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Perception and partnership: Developing forest resilience on private estates

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A B S T R A C T

Scotland has the highest concentration of private land ownership in Europe and private estates in the Highland region cover the vast majority of the land. On many private estates forests share the land with a strong tradition of sporting use that has inhibited the development of forest management culture. Land managers are seeking ways to diversify that are relevant to both local practice and wider environmental issues to align with Scottish woodland expansion policy, increasing emphasis on resilience strategies and adoption of ecosystem approaches. This research focusses on four regionally diverse case study areas, each containing three neighbouring private estates in the Scottish Highlands. Using mixed-methods that includes an adapted walking interview technique, collaborative action discussions and a novel approach to mapping spatial resilience this study explores resilience and forest culture through individual perceptions of the participating land managers. This work expands understanding of spatial resilience that is relevant and meaningful to land manager decision-making and local practice, which could offer policy makers with an effective avenue to realise and implement resilience aims through local action. Key synergies between renewable energy, carbon marketing and forest development are identified alongside perceptions of resilient forest types. Support mechanisms such as regionally trusted capacity building and facilitation are recognised as crucial to mobilising six landscape partnerships (land manager identified) that could both strengthen estate and forest resilience.

1. Introduction

In the Highlands of Scotland the vast majority of land is in private ownership (Scottish Government, 2014; SNH, 2016), which suggests that the decisions and management actions of these managers has significant influence on the shape and subsequent services produced by regional landscapes (Warren, 2009). In recent decades, diversification of ownership patterns has occurred in the Highlands with increasing NGO and community landownership, resulting in an accompanying shift in land management objectives, from predominantly sporting land use to an increase in environmentally oriented aims (MacMillan et al., 2010; McMorran, 2013). Dandy (2016) describes a deep-rooted practice of woodland management neglect due to land managers' limited understanding of woodlands producing a culture of under-management, which has since manifested as a social norm. However, there are many other influences, such as economies of scales, public policy and timber markets that distort forest management interactions. Forest resilience is normally viewed through the frames of forest health and climate change, focusing upon structure, diversity and species suitability

(Cavers and Cottrell, 2015; Forestry Commission Scotland, 2016), this focus has undermined the importance of socio-economic factors such as markets, and social drivers (including manager attitudes and values).

This research aims to develop current understanding of forest resilience from the perspective of land managers on private estates to help reduce the gap between unclear, broad policy aims, and meaningful management activities for practitioners. A spatially tracked walking interview is used as the primary research method to examine the relationships between the manager, land use practice and landscape. The synthesis of forest management culture on private estates and land managers' spatial interpretation of popular resilience concepts is the primary focus of this research. Developing approaches based on individual and collective land manager perceptions that strengthen overall estate resilience alongside an expanding forest resource could play a key part in realising Scottish woodland expansion targets by providing valuable insights into forestry culture in the wider landscape management context. This research explores three aims to i) expand understanding of forest resilience through spatial perception ii) gain insights into socio-economic factors and drivers that effect forest

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resilience management iii) and identify meaningful action to reduce the gap between policy and practice.

Essentially, this study translates land manager decision-making and experience of local practice into a spatial transcript of perceived resilience and then uses this information in case study led collaborative discussions to formulate relevant actions at landscape level. Such an approach is crucial for developing a greater understanding of effective collaboration across landscapes. In this study six landscape partnerships were identified through the interviews and collaborative case study discussions, three of which were strategically mapped over the case study areas to optimise transboundary cooperation. These partnerships underpin a local ecosystem approach, which could support a more vibrant forest management culture on private estates. This methodology is easily replicable and could be applied to various land ownership contexts globally to map resilience and assess local practices, resource use and influence of cultural norms.

This research connects common resilience concepts of stability, adaptation, transformation and collaboration with land manager perception of land use practice and spatial planning on private estates. Each concept is physically mapped through a spatially tracked walking interview and follow-up consultation with the land managers. Utilising an applied bottom-up approach to interrogate a typically top-down policy provides an effective route to identify and develop links between individual land use practice and broad policy goals, which are, for the individual, difficult to understand and reconcile with personal management aims.

2. Literature review

2.1. Conceptualising resilience

The traditional view of resilience refers to the capacity of a system to absorb disturbance and reorganise while undergoing change, to essentially retain the same function, structure, identity, and feedback systems (Holling, 1973; Walker et al., 2004). Now a popular policy goal, resilience is a challenging concept for land managers to understand from a practical perspective (Newton, 2016). In Scotland, resilience is viewed through adaptation to climate change and enhancing biodiversity to create more resilient ecosystems that can continue to supply ecosystem services, which supports the economy and develops communities (Scottish Government, 2009).

Despite the policy-heavy nature of resilience it has potential to complement ecosystem approaches and landscape management (Thompson et al., 2009) providing guidance on key areas of development, such as biodiversity, climate change and water management (Scottish Government, 2016; Sniffer, 2016). Resilience and ecosystem approaches share the challenge of effectively interpreting complex multi-layered concepts in ways which can facilitate understanding among land managers in relation to how these high-level objectives should influence practice. Aichi Biodiversity Target 15 of the CBD commits signatories by 2020 to ensuring 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 Government (DEFRA, 2011) stance on securing the value of nature aims to create, “a more resilient natural environment for the benefit of wildlife and ourselves”.

Presently, there is little guidance on operational definitions, levels of system resilience, successful application and resilience management techniques (Cavers and Cottrell, 2015). Several extensions of resilience theory have been developed moving toward adaptation of management and systems to shocks, disturbances and episodic events, which ultimately transform and change the environment to a new stable state with different regimes (Scheffer, 2009; Folke et al., 2010). This continual adaptation emphasises the dynamism and continual evolution of

environments in response to change and new interactions (Wilson, 2012).

2.2. Conceptualising resilience in forestry

Forestry Commission Scotland produced a set of forest resilience-building measures, which advocates the application of current best practice with the view to creating long-term resilience for Scottish forests (Forestry Commission Scotland, 2016). These measures include selecting the most suitable species and genotypes for sites enabling the woodland to cope with future stresses, reducing pressures from deer, invasive species and fires, maintaining and adding diversity in structure and species, and accounting for the potential effects of climate change to forestry operations and design (Forestry Commission Scotland, 2016). The private forest sector emphasises the importance of planting more trees to fill the impending gap in timber supply that is due in 30 years, as well as securing and growing the industry through planting new productive woodland for a robust rural economy and resilient Scotland (CONFOR, 2016). Planting trees to reduce flood risks has become a powerful driver, as evidenced by the recent catastrophic flooding in Britain that has caused millions of pounds in damages (Spray et al., 2015; Monbiot, 2015). Such events, as well as the resulting damage and emergency expenditure could be reduced, if not mitigated, by developing well designed woodland in upland areas, around rivers and water catchments. Managers often remain distant from policy aims and without the mechanisms and insights to align resilience on a national scale to management on a local scale, targets and aims will continually fall short (Raymond et al., 2016).

