the carbon uptake affect your decisions-for emerging market, climate change or recognition of greater value to land use?
− Does the species of the tree effect your potential decision or the perception of the land conifer vs broadleaf?
− How profitable would forest energy have to be for you to consider converting land?
− What are the hooks, the attraction of diversifying your land use?
- What are the concerns, the temptation to follow the current practices and maintain the status quo?

- Has there be a shift in your thinking toward land use in the past decade, if so why?

- Is there a gap in generational thinking or between landowner and manager?

- What stops you from committing to a change that is clearly profitable, has value beyond the product and will help build regional or land parcel energy independence?

- What would forest energy schemes have to do to attract initial commitment to planting? A joining incentive like banks opening new accounts?

- Have you considered the land leasing scheme through the Forestry Commission?

- What do you think of forestry and its management practices?

- How does it fit in with your parcel of land?

- Is there any appropriate spots you would consider for tree (forest energy) planting?

- What do you think of mixed systems, trees and livestock?

- Would you consider installing a wind turbine for long-term energy generation? Especially for upland sites that has no productive land use?

- What would you say in the business priority for the land?

- What would you say is your personal priority for the land?

- Do feel your aims and goals are aligned with government strategies, are they compatible?

- How do you feel about collaboration with surrounding land estates to cut down transaction and management costs as well as generating a competitive resource supply?

- Would you be willing to manage resources across boundaries and share resources, energy production and profits?

**Explicit Cultural/Social Questions**

- Does working the land for one purpose have greater significance and attachment?
- Do you feel you lack the experience or professional expertise to work with trees?
- What do you see yourself as foremost in regard to managing the land?
- What do you think of when you walk the land, plan for activities, perform work?
- What sense or feeling does the site of your land in healthy production evoke?
- How would that differ if patches or parcels of trees were present?
- Is there safety and continuity in seeing the land as something static and unchanging—a constant, something incorruptible through time and action?
- Is there a lineage in the land that you feel you have to maintain otherwise one is not respecting the efforts of those that worked the land in the past?
- How do you see the land looking for the foreseeable generations to come?

**Border/Collaboration**

- What is the relationship with the other land parcels surrounding the estate?
- Any conflict of interests?
- Any common practices?
- What happens around the boundaries?
- Any cooperation, meetings, communication or awareness of one another’s plans?
- Sharing of resources or expertise?
### Example of transcription and coding

<table>
<thead>
<tr>
<th>Transcription</th>
<th>drivers</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-2 min</td>
<td></td>
</tr>
<tr>
<td>Talking about memory and its recession.</td>
<td></td>
</tr>
<tr>
<td>E: Explains Cairngorms case study....</td>
<td></td>
</tr>
<tr>
<td>Well invercauld have got a big scheme on at the moment at the back of Braemar, they’ve fenced in about 1000ha, which they are going to establish by natural regen and planting, but it will never produce a wood I think.</td>
<td></td>
</tr>
<tr>
<td>2-4 min</td>
<td></td>
</tr>
<tr>
<td>E: Prime land suitable for forestry taken up by grouse moors, never released.</td>
<td>Grouse almost indefinitely block forestry expansion</td>
</tr>
<tr>
<td>I think something going to have to happen about the management of grouse moors because certainly I was looking at one the other day and all the sapling that were growing up around the edge of the moor were being cut down</td>
<td>Grouse management needs to change</td>
</tr>
<tr>
<td>E: Affecting cycle of the system...</td>
<td>Woodland encourage but for enhancement of other uses</td>
</tr>
<tr>
<td>I’m involved in the River Dee fisheries trust and Salmon fisheries board and we’ve got this upper riparian woodland scheme where we are planting 70 odd kilometers of riparian woodland on the in the upper catchment to try and reduce in time temperature by shading and also to put in some more, to stabilize the banks and put more organic matter and nutrients into the river. I suppose in time that will reforest some of it. I suppose the only plus side, actually its not a plus side of the way these grouse moors are being managed is that you will get more tree regen as they are knocking out all the deer and hares.</td>
<td>More room for regen in grouse moor</td>
</tr>
</tbody>
</table>
E: What do you think of the burning?

I think burning management can always be improved, a certainly can here, you have such a small window, last year we didn't burn anything or any heather because we were covered in snow up until the 15th of April. We didn't burn any heather at all. It's a very long cycle here where in north Yorkshire and Durham you would be burning it every 5 years, here we're burning very 10/15 years. I think, there are so things that happen with heather, with muir burn is done because its easier, you burn into a burn. And no matter how much you say please don't do that it does happen. We can't cut around it, which a lot of people do, well we'll see when we go out, so many bloody stones, so you can't do that. We've got fobbing units and everything but they do get away but we don't manage our moors intensively, we're primarily a deer forest with grouse on the side of it. We're fortunate because we don't have the pressures as other estates do because all we have to do is provide 12 days grouse shooting for the family and with other 60,000 acres we should be able to do that and they don't want big bags, so they don't have medicated pressure, we're actually putting out big grips for the first time this year.

and they like to shoot 200 stags, we can do that but there are pressures, we are just coming to the end of a very long consultation, I hope, over management of the Ballochbuie, which is the SPA, SAC. Which we were told by Moss and Watson in 2003 was in unfavourable condition.

E: How did the consultation go?

Grouse management and burning is problematic and in long cycles although it is a marginal management consideration.

Rotational fencing program-and simple restorative methods for forestry.
Ha, it's now 2013, so...I sort of inherited it 2009 from my predecessor who basically tried to argue it into the long grass but we've actually now got a management plan that's been agreed by SNH and the FC.

E: Are you happy with the plan yourself?

Yep, well it's taken a lot of the SNH position originally, when I became involved was no deer, no fencing—so we said well we have more than one objective, we want trees we want stalking. I have now agreed on a rotation fencing program, there are areas of the forest that are overgrazed, I would be the first to admit it but it does mean the forest is lost because all you have to do as the Duke of Edinburgh proved in 1972 you reduce the canopy, do a bit of scarification and as long as you've got the seed trees, then generally you'll get it. Don't whether you've seen the Balochbuie?

8-10 min

We'll go and see it. But they are worried about Capercaillie flying into fences and there are Capercaillie in there and we do lots of work for them but we've marked all our fences.

E: And are the fences visible from roads and tourism vantages?