Current thinking on woodland resilience in Britain focusses on adaptation to climate change, as well as developing species and genetic diversity that enhances evolutionary resilience (Ennos, 2015). Such thinking highlights the key relationship between diversity and resilience to develop system redundancy in woodlands by spreading the risk to threats and creating more complex structures that are less vulnerable to change and disturbance. Mostly positive relationships are drawn between high diversity and stability (Laliberté et al., 2010); but these may be strongly mediated by socio-economic factors in forest ecosystems e.g. species mix choice, planting time scales etc. (Wellnitz and Poff, 2001). Clarifying the form of resilience that a land manager or policy-maker is seeking for a particular land use (e.g. pest resistance or climate adaptation) is critical to the development of practical approaches to operationalising and measuring the success of resilience actions in forestry. For example recommending levels of the structural diversity, species mix or the intra specific genetic diversity that enhances the ecosystem processes and species resilience (Cavers and Cottrell, 2015). Part of this resilience action could focus on particular ecosystem services, the wider role of management and outcomes within the region, such as watershed protection, carbon sequestration, timber production or recreation.

2.3. Resilience mapping

Resilience mapping is predominantly associated with climate, disaster, risk and health issues that examine comparative state of multiple communities (van Zandt et al., 2012; Allen et al., 2013; Shaw, 2014). Resilience from a floodplain restoration perspective investigates longitudinal patterns that are influenced by biophysical and socio-economic characteristics (Hulse and 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 and Cottrell, 2015; Ennos, 2015), as well as spatial patterns for silvicultural prescriptions at stand level (Churchill et al., 2013). Current resilience mapping for forests is increasingly focussed on ecosystem services assessment in response to disturbance and new regimes (Barredo et al., 2015; Seidl et al., 2016). In Scotland the Tweed Forum has rolled out a pilot project for the Scottish land use strategy (2011)

that presents new ways to manage land and employ an ecosystem approach. A map-based tool helps managers make better long-term decisions about land use at a time of rapid environmental, economic and social change (Tweed Forum, 2015). This focuses primarily on four types of services: Provisioning, regulatory, cultural and supporting within an integrated catchment management plan (UK NEA, 2014). In New York Campbell et al. (2015) assessed the value of parklands cultural ecosystem services on a spatially explicit level to strengthen social meaning within natural greenspace. This develops a more comprehensive resilience planning methodology easily replicable by other practitioners, however the scale remains at the park level and does not map social meaning within specific areas to further aid spatial planning for more detailed local scale analysis.

2.4. Adaptive management and collaboration

Social factors are recognised as a core influence on ecosystem resilience, consequently impacts of management actions on ecosystems are tested, monitored and adapted again to management objectives, depending on the perceived success (Folke et al., 2010; Cumming et al., 2016). Adaptive management is seen as a way for tackling risk and uncertainty over long-term planning (Yousefpour et al., 2012). In Sweden adaptive management is expected to help evaluate new silvicultural methods that might improve the cohesion of joint policy goals of biomass production and increased levels of beneficial environmental status (Rist et al., 2016). Resilience theory suggests that adaptive management is key to facilitating practical initiatives and projects at smaller scales (Walker and Salt, 2012; Schultz et al., 2015). Thus, adaptive management is an aid to decision-making through comparative and iterative learning process that advocates collaboration and participation to reduce conflict and enhance contributions to the process through wider knowledge-base (Holling, 1973; Fabricius et al., 2007; Boyd and Folke, 2013). This is crucial for land use practice, as continual change and interactions of ecological, economic and social factors requires informed, flexible and innovative approaches (Wilson, 2012; Cocks and Dold, 2012). Such an approach on Scottish estates may aim to balance the ecological threshold of deer numbers for natural forest regeneration ($4/\text{km}^2$) (Bunce et al., 2014) against land manager preferences and local experience (Gould et al., 2015).

Forest expansion transforms an environment, in ways which cannot always be traced at landscape scale with long-term impacts (Pelling et al., 2015). Cumulative actions of smaller actions or projects can lead to more identifiable benefits at larger scales (landscape/catchment) through combined learning processes (Prager et al., 2012; Spray et al., 2015). Chapin et al. (2010) suggests that transformation takes place through preparation, using barriers as opportunities and strengthening resilience by embedding and responding to social influences. These can be achieved through bridging organisations or trusted intermediaries that possess the capacity to operate between the smaller and larger scales (Olsson et al., 2004; Spray and Comins, 2011; Prager et al., 2012; Rouillard et al., 2015). Collaboration offers one way of recognising complex issues (Head and Alford, 2015), therefore institutional, as well as private sector cooperation is crucial to building both capacity and implementing effective change in forest management approaches (Lawrence and Dandy, 2014; Muñoz-Rojas et al., 2015; Ambrose-Oji et al., 2015). Finding collaborative synergies between Deer Management Groups (DMG), Forestry Commission, private landowners and community groups, which facilitates effective participation for regional scale action and management will require greater communication, knowledge, coordination and resolution of current implementation difficulties (Davies and White, 2012; Scarlett, 2013). This relationship underpins a way forward for adapting land use practice influenced by local culture and individual manager perception to both resilience and land use policy goals.

Current organisations that are exploring practical solutions for resilience are focussed on translating the conceptual side into accessible

and practical actions for managers, which is key to improving the cultural significance of the science-policy interface that will enhance application of resilience (Schultz et al., 2015; Lange et al., 2016; Cockburn et al., 2016; Sniffer, 2016).

2.5. Private land ownership and forest expansion in Scotland

Scotland has the highest density of private landownership in Europe (Lorimer, 2000; Cahill, 2001; McKee et al., 2013), 30% of which is owned by 115 individuals and is suggested that only 17 landowners share 10% of the country (Wightman, 2010). Declining demand for farm products (wool), increasing infrastructural development that connected the Highlands to the rest of the UK and the patronage of the British Royal family at Balmoral Estate drove the impetus for large areas of land to be bought up by the wealthy (Devine, 1994). Known as ‘Balmoralisation’ the acquisition of Highland estates as status symbols, for recreational retreats and privileged lifestyles, has led to a relatively unchanged landscape in the Scottish Highlands over the last 150 years (Warren and 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). This led to open hill landscapes synonymous with estates; while relatively large areas of land may be used for sporting purposes, estates are characterised by multiple land use supporting agriculture, grazing, tourism, housing and tenant farming among others (Hindle et al., 2014).

Productive forestry and native woodland management for conservation and amenity normally rank as third or fourth largest land area for estates (McMorran et al., 2014). Wightman and Higgins (2000) suggest that there are some 334 sporting estates in the Highlands and Islands equating to approximately 2.1 million hectares with individual holdings ranging from 2000 to over 40,000 ha. The Scottish Land Reform Review (2014) states that private land accounts for 89% of the country and that 432 owners own 50% of private rural land in Scotland. Estate capital value is based upon the current value of the available game (McKee et al., 2013), which results in inflated prices for heaths and moorland due to the social value attached to sporting interests (McCarthy, 1998). Absenteeism is a notable characteristic of Highland estates, where wealthy non-resident owners buy for recreational purposes with no economic objectives (Warren, 2009; MacMillan et al., 2010), this brings investment to the land and community but has reduced investment in other activities e.g. forestry and food production (Bryden and Giesler, 2007). Although the Scottish situation is unique due to the concentration of private ownership the phenomena of hunting estates, which impacts land use, resource production and local cultures are wide spread. Several examples exist, such as Andalusia in Spain where land abandonment from declining livestock industry has led to reliance on commercial hunting, creating tensions between local economies, ownership aims and environmental considerations (Herruzo et al., 2016). Wide spread expansion of recreational hunting estates around the world in rural areas including Africa, North America and Europe has drawn attention to the potential trade-offs between economic, environmental and social impacts, as well as the multi-functionality and broad benefits of these growing landscapes (Fischer et al., 2013; Herruzo, 2013).

Forests in the Highlands cover 13.5% (approximately 341,323 ha) of the region (FCS, 2014) and hold 85% of the Scotland's native Caledonian pinewood resource (*Pinus sylvestris* dominated woodland) (Highland Council, 2006). Native woodland accounts for 37.7% of the cover, so the majority of the Highlands is under non-native species woodland structure (FCS, 2014). This is the legacy monoculture plantation forestry, focussed on production of fast growing conifer species, such as Sitka spruce, lodgepole pine, Douglas fir, as well as some larch and Norwegian spruce, which were planted from the 1960's onwards (Highland Council, 2006; Hobbs, 2009; Dandy, 2016). More recently efforts have shifted to expanding forests that provide multiple benefits

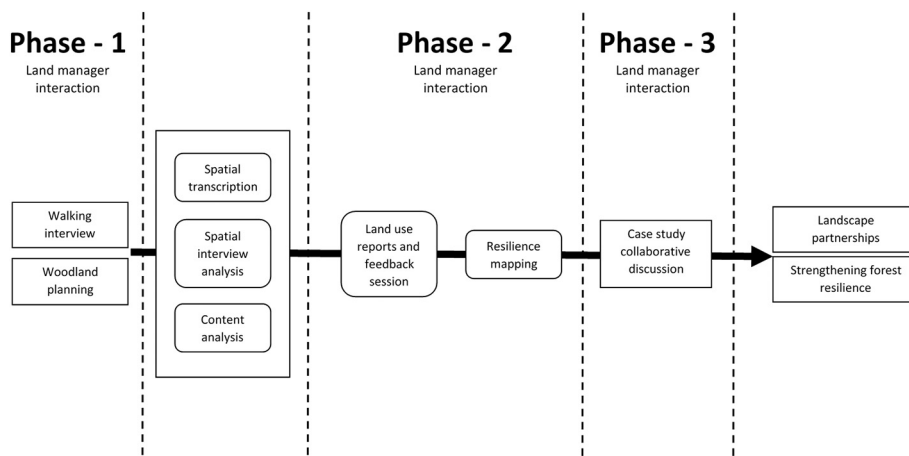


Fig. 1. Diagram of methodology.

for biodiversity, recreation and landscape amenity (Woodland Expansion Advisory Group, 2012). The region has the highest proportion of recruitment for farm woodland schemes (FCS, 2016) and is encouraging diversification of productive forestry, adoption of renewable energy and ecosystem services approach. Forestry's economic, environmental and social value to the country is increasingly recognised (Scottish Government, 2015), resulting in the need to identify new areas for expansion, to understand the culture of land managers and develop new approaches to reduce the gap between policy and practice (Woodland Expansion Advisory Group, 2012; Scottish Government, 2016).

3. Methodology and materials

The methodology outlined here has been designed to engage individual estate managers at a local scale (single land boundary) using in-depth walking interviews that explore the spatial relationships of perception and practice. Fig. 1 shows the methodology process from interview to the outputs of maps and qualitative outcomes that characterize an interpretation of an ecosystem approach. Highlighted in Fig. 1 are the three phases of land manager interaction 1) walking interview and planning session 2) Land use report discussion and follow-up and 3) Case study collaborative discussions. These stages led to the mapping of landscape resilience and identifying key landscape scale management considerations. The land use reports provided background estate information, maps of planned woodland expansion, potential woodfuel and carbon revenue, as well as core interview themes and analysis (cultural land use drivers). These reports provided an important iterative process for verifying the effectiveness of the methodology, subsequent analysis of the interview content and refined the understanding between land manager and researcher.

3.1. Case study areas

The case study areas were chosen to represent the diversity of environmental conditions, management influences and local socio-economic contexts in the Highlands. As significant areas of land need to be converted to forest in order to meet targets, the woodland expansion policy needs to engage with various private landowners driven by different conditions, goals and motivations. Social science research recognises that effective engagement requires taking account of the nuances rather than adopting a blanket approach that ignores important factors occurring at the local level. Table 1 demonstrates the differences between and within the case study areas emphasising the nuances that occur over the landscape and at the local level. Fig. 2 shows the distribution of private land ownership and the geographical spread of the case study areas, which constitute 4.75% of the region and

5.6% of private ownership in the region.¹

Twelve estates were interviewed over four case study areas, each area containing three contiguous estates of varying size but with sporting interests as the main management aim. Additionally the estates possess large areas of open land that have potential for woodland expansion, alongside historically competing land uses (MacMillan et al., 2010; Woodland Expansion Advisory Group, 2012). Neighbouring estates were selected to explore the potential of a given case study area for collaborative management across boundaries from a regional network perspective. This design aims to develop regional working units by identifying meaningful activities within the case study areas, which are potentially significant to strategic decision-making (Elwood and Martin, 2000; Scott et al., 2009; Woodland Expansion Advisory Group, 2012).

3.2. Walking interview

The walking interview builds upon the concepts of the 'walking', 'go-along' and 'mobile' interviews employed in a variety of disciplines from health and recreation to urban planning (Anderson, 2004; Carpiano, 2009; Evans and Jones, 2011). A flexible interview approach was used with a focus on a few topics to guide the discourse (estate use and history, woodland management, personal history with the landscape), alongside the more conversational interview structure (Skerratt, 2013; Raymond et al., 2016). This approach enables the researcher to draw out emergent themes and content from the interviews relating to each individual estate, case study areas and for Highland private estates in general. Hitchings and Jones (2004), as well as Evans and Jones (2011) assert that walking interviews generate richer data, which provide insights that cannot be captured in conventional interviews, such as landscape histories on small areas of land and personal narratives that inform their relationship with the estate and local practice. This technique was adapted to explore land management issues and decision-making on a spatial level, with the aim of identifying core land use themes and drivers on participating estates and linking them to current practice.

The walking interview uses the familiar environment and movement through the landscape to enhance the interview's scope and effectiveness (Elwood and 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, but in-depth approach, creates an informal atmosphere. A topic guide is used as a point of reference throughout the

¹ This figure is extrapolated from SNH natural spaces dataset (2016) that supports 83% private ownership in the Highlands, the majority of which are sporting estates.

Table 1
Diversity of case study areas.