Some of them are but you have to know where they are in order to see them. They're not obvious, we did have someone who decided they didn't like them and cut a hole through them, which was handy. There was a gate 300 yards either side but they decided to go straight through middle, cut it from top to bottom. So that was a bit annoying, luckily we found it before anything got in. So we've been getting on with that, I've got a meeting on the 26th or the week after and that is hopeful to try and to agree, sort of sign it off although
RSPB have suddenly raised their heads and want us to shoot all the deer, but we’re not going to do that.

E: Why do they want you to shoot all the deer?

Because they don’t want us to have any fences...because the last remaining capercaillie who hasn’t been eaten by a pine marten might fly into a fence. That’s all entertaining, and we’re hoping by having the management plan agreed, we will be taken out of unfavourable to unfavourable recovering, which would be nice. We think by doing this we can get it into, the frustrating thing about these bloody agencies is that they want everything immediately.

10-12 min

Produces specific estate cultural drivers, see example land use report appendix G, 162 in total, 31 of which are detailed below. These drivers are then broken down into codes.

<table>
<thead>
<tr>
<th>Driver</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Deer Management strongly influences Estate’s activities-dominating future plans</td>
<td>DM, E</td>
</tr>
<tr>
<td>2. Loss of confidence in trees as a viable resource due to past practices</td>
<td>PP, WL</td>
</tr>
<tr>
<td>3. Iconic landscape is a fundamental characteristic of the Estate</td>
<td>TH, L</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>-----------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>4.</td>
<td>Traditional practices are becoming unsustainable - lacking diversification and any real profit</td>
</tr>
<tr>
<td>5.</td>
<td>Historical conflict has isolated woodlands use in the landscape and mindset of managers</td>
</tr>
<tr>
<td>6.</td>
<td>Strong lineage and inheritance of values and perception influences land management practice</td>
</tr>
<tr>
<td>7.</td>
<td>Common avenues are needed to align past &amp; future management practices</td>
</tr>
<tr>
<td>8.</td>
<td>Balancing passion for the land with economic realities - making profit from passion</td>
</tr>
<tr>
<td>9.</td>
<td>The Estate does not benefit from most tourism - there’s no monetary capture</td>
</tr>
<tr>
<td>10.</td>
<td>The Estate is managed as a ‘Highland Wildland’ with traditional stag hunting</td>
</tr>
<tr>
<td>11.</td>
<td>Active management and business operations are detrimental to the idea and realisation of a ‘Highland Wildland’</td>
</tr>
<tr>
<td>12.</td>
<td>The Estate is run purely for the land owners enjoyment and nothing more</td>
</tr>
<tr>
<td>13.</td>
<td>Deer stalking is the primary purpose or use of the Estate</td>
</tr>
<tr>
<td>14.</td>
<td>The Estate is run as an unrealistic model of sustainability, more a preserve or museum of idyllic highland life</td>
</tr>
<tr>
<td>15.</td>
<td>Undeveloped markets and unreliable supply produces a lack of confidence in developing resources</td>
</tr>
<tr>
<td>16.</td>
<td>Farming decline in the region—it is no longer a viable land use activity but a part of the romantic Highland imagery</td>
</tr>
<tr>
<td>17.</td>
<td>Amenity woodland, shelterbelts, and fisheries benefits would be the only reason to expand the woodland resource—production is out of the question</td>
</tr>
<tr>
<td>18.</td>
<td>Past browsing has impeded and damaged woodland establishment (wild goats)</td>
</tr>
<tr>
<td>19.</td>
<td>Strong native species preference as there is an antipathy towards non-natives that have taken over the landscape in big blocks</td>
</tr>
<tr>
<td>20.</td>
<td>The Estate and land is private with no external interference wanted or needed</td>
</tr>
<tr>
<td></td>
<td>Little trust and understanding of woodfuel supply and market</td>
</tr>
<tr>
<td>---</td>
<td>------------------------------------------------------------</td>
</tr>
<tr>
<td>22.</td>
<td>Owners and Trust lack local knowledge and prioritise the aesthetic appeal of the Estate over the ecological function</td>
</tr>
<tr>
<td>23.</td>
<td>What was once presence in the landscape (trees and fauna) doesn't necessarily belong there anymore</td>
</tr>
<tr>
<td>24.</td>
<td>Economic income and potential dictates the focus of the Estates activities: tourism and landscape coming in as priorities and diversification coming afterwards</td>
</tr>
<tr>
<td>25.</td>
<td>Traditional farming is no longer sustainable or profitable-no longer a viable business option</td>
</tr>
<tr>
<td>26.</td>
<td>Little value in commercial forestry-plantations are ugly and provide no benefits for the Estate</td>
</tr>
<tr>
<td>27.</td>
<td>Native mixed woodland and Caledonian pine expansion is seen as a favourable option but only for amenity</td>
</tr>
<tr>
<td>28.</td>
<td>The traditional Highland estate experience is vital to the operation of the Estate and its appeal to visitors</td>
</tr>
</tbody>
</table>
29. Fisheries have potential for expansion in the region but are too unreliable and weather dependent to become a main staple for the Estate

30. Deer stalking will remain the cornerstone activity of the Estate—providing revenue and Iconic highland status

31. The Estate had to be restored (set up for visitors) before other management activities could be considered. It's a labour of love, connecting heritage of the land

These 79 codes produced from the analysis of the 162 cultural drivers are detailed below.

1. DM – Deer management dominating estate management and plans

2. WL – Loss of confidence in woodlands as resource

3. IL – Iconic landscape is important

4. Tus – Traditional practices unsustainable

5. HW – Historical conflict with woodlands

6. InM – Inheritance of values influence management practices

7. P-F – Past and future align
8. **Pass-R** – balancing passion and realities

9. **T-e** – no monetary benefit from tourism

10. **Wild** – wildland management

11. **As** – run for aesthetics

12. **Tus** – unrealistic sustainability, museum like

13. **Ud** – undeveloped markets lacks confidence in developing resources

14. **WC** – woodland no commercial worth

15. **WA** – woodland soloey for amenity and shelter

16. **Ag** – agricultural conflict

17. **Nat** – strong preference native species

18. **WU** – woodland ugly

19. **Priv** – privacy of owner and management important

20. **Bio – U** – little understanding of biomass market

21. **KL** – lack of local knowledge

22. **W-old** – woodland shouldn’t have a strong presence in the landscape, no longer belongs