	Size hectares	Ownership	Environment	Management influences	Social-economic
Wester Ross	<ul style="list-style-type: none"> ● 12,881 ● 25,632 ● 4652 	<ul style="list-style-type: none"> ● Second generation family ● New owner – absentee (2002) (Scottish) ● Absentee owner (1984), consolidated two neighbouring estates (Dubai) 	<ul style="list-style-type: none"> ● West coast Highlands ● Iconic landscape views ● Higher rainfall ● Crofting 	<ul style="list-style-type: none"> ● Deer stalking and fishing ● One estate prohibits any commercial activity ● Once diverse broadleaf forests 	<ul style="list-style-type: none"> ● Crofting community ● High amount of tenant farmers ● Greater connectivity – infrastructure and between owners ● High potential for multiple hydro schemes
Lochaber	<ul style="list-style-type: none"> ● 6488 ● 7034 ● 26,316 	<ul style="list-style-type: none"> ● Clan owner (1655) ● New owner – running business since 1995 ● New owner – family recreation since 1994 	<ul style="list-style-type: none"> ● West coast Highlands ● High rainfall ● Historically more forested ● Close to forestry processing 	<ul style="list-style-type: none"> ● Some forestry, deer stalking ● Land leases ● Immobile landowner ● Wild boar introduction 	Lochaber
Cairngorms (Deeside)	<ul style="list-style-type: none"> ● 19,237 ● 16,321 ● 40,533 	<ul style="list-style-type: none"> ● Family ownership since 1782 ● British Monarchy since 1850 ● Family ownership since, run by a board of trustees 1632 	<ul style="list-style-type: none"> ● Extensive grouse moors ● Caledonian pinewood stronghold ● High elevations ● High sunlight capture ● Extensive natural heritage designations 	<ul style="list-style-type: none"> ● Grouse shooting ● Private shooting syndicates ● Wider tourism ● Higher employment on estates 	<ul style="list-style-type: none"> ● In National Park (NP) ● Owners feel separate from NP ● Greater tourism impact ● Some potential for hydro schemes, as well as solar
East Sutherland	<ul style="list-style-type: none"> ● 14,218 ● 9383 ● 9488 	<ul style="list-style-type: none"> ● Family second generation ownership since 1953 ● Family second generation since 1948 ● Family ownership since 1894 	<ul style="list-style-type: none"> ● Northern areas of Highlands, remote (2 people/km²) ● Extensive wetlands/peatlands ● Low elevation 	<ul style="list-style-type: none"> ● Loss of grouse shooting ● Mainly deer stalking and fishing ● High profile case of poor forest expansion policies in past 	East Sutherland

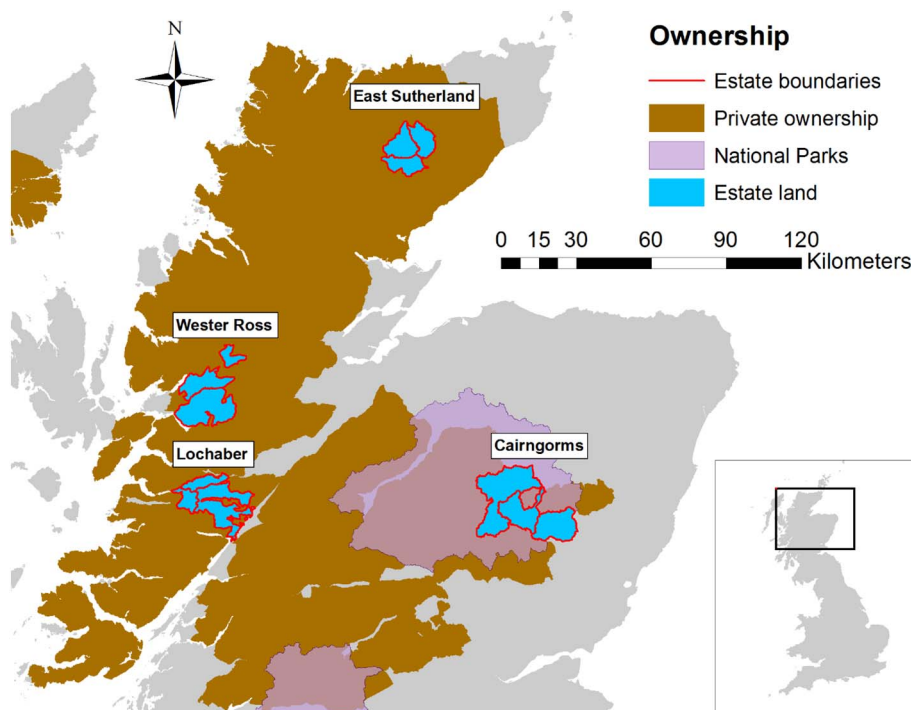


Fig. 2. Map of case study areas in the Highlands of Scotland.
Adapted from SNH Deer Management Groups, 2016.

interview, which lasts between 1.5 and 6 h, depending on the size and accessibility of the estate. This factor limits the consistency of the study with regard to time spent with the land managers and the level of interaction with areas of the estate, however this is indicative of estate variability in both size and infrastructure. In order to minimise this inconsistency and explore the entire spatial aspect of the estate, discussions before and after the interview were conducted using large ordinance survey maps and a tablet with GIS App (GISKit ©Garrafa 2015), which was used to identify and plan around areas of interest during the interview.

3.3. Mapping the interview

Each interview was conducted through a combination of walking and driving around the estate with the land manager in a 4 × 4 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 (©Garmin). Interview script is then time-indexed and matched to the interview route using google earth GPX file (Google Earth 2017), which spatially links to specific areas of

the estate resulting in a spatial transcript of the area (Jones and Evans, 2012). This process connects land manager perceptions and decision-making processes to physical areas of the estate and practices. However, general themes were often discussed with no direct connection to the landscape, these points were included in the analysis without spatial reference on the estate maps. Land uses and areas of management practice that were referred to from a distance were also noted during the interview and then spatially connected during transcription. These areas, significant spatial practices and perceptions were annotated and manually added into a cultural transcript in Arcmap (ESRI Arcmap 10.2). For example, certain areas are valued for their landscape aesthetic, others such as deer wintering areas are important for economics, recreation and estate identity. Whereas other areas possess a personal aspect connected to memory, history and specific emotions of the land manager, which may inform a type of legacy and familial lineage that defines a particular area for an individual. During the transcription process perceptions and practices were coded manually with time indexed spatial coordinates, producing spatially explicit discourse associated with practice, management and land manager perception (Evans and Jones, 2011; Jones and Evans, 2012). This map, initial thematic and content analysis was presented to the land managers in the land use report to aid consideration of estate resilience, using four dominant resilience concepts (Folke et al., 2010; Haines-Young and Potschin, 2010).

3.4. Case study area collaborative discussion

Utilising the land use reports, phase 3 aimed to bridge individual land managers to a cluster of land managers from neighbouring estates to explore potential transboundary land use planning, which could cut management costs, strengthen social links and increase economic stability. Discussions focussed on the links between spatial planning and cultural land use drivers to identify practical management innovations, such as areas for regional timber hubs, 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 within the estate clusters. Advancement toward such goals are at times hindered by strong agendas (sporting management), therefore these discussions are designed to strongly link deer and woodland management to other land uses.

Group discussion aided the land managers in clarifying management challenges, including the identification of 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.

In the discussion groups, each land manager was encouraged to give feedback on their individual land use report and highlight key issues and prospects for future management. Afterwards the researcher posed questions on matters that had arisen from the walking interviews, which subsequently became central management concerns for the group. 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 a reference aid for land managers during these discussions. This also enabled them to locate and identify potential areas for collaboration that aid operations on both estate and regional level. To prevent participatory fatigue the discussion groups were limited to an hour, encouraging an informal atmosphere, which aided effective and open engagement with the material (Kangas et al., 2010; Saarikoski et al., 2010). The multi-method 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 et al., 2009; Connolly et al., 2013) informing overall estate and forest resilience. A forest resilience diagram (Section 5, Fig. 5) was developed from the four case study collaborative discussions focusing on ways in which forest management could be strengthened to benefit estates. This was achieved by identifying and honing the central themes that emerged during the analysis period. Land manager consensus focussed these themes during the case study discussions, which were then compared across the four collaborative discussion groups. This comparison shaped the themes that describes land managers perceptions of forest resilience. Additionally the collaborative discussion groups along with supported individual interview data informed and enabled the development of mutually agreed upon landscape partnerships (Figs. 1 and 4).

4. Results

This section presents the results by firstly exploring the partnerships and management areas identified through the walking interviews and discussion groups that could support both forest resilience and overall estate aims through collaborative actions. Secondly, forest types that land managers associate with resilience concepts are presented, which informs current views on woodland structure, species and purpose over the case study areas. Thirdly, specific ways to foster knowledge and innovation for estate forestry is presented and discussed in a diagram that was compiled representing the strongest themes from the interviews, land use report feedback session and discussion groups.

4.1. Spatial landscape resilience

In order to provide a meaningful connection between resilience and local practice, land managers interpreted four common concepts associated with resilience to describe spatial resilience over their estates. This exercise was conducted during the interview follow-up sessions (Phase 2) where areas corresponding to the four resilience concepts were spatially mapped for each estate by the land manager, which uses the land use reports as a platform to further refine and validate the analysis. This resulted in a spatial resilience map of the estate, which effectively identified land managers perceptions of estate land use and practice from a resilience perspective. For example areas in which deer wintered along with feeding areas are perceived by all land managers as ‘Stable’ i.e. areas perceived as strengthening and contributing to the estate’s overall resilience. This process results in land uses and practices including forest types 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)

Land managers provide an individual and site-specific interpretation of these concepts, as applied to estates, which creates an insight into the perception of resilience on a scale that is meaningful to them. A core purpose of this research is to generate an understanding and utility of resilience through land manager spatial perception out with the literature on resilience in Section 2 (Holling, 1973; Gunderson, 2000; Folke et al., 2010; Haines-Young and Potschin, 2010; Cumming, 2011).

Fig. 3 shows the spatial distribution of resilience over the case study areas, which highlights that the majority of estate land is perceived as Stable, on average approximately 56% of the case study areas are

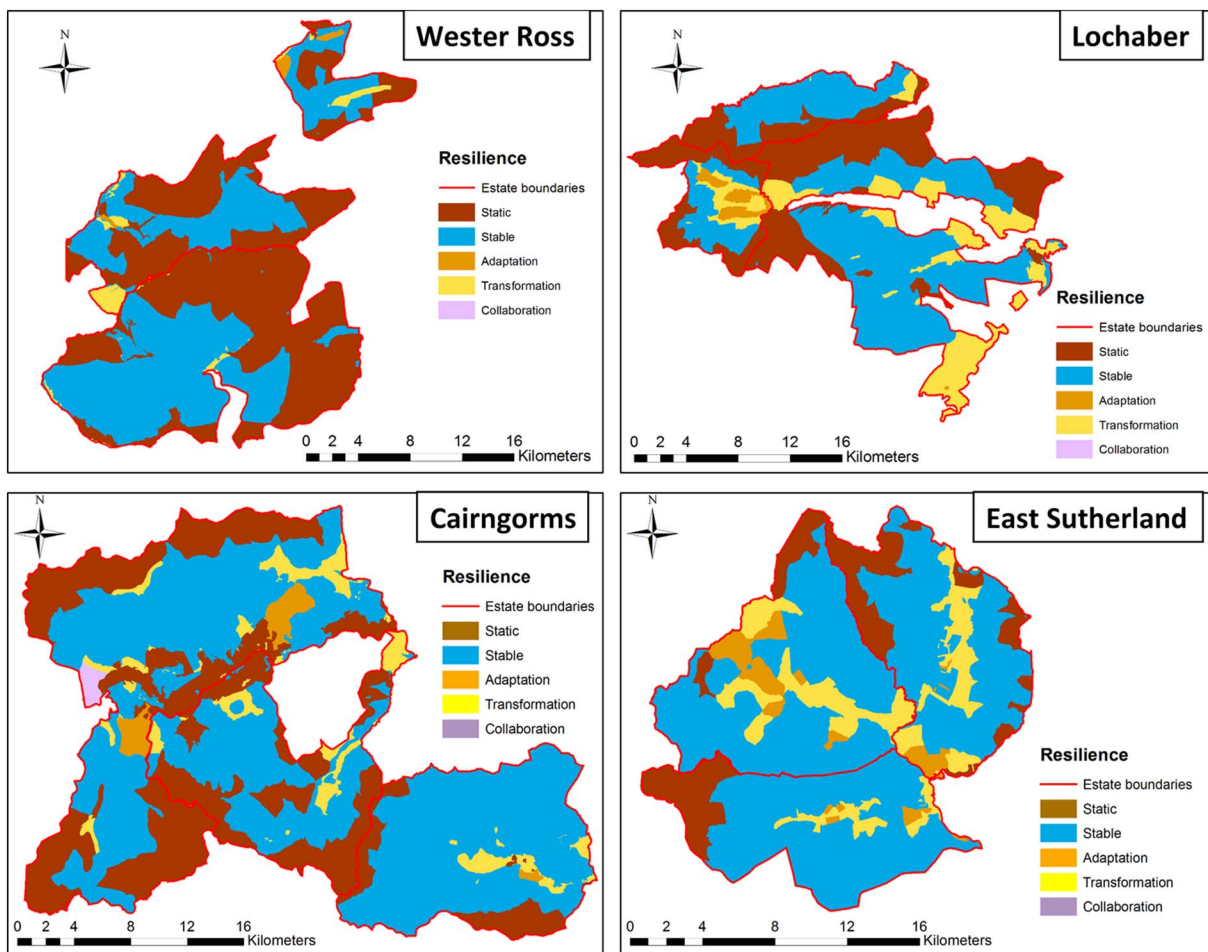


Fig. 3. Landscape resilience map for each case study.

perceived as being Stable (Table 2). “Most of the land is for sporting use, for deer feeding and preserving the iconic open landscape”. However, a new resilience concept, ‘Static’, was identified by land managers, which relates to areas of land that persist in an unchanged state adding no benefit to the estate and often represent loss. “A lot of this land is either high elevation or has no infrastructure, which lock-ups land potential”. These Static areas are the second largest resilience category covering approximately 33% of the case study areas and over 51% in Wester Ross. East Sutherland has the lowest percentage of Static land, as the majority of the land was under deep peat and seen as productive. “One of our main activities for the ecosystem is conserving the deep peat habitat”. (Fig. 3.)