23. **A** – Aesthetic appeal most important

24. **E-Pri** – Economics are a priority
25. **Pot** – potential for greater use and management

26. **Unre** – unreliable resource

27. **EI** – estate infrastructure poor

28. **Pass** – it's a passion. Labour of love

29. **Hy-E** – hydro potential on estate creating better economic stability

30. **Est-adap** – estate has an adaptive management approach

31. **Risk** – risk investment prospect

32. **R-pov** – rural poverty through various factors, employment and community

33. **DMG** – n – Collaboration through DMG is ineffective

34. **PP** – Influence of past practices

35. **LB** – land boundary conflict

36. **F** – fencing issues

37. **DC** – deer management conflict

38. **WP** – woodland polices conflicting

39. **WU** – WOODLAND PERCEIVED USE

40. **UN** – uncertainty and change

41. **Divers** - Diversification
42. **T-E** – tourism provides no economy

43. **Rest** – restructure current resources

44. **ESS** – ecosystem services

45. **HIS** – Historic links and lineage

46. **FAM** – family orientated

47. **SHIFTMANGT** – management shift and restructuring to approach and mindset

48. **IR** – resource improvement

49. **EST-CONT** – contribution of estates

50. **CPCN** – current practices and names

51. **Adapt** – adaptation important and needed

52. **COMP** - compromise

53. **FASH** - fashion

54. **LONGT** – long term cycles and management

55. **PEOP** – people

56. **T** – time scales

57. **NEG ATT** – negative attitudes and perception focus

58. **GM** – grouse management priority

59. **BIO-DE** – demand for biomass
60. **FO** - forest operations

61. **LU-V** – land use values

62. **OP** – owner preference

63. **SUPP-F** – supply existing and fulfilled

64. **CWS** – current working systems

65. **WR** – water resources crucial

66. **H** – hardwoods encouraged

67. **DIVERS-W** – diversification woodland

68. **GEN** – generational concern

69. **PEAT** – peat land priority

70. **LM** – local management connection

71. **LK** – local knowledge connection

72. **Tour-P** – Tourism priority

73. **Conf** – Conflict

74. **Undeve** – Undeveloped structures or markets

75. **Nat** – Strong native species preference

76. **Mar-e** – Emerging markets have an economic impact
77. R – Remoteness

78. P – Policy conflict

79. WM – Woodland management and perceived influence
These codes are then applied back to the individual estates within the case study areas

<table>
<thead>
<tr>
<th>Attadale</th>
<th>Inverinate</th>
<th>Glencarron</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ex3</td>
<td>Wildx2</td>
<td>E-Px3</td>
</tr>
<tr>
<td>PPx2</td>
<td>Tusx2</td>
<td>DMx2</td>
</tr>
<tr>
<td>ILx2</td>
<td>Ax2</td>
<td>ILx2</td>
</tr>
<tr>
<td>DMx3</td>
<td>H-tradx3</td>
<td>UNx2</td>
</tr>
<tr>
<td>-----------</td>
<td>------------</td>
<td>------------</td>
</tr>
<tr>
<td>HW</td>
<td>WC</td>
<td>WC</td>
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<tr>
<td>WL</td>
<td>WA</td>
<td>WA</td>
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<td>-----------</td>
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<tr>
<td>Tus</td>
<td>WU</td>
<td>Bio-u</td>
</tr>
<tr>
<td>P-F</td>
<td>Bio-u</td>
<td>-----------</td>
</tr>
<tr>
<td>Pass-R</td>
<td>W-old</td>
<td>Wild</td>
</tr>
<tr>
<td>Pass</td>
<td></td>
<td>Tus</td>
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<td>-----------</td>
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</tr>
<tr>
<td>InM</td>
<td>Ag</td>
<td>Risk</td>
</tr>
<tr>
<td>Tour-e</td>
<td>Priv</td>
<td>Ag</td>
</tr>
<tr>
<td>Diver-n</td>
<td>LK</td>
<td>-----------</td>
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<tr>
<td>Undeve</td>
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<td>Pot</td>
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</tr>
</tbody>
</table>

442
Regional drivers and themes are then identified in the comparative estate matrix above (Chapter 7.4 Regional)

<table>
<thead>
<tr>
<th>Sub-themes</th>
<th>Main drivers</th>
<th>Themes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Woodland lack worth or visual appeal</td>
<td>Economics drives the land uses</td>
<td>Uncertainty &amp; risk</td>
</tr>
<tr>
<td>Traditional uses unsustainable</td>
<td>Deer management is the dominant activity, which drives all considerations and concerns</td>
<td>Rural poverty</td>
</tr>
<tr>
<td>Little knowledge about biomass</td>
<td>Iconic Landscape is very important to the identity of the estate</td>
<td>Passion for the land</td>
</tr>
<tr>
<td>Hydro-opportunities</td>
<td>Wild Highland maintaining the aesthetic appeal and visual impact</td>
<td>Woodlands as a negative land use</td>
</tr>
</tbody>
</table>
## Appendix D – Forest Energy Tool fields