Static and Stable resilience account for almost 90% of the case study

areas, emphasising that a small percentage of land is perceived as being open to change, 8.5% of this land is seen as transformational. “This abandoned pasture and small areas of isolated woodland could be something but there is little will to do anything different”, these areas provide a potential focus for forest expansion policy. Adaptation, representing areas currently or recently under management/land use change accounts for approximately 2% of the case study areas on average. “We have planted some broadleaves and have hydro scheme being installed, basically all the change.... We have adapted the loch and access for disabled anglers, which has received some notice”. Collaboration is admittedly a very uncommon activity over the case study areas (0.2%), “Not much cooperation or work between the states, we help each other with the deer count and if there is an emergency like

Table 2
Break down of spatial resilience concepts over the case study areas.

	Static	Stable	Adaptation	Transformation	Collaboration
Wester Ross	51.0%	45.8%	0.7%	2.5%	0.0%
Lochaber	32.9%	49.4%	1.9%	15.9%	0.0%
Cairngorms	31.5%	59.7%	2.2%	6.1%	0.6%
East Sutherland	13.5%	68.9%	4.7%	12.9%	0.0%
Total	33.4%	55.7%	2.2%	8.5%	0.2%

Table 3
Forest types found on Highland sporting estates and the associated resilience view by land managers.

Resilience concept	Forest type
Static	Commercial conifer plantations (unmanaged and windblown)
Stable	Deer shelterbelt, amenity, Caledonian pinewood (<i>Pinus sylvestris/betula</i> spp. mix), and Christmas tree plantation
Adaptive	Natural regeneration, planted broadleaves (small areas), and riparian woodland
Transformative	Small copses and inaccessible areas (vulnerable to disturbance and change)
Collaborative	Jointly planned transboundary woodland with NGO owner

a fire, but nothing to do with land use change or management". As Fig. 3 demonstrates the map provides a spatial description of land manager perception of resilience over each individual estate.

4.2. Resilient forest types

Table 3 presents land manager perceptions of forests types associated with mapped resilience concepts. Static areas are typically associated with conifer plantations of Sitka spruce (*Picea sitchensis*) and lodgepole pine (*Pinus contorta*) that have been damaged by severe windblow, exhibit low structural and species diversity, and are cited as landscape eyesores. These plantations offer little opportunity for harvesting and restructuring and are a legacy of government forest policy between 1960's and 80's, which continue to highlight consequences of previous government-led woodland expansion policies.

Caledonian pinewoods (*Pinus sylvestris* - variable structure), which are valued for heritage, landscape and amenity is considered the most resilient forest type. Shelterbelt forests are valued for providing shelter and increasing the health of deer populations; however many of these forests are unmanaged monocultures that serve that singular purpose. A notable exception in land manager's attitudes toward commercial forests is a marginally profitable Christmas tree plantation, which supplies annual income on a short rotation tree crop. Adaptive forests are broadly categorised as those which exhibit diversified structure and species mix, which includes encouraging natural regeneration, planting small areas of mixed broadleaf species, and creating new forest corridors along riparian areas. Productive aims and management is notably absent from adaptive forest types, suggesting that productive forests are considered a low priority and something that belongs in the past on these sites. Transformative forests are viewed as those which are vulnerable to episodic disturbances that would change the land cover to open ground, and are considered too small to be of any economic, ecological or amenity value. Collaborative forests require transboundary coverage with at least two different parties explicitly responsible for both planning and management. In this instance the two estates have contrasting visions and management goals but found common ground through conservation objectives.

The following section will present further results, which examines the role of partnerships in strengthening forest resilience for private estates and the types of forest structures associated with the resilience concepts.

4.3. Forest resilience through partnership

Fig. 4 shows landscape partnerships and estate-level integration that was collectively identified by the land managers during the collaborative discussion groups. These are characterised by action that will require spatial management, coordinated administrative duties and knowledge brokering by an external organisation.

Land managers in the study continuously emphasised the importance of diversifying to support traditional sporting land uses. This is

evidenced by woodland expansion interest being expressed as shelterbelt development, which supports deer health and habitat (Armstrong, 2015). "We are interested in deer health and woodland improves deer health, especially through harsh winters, so linked and diverse habitat for them is a priority". Explicitly linking woodland planning with sporting interests could provide contextual appeal for matching the inherent short-term goals of sporting management with longer-term goals of forest and landscape management. All managers in the study echoed this statement, "our responsibility is to maintain cultural landscapes important to the public and local traditions including upland agriculture and deer stalking". In tandem with venison marketing to further explore the potential of local market coordination and cutting of transaction and transport costs places sporting production at the heart of land manager concerns. "There is a gap in the way we manage, transport and export our venison resource, it's a market that is either under the table or taken out of the region and costs the estates more than it should". A central resilience goal for land managers is heavily influenced by preserving landscape traditions dominant in the Highlands. This focus on tradition is heavily dependent on the individual manager's interpretation in which forest is viewed as a minor component of the open landscape tradition, associated with living memory of the manager and the recent historical memory of the region and land use type. "This landscape has been like this for as long as I remember, it works, forest should be here but only in ways that benefit the estate and economy, which is to support the deer and sport – we can't go back, too much human influence". Perception of landscape has clear limits, the window of time allotted to looking back, which limits the capacity, structure and range of forests, knocking-on to the inherent meaning and shape of landscape. Such perceptions can be in part explained by the "loss of forest knowledge and appreciation that has drifted away from these areas". Creating the assumption that they are the peripheral and unsuccessful land use of recent history.

At estate level developing hydro schemes are viewed as stabilisers for estate economies in the Highlands, which can in turn release investment and time for other resources including woodfuel and productive forests. "Hydro is the big thing at the moment, we are developing several in partnership and relying on both the energy and income to help estate economic sustainability". However, some coordinated activity on the landscape level could help release that potential, if targeted grid connections could bring multiple schemes online. "Lack of grid connections is holding up development and losing multiple estates money every day". The potential short-term economic benefit of woodfuel provides managers with the means to introduce timely silvicultural intervention in order to develop better quality forest stands for multiple products (Röser et al., 2011; Dandy, 2016). "The introduction of hydro could help development of other resources and locally produced short-rotation woodfuel could be possible with some lower transaction costs and a little knowhow on the ground". This demonstrates the important link between mixed land use and renewable energy approach. Identified timber hubs that serve the case study area and potentially more estates could provide an important step toward reducing transaction costs and a staging area for other timber products produced in the region.

Carbon sequestration is viewed as a promising activity to develop a stronger estate resource base, as well as providing additional value to forests. "I'm interested in the value carbon could provide for woodland, this could be the extra income needed to make woodland worthwhile pursuit again but I don't know much about the process". A landscape level partnership could provide this needed capacity building role to access and understand carbon markets and management. Infrastructure is a limiting factor for estate activity and the ability to access certain areas can determine the scope of management and scales of economy. "There is a lot of land that remains locked away due to the undeveloped infrastructure, mostly lack of tracks or roads but sometimes due to the elevation – this means only a small proportion of the estate is viable for productive use". Therefore targeted road upgrades and use of rail could

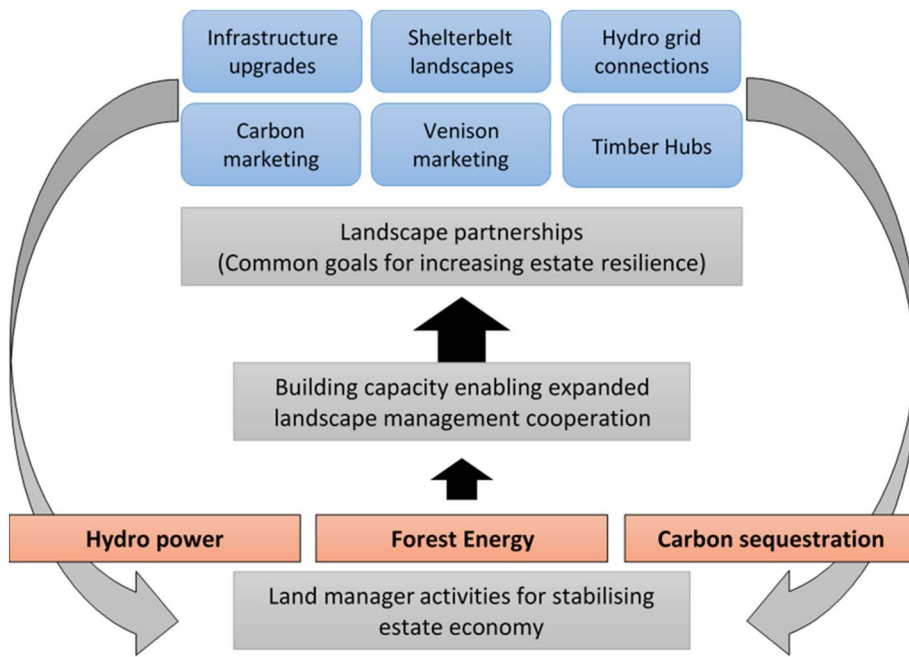


Fig. 4. Partnerships supporting forest resilience in a wider landscape (land manager perception).

release more land to production but funding is mostly non-existent, which could benefit from a landscape funding pot to identify priority areas, as well as manage and distribute funds.

4.4. Strengthening forest resilience

Fig. 5 presents a synthesis of land manager perception of forest resilience, emphasising the knowledge and innovation needed to develop greater integration benefits that complement estate priorities. This diagram was constructed by identifying and compiling land manager perceptions of beneficial forest culture development.

Land managers require both confidence and trust despite personal interest to invest in diversified land use management actions, which is currently absent for many of the land managers. "I like the idea and principles of forest expansion and diversified species and products but it's a leap of faith I'm not willing to make right now, not without some security and financial benefit". This statement is undercut by the low levels of forestry knowledge, "We really don't have any forestry expertise here, this sits with the agent, which makes it all rather distant from the estate – I would like to see more species and better timber but uncertain whether that is possible". Other managers believe that the landscape in which they have worked for decades represents the limited

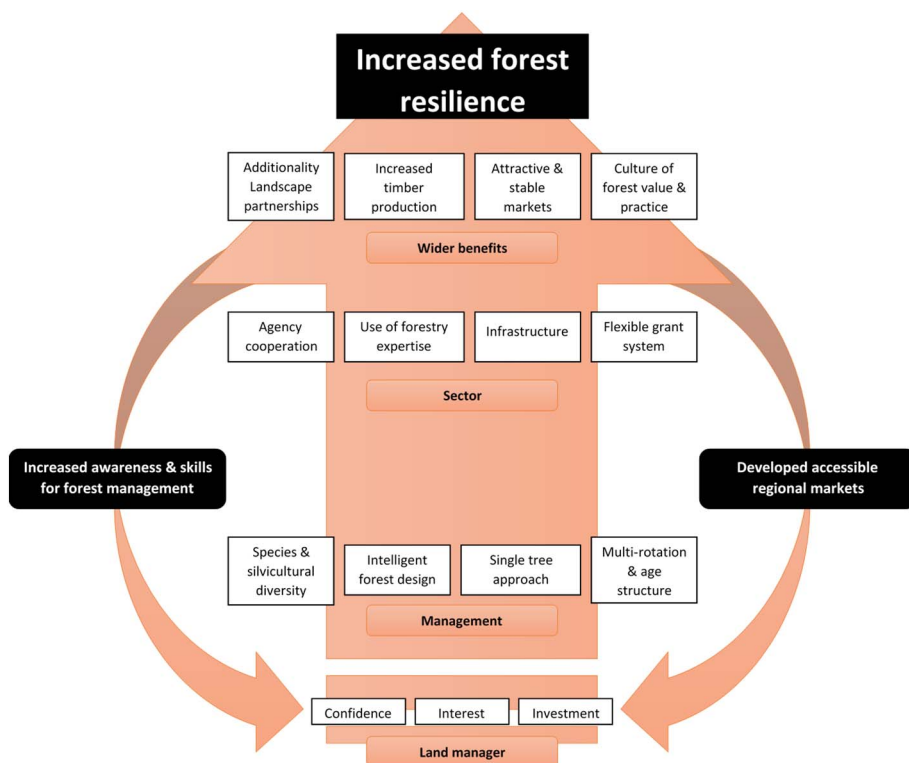


Fig. 5. Fostering knowledge and innovation for a resilient forestry economy.

potential of forests in the Highlands, “There shouldn't be many forests here this has been open land and not much would grow and couldn't supply the demand”. Despite the lack of knowledge and expertise land managers recognise the need for new approaches, “I like how they managed the forests in Denmark and such places single tree approach, producing great quality timber..... there needs to be more thought and intelligent design put into forest expansion with various species and planted with both production and conservation in mind, not sure how to that though”. Referring to institutional involvement land managers stated, “There are too many agencies not working together, confusing the process, more cooperation could improve matters.....grants that provide flexible and adaptive solutions to specific land management issues would be more attractive”. Overall land managers agreed that, “greater finances to the estates and forest management activities need a sector that has strong regional market base... such incentives would be additional value through carbon or attractive markets for quality timber and inexpensive forest management approaches implemented at early stages with accessible guidance”. In spite of this general advocacy for better forests together these small barriers trigger a default resistance in land managers that impedes acceptability and action for planting more trees and increasing forest management activities.

5. Discussion

Increasing pressure to ensure the accessibility of resilience aims to practitioners, requires tools to capture individual perceptions and priorities for resilience to better tailor local and regional management strategies (Quine et al., 2013). Therefore, aligning forest expansion and management with the aims of private landowners, (the dominant landownership in Scotland), is vital for supporting and developing best practice and effective land use policy (Scottish Government, 2014; Olsson et al., 2015). The mixed methods used in this research produces meaningful results that provide insights into local management and practical interpretation of resilience concepts. Landscape resilience maps can be a staging ground for practical planning between the individual manager and policy-makers looking to implement realistic changes. This process also gives land managers the opportunity to reflect their perceptions of land use practice and subsequent effects on future sustainability including long-term economic viability and their role as landscape managers (Raymond et al., 2016; Raymond and Kenter, 2016).