**Forest Energy Tool – Individual fields and sources**

<table>
<thead>
<tr>
<th>Field</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Compartment ID</td>
</tr>
<tr>
<td>2</td>
<td>Current Land Use ID</td>
</tr>
<tr>
<td>3</td>
<td>Current Land Use Name</td>
</tr>
<tr>
<td>4</td>
<td>Perimeter</td>
</tr>
<tr>
<td>5</td>
<td>Area</td>
</tr>
<tr>
<td>6</td>
<td>PLU ID</td>
</tr>
<tr>
<td>7</td>
<td>Forest Energy (species choice)</td>
</tr>
<tr>
<td>8</td>
<td>Land Class</td>
</tr>
<tr>
<td>9</td>
<td>Soil Type</td>
</tr>
<tr>
<td>10</td>
<td>Land Class Depreciation factor</td>
</tr>
<tr>
<td>11</td>
<td>Elevation</td>
</tr>
<tr>
<td>11</td>
<td>Elevation depreciation factor</td>
</tr>
<tr>
<td>12</td>
<td>Harvesetable product</td>
</tr>
<tr>
<td>13</td>
<td>Harvestable area</td>
</tr>
<tr>
<td>14</td>
<td>Rotation period (20-35 years)</td>
</tr>
<tr>
<td>15</td>
<td>Wood volume</td>
</tr>
<tr>
<td>16</td>
<td>Annual volume</td>
</tr>
<tr>
<td>17</td>
<td>Value: £/m³</td>
</tr>
<tr>
<td></td>
<td>Description</td>
</tr>
<tr>
<td>---</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>18</td>
<td>Annual value</td>
</tr>
<tr>
<td>19</td>
<td>20 year volume</td>
</tr>
<tr>
<td>20</td>
<td>20 year timber value</td>
</tr>
<tr>
<td>21</td>
<td>25 year volume</td>
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<tr>
<td>22</td>
<td>25 year timber value</td>
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<tr>
<td>23</td>
<td>35 year volume</td>
</tr>
<tr>
<td>24</td>
<td>35 year timber value</td>
</tr>
<tr>
<td>25</td>
<td>Economic carbon value: £/t</td>
</tr>
<tr>
<td>26</td>
<td>Social carbon value: £/t</td>
</tr>
<tr>
<td>27</td>
<td>Carbon: tonnes/year</td>
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<tr>
<td>28</td>
<td>Annual economic carbon value</td>
</tr>
<tr>
<td>29</td>
<td>Total carbon 20 years</td>
</tr>
<tr>
<td>30</td>
<td>Total carbon 25 years</td>
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<tr>
<td>31</td>
<td>Total carbon 35 years</td>
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<tr>
<td>32</td>
<td>20 year economic carbon value</td>
</tr>
<tr>
<td>33</td>
<td>25 year economic carbon value</td>
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<tr>
<td>34</td>
<td>35 year economic carbon value</td>
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<tr>
<td>35</td>
<td>Annual social carbon value</td>
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<td>36</td>
<td>20 year social carbon value</td>
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<td>25 year social carbon value</td>
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<tr>
<td>38</td>
<td>35 year social carbon value</td>
</tr>
<tr>
<td>39</td>
<td>Woodland creation grant (per ha)</td>
</tr>
<tr>
<td>40</td>
<td>Woodland improvement grant</td>
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<tr>
<td>41</td>
<td>Sustainable forest management grant</td>
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<tr>
<td>42</td>
<td>Management/establishment costs (per hectare-first 4 years)</td>
</tr>
<tr>
<td>43</td>
<td>Fencing costs</td>
</tr>
<tr>
<td>44</td>
<td>Fencing grant</td>
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<tr>
<td>45</td>
<td>Restocking &amp; ground prep costs</td>
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<tr>
<td></td>
<td>Restocking &amp; ground prep grant</td>
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<tr>
<td>46</td>
<td>Costs (harvesting, extraction, processing and transport)</td>
</tr>
<tr>
<td>47</td>
<td>Net timber value-20 years</td>
</tr>
<tr>
<td>48</td>
<td>Net timber value-25 years</td>
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<tr>
<td>49</td>
<td>Net timber value-35 years</td>
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<tr>
<td>50</td>
<td>MWh/m³ (30% mc)</td>
</tr>
<tr>
<td>51</td>
<td>Calorific Value (annually)</td>
</tr>
<tr>
<td>52</td>
<td>Calorific value 20 years</td>
</tr>
<tr>
<td>53</td>
<td>Calorific value 25 years</td>
</tr>
<tr>
<td>54</td>
<td>Calorific value 35 years</td>
</tr>
<tr>
<td>55</td>
<td>MWh/m³ (40% mc)</td>
</tr>
<tr>
<td>56</td>
<td>MWh/m³ (60% mc)</td>
</tr>
<tr>
<td>57</td>
<td>Calorific value 20 years (40%)</td>
</tr>
<tr>
<td>58</td>
<td>Calorific value 20 years (60%)</td>
</tr>
<tr>
<td>59</td>
<td>Calorific value 25 years (40%)</td>
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<tr>
<td>60</td>
<td>Calorific value 25 years (60%)</td>
</tr>
<tr>
<td>61</td>
<td>Calorific value 35 years (40%)</td>
</tr>
<tr>
<td>62</td>
<td>Calorific value 35 years (60%)</td>
</tr>
<tr>
<td>Age of trees (years)</td>
<td>Net biomass (Mg/ha)</td>
</tr>
<tr>
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<td>---------------------</td>
</tr>
<tr>
<td>1</td>
<td>1,863.51</td>
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<tr>
<td>7</td>
<td>4,766.08</td>
</tr>
</tbody>
</table>

**Note:** The numbers in the table represent data for Attadale estate.
Appendix E – Interview walking routes

Walking routes for each estate

1) Attadale (Wester Ross) – 4 hours

2) Inverinate (Wester Ross) – 3.5 hours
3) Glencarron (Wester Ross) – 1.5 hours
4) Kingie (Lochaber) – 3 hours

5) Glen Dessary (Lochaber) – 6 hours
6) Achnacarry (Lochaber) – 2.5 hours
7) Invermark (Cairngorms Deeside) – 4 hours
8) Balmoral (Cairngorms Deeside) – 3.5 hours
9) Invercauld (Cairngorms Deeside) – 3.5 hours
10) Badanloch (East Sutherland) – 3 hours
11) Borrobol (East Sutherland) – 2.5 hours
12) Achentoul (East Sutherland) – 3.5 hours
Appendix F – Case study discussion group structure

Collaborative Land Use Workshop
Structure & Content

Equipment

A0 Map of the 3 estate’s borders
2 Dictaphones for recording coverage
Camera
Laptop
Pens
Post-its
Copies of the estate’s land use reports
Cake
I-pad (recording potential video exerts)

Structure

Introductions and chitchat
Explanation of task
To get the ball rolling ask whether there were any questions or issues with the land use reports

Content

Woodland Expansion

- How can forestry attach itself to widespread hydro schemes?
- Need to remove the rubbish (Sitka spruce, lodgepole and exotics), which is now losing value-depreciating the land and rendering it inert.
- Operation of the raw resource with infrastructure
- Scars of past forestry policies in the landscape-constant reminder of ill-advised investment
- Any type of commercial forestry is suffering and without a commercial base, a forest that works, other forests and their environment will in turn suffer
- Trophic cascades…. The wolf-broadleaf forests, connected...
- The identity and perception of forest/woodlands in the Highlands?
- Broadleaf forests?

Forest Energy
- How to use amenity and SRF together to bring in energy within losing the landscape aesthetic?
- People have a hard time reconciling forestry as a short rotation-farming concept—they see it as stripping out the remaining value of forests as a landscape improvement
- The awareness of management, installation systems-start up kits...

**Ecosystem Approach (Collaboration/cooperation)**

- DMG-deer counting, forum for resolution of conflicts, embedded principles—could this be used more efficiently could it extend to cooperation for other land use matter woodlands/renewables. Perhaps a centralized organisation to trade the DMG's carbon credits?
- What does an Ecosystem Approach mean to you?
- Could collaboration come from estate clusters in regard to supporting localized forestry industry?
  - If so what would be the key operational factors
  - Incentive factors
  - Support factors (institutional and local)
- How to address the declining and deskillig communities?
- How can estates support one another and potentially cut costs?

**The future of carbon**

- Do you believe carbon can play an active role in management?
- How would a market for carbon help the woodland incentives and repurposing in your eyes?

**Deer as a gravitational force in the Highland**

- Everyone avoids, ‘The Deer Issue’ as is eloquently put by many land use professionals-
  - Is it too complicated to tackle?
  - Is there a way that other land uses (woodland) can proliferate with balanced deer numbers?
Appendix G – Example ‘Land Use report’

Wester-Ross Cluster
Inverinate Estate

Land Use Report

Euan Bowditch
University of the Highlands & Islands
Inverness College
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1.0 Summary

This section summarises the outputs from potential areas of Short Rotation Forestry planned on Inverinate Estate. Detailing net economic return, carbon value and calorific value based upon current market prices as well as timber volumes based upon local species yield in the local area.

Type of land: Soil is from the Kildonan series and Badanloch series, peaty podzols-peaty surface with greyish subsoil. As well as peaty gleys, which suffer from poor drainage and a high mineral layer of rock within 50 cm of the surface. Plantings range from 20 metres to 200 metres in elevation.

Total land compatible for short rotation forestry: 402.71 hectares

Species planted: Douglas fir (69.58 ha); Scots pine (65.73 ha); Hybrid aspen (43.11 ha); Sycamore (23.22 ha); Scots pine/Birch mix (66.08 ha); Hybrid aspen/Sycamore mix (12.19 ha); mixed native amenity woodland (122.78 ha).

Timber volume at 20 years: 46,562.89 m$^3$ (harvesting between 30-90% of different parcels of planted woodland: Options for 25 & 35 years)

Net economic value at 20 years: £939,222.2 (current market value: options for 25 & 35 years)

Carbon sequestered over 20 years: 92,862.6 tonnes

Economic carbon value over 20 years: £474,528 (@£5.11/tonne)

Calorific value Mwh over 20 years: 64,273.16 (30% moisture content)

Calorific value (oil equivalent/litres) over 20 years: 321,365.8 (£192,819.49@60 pence/litre)

Difference compared to set aside land:

LFA £160-230/ha up to 200 ha for 10/15 years (£60/ha for 80 ha of unimproved land).

Short rotation forestry: £116.61/ha per year but for 20 years and in perpetuity, if one restocks in rotation

Economic carbon: £58.92/ha per year

Social carbon: £599.54/ha per year (non-monetary market value)

Calorific value: 7.98 MWh/ha per year

Associated Benefits:
- Shelterwood for deer.
- Soil stability, nutrient fixing for the soil.
- Improving water quality.
- Habitat creation.
- Aesthetic appeal.
- Increasing native forests.
- Supporting a domestic market and local development.
- Potential to supply own heat resource for property and local region. Supporting local energy investment in pace of foreign oil import.
- Displacing a greater carbon balance supporting local climate change efforts. Retain native multiple age-structure woodland.
- Shade and food for fish populations with riparian plantings.

**Potential Challenges:**

- Designing areas that do not interfere with stalking, giving deer rides and space to move around the Estate.
- Episodic events like windblow, severe climatic conditions as well as pests or diseases (the species chosen are the more resistant than others and do not currently have any major threats).
- Linking to emerging markets and supply chain.
- Converting to biomass based heating systems for Estate buildings (Grants can be attained through ROCS, Carbon Fund etc)

### 1.1 Current Land Use

The estate is primarily an example of a Highland wildland with no commercial activity whatsoever, it is managed and well-staffed but only as a preserve of the traditional highland experience. Originally the estate was 3 smaller estates: Inverinate, Killilan, and West Benula but was consolidated when the current owner purchased them 30 years ago and comprises of 25,631.6 hectares. In total approximately 94% of the ground is under rough grazing and amenity with some of the land given over to crofting and common grazing in the south-west of the estate (See Figure 1 and 2).

There are four lochs and one part of a larger loch on the estate, covering 368 hectares and the south border of the estate skirts along the north shore of Loch Duich. There are 2 farms on the estate that keep several herds of Black face sheep and a herd of Highland cattle. Recently the estate bought 2 areas of forest from the Forestry Commission, which brought 2 pieces of land back into the Estate that were sold off to the Forestry Commission between the first and second world war. The 2 areas of forest together are approximately 600 acres of mature, unmanaged Sitka spruce. The national Trust bought a slither of land that runs through Inverinate called Glomach Falls, a place of outstanding natural beauty, although the Estate has retained the shooting rights.
There is a significant presence of crofting communities running through the south region of the Estate, many houses and some common grazing that is currently used and has a forestry scheme upon it. In the past the Estate was focused upon livestock farming with several shepherds and substantially greater presence of sheep grazing on the land from Inverinate all the way over Killilan where the ground is more elevated and rougher. Now the former farmhouses and buildings are abandoned, derelict in some cases and stand in the landscape as relics.

Figure 0.1 – Pie chart of current land use break down for Inverinate estate

Previously the estates mainly employed shepherds. Now the Estate has a permanent staff of 12: The Estate manager, 4 Stalkers, 3 Gillies, 3 Shepherds and an administrator working from the main Lodge. They employ a lambing assistant, vets, masons and other staff when and where they are needed. The main duties are keeping the animals in good health ready for shoots, distributing feed and maintaining the infrastructure of the estate.

The estate has very good relations with the local community; it provides employment as well as donating and renovating a building for a community, and given land to the Highland Council for assisted housing development. The estate used to have 5000 head of deer but due to a culling regime, it has been taken down to 3000, where 120 stags are...
culled each year. There are feeding stations throughout the estate where deer herds congregate on lowland areas.

A part from the 2 areas purchased from the Forestry Commission there are a few patches of forestry that has been planted through the forestry Schemes, areas of birch and pine. Some had to be replanted as they were browsed by feral goats during their establishment. Throughout the estate there are patches of birch and pine but they form very small islands with no sense of connectivity or continuity. There is very little regeneration due to the browsing livestock. There is salmon in the lochs, exclusively fished by the owners and his guests.
Figure 0.2 - Current land use on Inverinate Estate
1.2 Forest Energy Potential

The potential Short Rotation Forestry (SRF) areas were identified using multiple criteria:

- Low-lying sites that were relatively close to a track or a road.
- Potential soil suitability.
- Least inference with other land uses.
- Planned roads that will give new access.
- Improve aesthetic of land.
- Not reduce current landscape value.

The SRF is planned in smaller stands to work with the landscape and not present a great intrusion into the landscape but the scope remains to connect the woodlands in the future. The new mosaic would be designed to provide deer rides, access for extraction and create woodland that flowed with the landscape. The species chosen are a mixture of native and production conifers, so conservation production objectives offset one another. A mixed-woodland will improve the biodiversity and successional age structure of new native woodlands. Each woodland parcel has multiple management options:

- Harvesting a percentage of the timber at the end of the 20-year rotation for woodfuel, restocking and keeping a significant native stand to grow to maturity.
- The rotation of the timber can be extended to make it viable for another market (e.g. roundwood).
- The timber harvested could be classed as ‘additionality’ (additional use/purpose) to the growth and therefore not interfere with expansion and subsidies of the mixed native woodland resource.
- A first thinning taken out for SRF and be replanted and become part of a shelterbelt system for the deer herds.

These new woodland plantings will all be viable under the Woodland Carbon Code and other carbon initiatives producing tradable carbon credits.
Figure 0.3 - Potential areas of Short Rotation Forestry
Below Table 1 explains the criteria for allocating areas of land with a compatibility rating for short rotation forestry, which informs Figure 3 the map of site compatibility.

**Table 0.1 - Short Rotation Forestry land compatibility criteria**

<table>
<thead>
<tr>
<th>Site Compatibility</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compatible</td>
<td>Low elevation, suitable soil, limited wind exposure, close to transport routes and estate infrastructure, current fencing, unmanaged land not conflicting with other uses.</td>
</tr>
<tr>
<td>Compatible but with constraints</td>
<td>Similar to the Compatible category but may have less access to infrastructure and transport routes and higher elevation that will increase harvesting costs.</td>
</tr>
<tr>
<td>Moderately compatible</td>
<td>Land that is suitable for SRF but has no access to estate infrastructure and borders other land uses-making it viable ecologically but not economically</td>
</tr>
<tr>
<td>Incompatible</td>
<td>Land that is neither ecologically or economically suitable but without any land use conflict</td>
</tr>
<tr>
<td>Very incompatible</td>
<td>Prohibitive land-High elevation rough grazing with no estate infrastructure, sizeable distance from transport routes, poor soil and aspect, conflict with wintering deer and other land uses</td>
</tr>
</tbody>
</table>
Figure 0.4 - Short Rotation Forestry land compatibility map
Figure 4 shows that there is only 4% of the estate compatible for short rotation forestry due to infrastructure, accessibility and suitable environmental conditions. A further 4-27% would be suitable for non-productive native mixed woodland.

**Figure 0.5 - Pie chart of Short Rotation Forestry land compatibility**

The following tables break down the results of the woodland expansion for Attadale Estate in terms of spatial change, species composition, net economic return, carbon and calorific values. Generated from the Forest Energy Tool that is specific to the estate’s region.

**Table 0.2 - Break down of potential land use change (Short Rotation Forestry)**

<table>
<thead>
<tr>
<th>Land Use Change</th>
<th>Area (Ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Douglas fir</td>
<td>23.93</td>
</tr>
<tr>
<td>Hybrid aspen</td>
<td>22.53</td>
</tr>
<tr>
<td>Scots pine</td>
<td>12.82</td>
</tr>
<tr>
<td>Sycamore</td>
<td>7.62</td>
</tr>
<tr>
<td>Scots pine/Birch</td>
<td>16.43</td>
</tr>
<tr>
<td>Scots pine</td>
<td>26.42</td>
</tr>
<tr>
<td>Hybrid aspen/Sycamore</td>
<td>12.19</td>
</tr>
<tr>
<td>Scots pine/Birch</td>
<td>15.46</td>
</tr>
<tr>
<td>Scots pine/Birch</td>
<td>12.21</td>
</tr>
<tr>
<td>Scots pine/Birch</td>
<td>21.98</td>
</tr>
<tr>
<td>Species</td>
<td>Percentage of Estate %</td>
</tr>
<tr>
<td>---------------------------------</td>
<td>------------------------</td>
</tr>
<tr>
<td>Hybrid aspen</td>
<td>20.58</td>
</tr>
<tr>
<td>Sycamore</td>
<td>15.60</td>
</tr>
<tr>
<td>Mixed native woodland Amenity (Scots pine)</td>
<td>122.78</td>
</tr>
<tr>
<td>Douglas fir</td>
<td>22.75</td>
</tr>
<tr>
<td>Scots pine</td>
<td>26.49</td>
</tr>
<tr>
<td>Douglas fir</td>
<td>22.90</td>
</tr>
<tr>
<td>Total area (ha)</td>
<td>402.71</td>
</tr>
<tr>
<td>Percentage of Estate %</td>
<td>1.57</td>
</tr>
</tbody>
</table>

**Table 0.3-** Net economic return from Short Rotation Forestry

<table>
<thead>
<tr>
<th>SRF Outputs</th>
<th>£</th>
</tr>
</thead>
<tbody>
<tr>
<td>SFR net 20 year revenue</td>
<td>£939,222.21</td>
</tr>
<tr>
<td>SFR net annual revenue</td>
<td>£46,961.11</td>
</tr>
<tr>
<td>SFR 20 year revenue per hectare</td>
<td>£2,332.24</td>
</tr>
<tr>
<td>SFR annual revenue per hectare</td>
<td>£116.61</td>
</tr>
</tbody>
</table>

**Table 0.4-** Calorific values from Short Rotation Forestry harvest

<table>
<thead>
<tr>
<th>Calorific Values (mc=moisture content)</th>
<th>MWh (Megawatt Hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 year- 30% mc</td>
<td>64,273.16</td>
</tr>
<tr>
<td>40% mc</td>
<td>63,518.33</td>
</tr>
<tr>
<td>60% mc</td>
<td>57.528.16</td>
</tr>
<tr>
<td>Annual- 30% mc</td>
<td>3213.66</td>
</tr>
<tr>
<td>40% mc</td>
<td>3175.91</td>
</tr>
<tr>
<td>60% mc</td>
<td>2876.40</td>
</tr>
<tr>
<td>20 year per hectare- 30% mc</td>
<td>159.60</td>
</tr>
<tr>
<td>40% mc</td>
<td>157.73</td>
</tr>
<tr>
<td>60% mc</td>
<td>142.85</td>
</tr>
<tr>
<td>Annually per hectare- 30% mc</td>
<td>7.98</td>
</tr>
<tr>
<td>40% mc</td>
<td>7.89</td>
</tr>
<tr>
<td>60% mc</td>
<td>7.14</td>
</tr>
<tr>
<td>Equivalent annual litres of oil fuel- 30% mc</td>
<td>321,365.8</td>
</tr>
<tr>
<td></td>
<td>£192,819.5 (@60 pence/litre)</td>
</tr>
<tr>
<td>40% mc</td>
<td>317,591.7</td>
</tr>
<tr>
<td></td>
<td>£190,555</td>
</tr>
<tr>
<td>60% mc</td>
<td>287,640.7</td>
</tr>
<tr>
<td></td>
<td>£172,584.5</td>
</tr>
</tbody>
</table>
Calorific value accounts for the amount of heat something will give off when burnt - 1 m$^3$ of hardwood timber will give off 1.4 Megawatt Hours of energy (e.g. a 60 watt light bulb will consume 0.00006 Megawatts per hour). The estate uses approximately 81,000 litres of oil a year for its various properties, the amount of energy generated by the woodland could cover that many times over but wouldn’t take affect until after the first rotation of 20 years. The remainder of wood could either be channeled into local woodfuel markets, for other product or for further enhancement of the woodlands.

<table>
<thead>
<tr>
<th>Carbon value</th>
<th>£/tonnes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Economic 20 year</td>
<td>£474,528.06</td>
</tr>
<tr>
<td>Economic annually</td>
<td>£23,726.40</td>
</tr>
<tr>
<td>Economic 20 year per hectare</td>
<td>£1,178.33</td>
</tr>
<tr>
<td>Economic annually per hectare</td>
<td>£58.92</td>
</tr>
<tr>
<td>Social 20 year</td>
<td>£4,828,856.97</td>
</tr>
<tr>
<td>Social annually</td>
<td>£241,442.85</td>
</tr>
<tr>
<td>Social 20 year per hectare</td>
<td>£11,990.84</td>
</tr>
<tr>
<td>Social annually per hectare</td>
<td>£599.54</td>
</tr>
</tbody>
</table>

Carbon value is the amount of carbon (CO$_2$) that the SRF sequesters and stores as it grows. Carbon credits have an established market and are tradable on various exchanges. Currently the carbon price is fairly low due to the market only recently being established but it is predicted to stabilise and grow-pushing prices closer towards the social price. At the opening of the trading floor in 2015, the UK is reportedly raising the carbon price to £18.08 (Reuters 2014), which will significantly raise the economic worth of the market and associated uses. Meaning that the carbon sequestered for woodland creation could be worth more than the timber.

Table 0.5- Carbon values accrued from Short Rotation Forestry (timber only)
2.1 Exploration of the cultural themes that characterise the Estate Management

Through the Mobile Field-Interview conducted on 4th April 2013 several cultural themes were identified that characterise land use and management of the Estate. The themes are displayed in order of greatest significance:

1) **The Estate is managed as a ‘Highland Wildland’ with traditional stag hunting**

   Predominantly the owner views the estate as an example of a traditional highland estate, a preserved piece of history or iconic landscape. Unlike other estates Inverinate can persist without any commercial activities but still support an infrastructure that employs a full staff, keeping unprofitable practices in the estate and making stag hunting for the owner and his guests the main drive of the estate. In the owner's view the estate is preserving a piece of the Highlands in a wild state.

2) **Active management and business operations are detrimental to the idea and realisation of a ‘Highland Wildland’**

   Due to the open funds that the estate can pull upon the estate has the freedom to be managed in an idealistic manner. A wildland in the Highlands is perceived as a place with roaming livestock, unmanaged forests (even those that were planted non-natives) and inaction, for the most part enable’s wilderness to be recreated. A commercial or business orientation to the estate would interfere with this ambit.

3) **The Estate is run purely for the land owners enjoyment and nothing more**

   Management on the estate is in essence maintaining the land for the stag shooting and recreation activities (walking) of the owners and their guests. The landscape and practices are kept up for the owner’s appreciation of owning a wild piece of the highlands. The staff are often poised for the arrival of an entourage with only 24 hours notice and in the between periods there is no other business activity.

4) **Deer stalking is the primary purpose or use of the Estate**

   Stag stalking, their count and culling like many estates is the main activity and form of management, it is at the core of many highland estates and remains one of the biggest draws for owners, tourists and visitors.

5) **The Estate is run as an unrealistic model of sustainability, more a preserve or museum of idyllic highland life**

   If the estate did not have its current financial resource the practices and staff that are currently being supported would not be able to persist. Without any revenue, even from rented accommodation and stalking/fishing packages, which most estates make their main revenue from, the estate would be in great deficit. Lacking the funds to keep many of their workers and continue many of the agricultural practices. Estates are barely able wash their faces with a diverse range of practices and engaging with government
subsidies-It is a picture of an idyllic highland rural area but not of sustainable or realistic land use.

6) Undeveloped markets and unreliable supply produces a lack of confidence in developing resources

Often for emerging markets or rebooting markets there is a time lag for supply and demand as well as the intermediary chin to reach an effective equilibrium to support a stable and growing market. A market that people want to invest and buy into but often markets cannot reach the state of sustainable growth and favourable awareness without a critical mass of a resource base. Due to a lack of awareness or incorrect or bad practice in the past (woodlands), there is a lack of confidence that the resource and be a reliable platform for a market.

7) Farming decline in the region-it is no longer a viable land use activity but a part of the romantic Highland imagery

Due to changes in the CAP, SRDP and rural markets much of the highland farming culture, livestock, has become unprofitable and unsustainable. Many estates, tenant farmers and crofters have stopped grazing cattle and sheep and rural markets and prices are in decline. Despite this the cattle and sheep of the highlands remain an indomitable part of highland life and the imagery that goes with it. This factor alone of belonging and perception of traditional lifestyles has kept livestock on the hills for nostalgic reasons, as well as to keep alive what was once a staple of rural communities and economies.

8) Amenity woodland, shelterbelts, and fisheries benefits would be the only reason to expand the woodland resource-production is out of the question

As the estate is run as strictly non-commercial activity policy woodland as a commercial resource would unlikely be realized. Woodland is never spoken about too favourably in production terms and will then turn to Sitka spruce, which is a non-native but seems to be the only species considered for commercial activities. Woodland and its uses are spoken about with warmer tones when planted and designed in mind to support the core purposes of the estate, shelterbelts for deer, fodder and protection along riparian ways for fish and erosion deterrents. Amenity mixed native woodland is seen as a good move as this is fiercely supported and pushed by government grants.

9) Past browsing has impeded and damaged woodland establishment (wild goats)

Regeneration schemes and planted woodland have been ruined by browsing activities on the estate. Consequently forcing restocking of entire sites, time delays and a loss of confidence and future investment in further woodland schemes. Browsing was not only from deer herds but semi-feral wild goats that are kept on the property. If woodland establishment is seen to be a futile or just difficult undertaking then future schemes maybe dismissed as unfeasible or too costly for both resources and time.

10) Strong native species preference as there is an antipathy towards non-natives that have taken over the landscape in big blocks

In the current climate non-native species, which were welcomed and planted widely in the 1960’s-80’s in place of native (e.g. Atlantic oak rainforests in the Lochaber area) species, are now villanised and seen as scars upon the landscape, without utility or movement. The brunt of the wrath relates to Lodgepole pine that is seen in dense
unhealthy woodland, often suffering from regular windblow, without recourse for removal. Even the Douglas fir is seen as an invaded and single trees like the Monkey puzzle detracts from the landscape. Along with these factors, the Scottish government has pushed mixed native woodland expansion and more landscape minded design. Giving an overriding preference and favour to non-productive native species, scattered over the landscape in a salt and pepper mix of conifers and broadleaves.

11) The Estate and land is private with no external interference wanted or needed
The owner has the view that the estate is private and wants to have minimum interaction with third parties and their possible involvement with the estate. Management activities and dialogue with NGO’s and government agencies is not desired. The estate is to be managed with the owner’s vision and is not necessary to become overly entangled with agencies-this is why the estate bought FC land to further consolidate it’s borders.

12) Little trust and understanding of woodfuel supply and market
Although the estate has considered biomass and had a brief foray into the market and resource 20 years ago-it remains dubious and doesn’t possess much trust in both the feasibility of the resource and market. The woodfuel market hasn’t been revisited and is often seen as a low-end supply of logs for a few fireplaces, without the scope, sophistication, abilities and potential market of other energy consumables. Awareness is lacking of the growth and development and the perception remains that it isn’t and proper market and growing woodland that supplements a growing local market or even the estates needs isn’t plausible, if not ridiculous.

13) Owners and Trust lack local knowledge and prioritise the aesthetic appeal of the Estate over the ecological function
As the owner is absentee and the management (Trust) is remote from the locality there is a lack of local knowledge and inherent sense of place. Due to being non-local owners and from a region in the world that shares very different climates and ecological conditions, the innate and assumed knowledge is lost and creates a disjointed discourse, which in turn affects the management practices and fluidity of land use. Subsequently the aesthetic is often placed at the forefront of the management considerations at the loss of underlying ecological function and enhancement.

14) What was once presence in the landscape (trees and fauna) doesn’t necessarily belong there anymore
The Scotland and the Highlands of the past to many is an unknown image and an alien place. It’s form is contentious amongst the experts and the Scotland of the past for many is only the last 50 years and at the most 200-300 years, going back just before the clearances. This means the landscape is distilled with a very specific agriculture and grazing lead mentality with little influence from woodlands and leans towards the human shaped landscape rather than what would have been the ecologically lead landscape. Swathes of broadleaf woodlands seems unnatural, the reintroduction of formerly native species seems reckless and is tampering with land practices in place, and already declining rural livelihoods.
Please provide any feedback on the Cultural Themes. Do you agree or disagree with the identified themes? Do you agree with the order of significance? Is there anything else you wish to add?
3.1 Clustered land use collaboration discussion group
Appendix H – Case study GIS maps
Case Study 1 – Wester Ross
Case study 1 - Wester Ross woodland landscape corridors
Case study 1 - Wester Ross woodland landscape corridors (Peat constraints)
Case Study 2 – Lochaber
Case study 2 - Lochaber woodland expansion

Woodland expansion area and species
- Estate boundaries
- Rail line
- B-road
- A-road
- Rivers
- Scots pine
- Scots pine/Birch
- Scots pine/Douglas fir
- Poplar
- Poplar/Birch
- Poplar/Sycamore
- Sycamore
- Douglas fir
- Sitka spruce/Scots pine/Poplar
- Current woodland

1:88,530
© Ordinance survey 2014
0 1.252.5 5 Kilometers
Case Study 3 – Cairngorms (Deeside)
Case study 3 - Cairngorms current land use

Land use:
- Estate boundaries
- B-road
- A-road
- Rough grazing/Amenity
- Woodland
- Livestock
- Ponies
- Tenant farm
- Loch
- Lochan
- Riparian land
- Heritage Centre/Wetlands
- Urban fringe
- Estate lodge
- Balmoral Castle
- Ski Resort
- Water Treatment

© Ordnance survey 2014

1:105,743

0 1.5 3 6 Kilometers
Case Study 3 - Cairngorms woodland landscape corridors
Case Study 4 – East Sutherland
Case study 4 - East Sutherland woodland expansion

Woodland expansion area and species
- Estate boundaries
- Rail line
- B-road
- A-road
- Rivers
- Scots pine
- Scots pine/Birch
- Scots pine/Poplar
- Poplar
- Poplar/Birch
- Poplar/Sycamore
- Sycamore
- Douglas fir
- Douglas fir/Birch
- Douglas fir/Poplar
- Current woodland

© Ordnance survey 2014

1:62,028

0 1 2 4 Kilometers
Landscape Partnership Networks
Appendix I – Flash drive content

The attached flash drive includes:

- 12 Estate land use reports
- 12 Forest Energy Toll matrices
- Case study maps