For the case study land managers, developing resilience is a limited activity for a single estate, therefore partnerships and collective action from multiple managers is viewed as one of the most promising ways forward (Fig. 4 – Landscape partnerships). This supports the need for bridging organisations and trusted intermediaries to facilitate or broker knowledge for complex landscape management issues (Rouillard et al., 2015). Such services are used increasingly for trading carbon credits through the UK Woodland Carbon Code where woodland growers are linked and matched to carbon credit buyers (Forestry Commission, 2015). Despite interest and growing participation in such schemes, none of the managers in the case study areas possessed knowledge of these mechanisms. Nevertheless, land managers showed interest in the associated possibilities, but are wary of increased bureaucracy and regulatory control over estate management.

Moving forward requires a collective or organisation that is both trusted and inspires confidence (Schultz and Fazey, 2009; Scott, 2011; Davies and White, 2012; Scottish Government, 2014). However, mistrust of increased government intervention has cultivated cautious attitudes in land managers with regard to joining collaborative schemes and partnerships (Glaves et al., 2009). In the Highlands, the Cairngorms National Park Authority is an example of an organisation with geographic and professional scope that is comfortably distant from government status. Land managers in the study cited the CNPA, as a trusted and professional body with a good reputation in the region that develops best practice and sustainable communities. National Parks are

designed to operate on a regional scale and manage complex and wide-ranging objectives through partnerships and could be well placed to expand into partnerships such as those in Fig. 4 (McMorran et al., 2014; Everard et al., 2014). This could be the case across the UK that National Parks provide a forum for facilitating landscape partnerships, developing best practice and providing a bridge for land managers to operate at otherwise inaccessible scales (Mills et al., 2011; Schultz et al., 2015).

Land managers in the case study areas view the preservation of traditional land use management in the Highlands as a central role of resilience practice. However, O'Hara (2016) suggests that this type of management approach may preserve a past that is unable to adapt to novel ecosystems that are being created by current anthropogenic impacts. This highlights that interpretation of ecosystems, culture and resilience will be localised and at times focussed through the perspectives of few individuals (Collier, 2015). Glass et al. (2013) showed that pro-active and engaged estate management is critical for long-term estate sustainability. Such engagement will prove crucial for furthering forest expansion policies and sustaining beneficial resources.

One notable area of mutual land use development is the synergy between forest management aims and renewable energy, this is supported by Sutherland et al. (2016) in regard to Scottish farms that demonstrate a tendency to develop afforestation and renewable production in parallel. For many of the land managers investment in forestry and ability to diversify estate activities are dependent upon the stabilising effect of hydro schemes. These synergistic land uses provide a series of gateways for land managers, each one releasing further potential and benefit for the estate and region. This cascade effect is similar to the approach of bundled ecosystem services that pull upon an array of services to form payment packages for landowners (Deal et al., 2012). Fig. 4 demonstrates the formation of a bundling approach that could be developed further to represent local ecosystem approaches.

Engaging in an accessible and user-friendly carbon market could support the planting of new woodlands and encourage silviculture treatments to estate forests (Grace et al., 2014). Additionally, carbon sequestration along with use of renewable energy could provide an applied framework to establish the sought after recognition by many estate land managers that acknowledges the estate's contribution to climate change and broader environmental values (Fontaine et al., 2013). This creates an important link between local action, landscape initiatives and global issues. Another key operation that land managers identified to aid mobilisation of both local and regional action is infrastructure upgrades (Scottish Government, 2015), both to support immediate development of renewable energy opportunities and to open up productive areas of the estate. Targeted infrastructure development between multiple estates could increase management and production potential to benefit local rural economies that could cumulatively scale-up their activities and impact. Even additional funds from landscape partnership buy-ins could target and channel into strategic infrastructure upgrades within the region.

Improving awareness of forest structure and species range within the Highlands, as well as incorporating emergent markets for ecosystem services to stabilise revenue are both fundamental for attracting land manager support to further develop forestry on estates. This involves a radical change in land manager mind-sets toward the value and place of forestry within the wider landscape alongside ownership behaviours that have been dominant for more than two centuries (Morgan-Davies et al., 2015). Despite subsidisation from private wealth many estates depend on diversification for survival, which supports the delivery of wider public and ecosystem services. This includes non-timber orientated productive forestry aims, such as domestic energy, carbon sequestration, recreation and deer shelterbelt enhancement. These aims and potentially further investment in timber production are contingent on the success of other activities, such as hydro schemes, to stabilise both energy supply and income streams. Integral to fostering perceptions that support more resilient forests are focussed cultivation of silvicultural knowledge, greater practical expertise and appropriate policy

support mechanisms and guidance. This would involve a reversal of the increasingly desk-based, broad blanket approaches to land manager engagement and grant evaluation, and finding ways to connect with individual managers to develop a new wave of forestry knowledge. Investing in individual managers is key to realising cumulative value in the future for estate and regional forestry growth.

Capacity building that increases resilience by scaffolding land uses and services of a localised area, which is underpinned by forestry knowledge extension and additionality mechanisms is crucial for creating widely valued and valuable landscape (Fig. 5). These roles start with the land manager increasing diversity and modifying silvicultural approaches but depends on the sector providing opportunities through adaptive policy and grants to implement these changes. Encouraging buy-in from land managers requires inspiring interest and confidence, social capacity, as well as financial incentives to generate the necessary motivation (Folke et al., 2005; Berkes, 2009). These managers consider themselves stewards of landscape tradition and local cultural practices, which need to feed into any new approach, accommodating the living memory of the landscape and the influence upon management. Therefore, traditions important to the land managers need a recognisable place alongside expansion and diversification.

6. Conclusion

Forest resilience in the Scottish Highlands has changed rapidly over the last century due to socio-political environments, changing ownership patterns and needs of society, which continues to impact individual perception of land use and forests in the landscape. Evidently forest management culture and knowledge has decreased in part due to the dominance of sporting management that focusses on deer stalking and grouse shooting. These habitats have perpetuated a marginalised environment for forests in the Highlands, which has resulted in a suppressed timber production culture that for the most part fails to meet the demand for high quality or domestic timber markets. Private land managers are unwilling to see sporting use, the economic staple of the estate compromised by tree planting. However, many land managers would reconsider, if forest expansion could demonstrate greater economic return early-on and throughout the life-cycle, as well as recognising the contributions to climate change, landscape and ecosystem services. Additionally, linking forest expansion aims with deer shelterbelt design and enhancement could shift perception and increase interest in diverse silvicultural approaches, which produces higher quality timber alongside healthier deer habitat. Key to mobilising these shifts in perception that lead to shifts in capacity will be partnerships and networks that tie into strong landscape synergies for private estates. As demonstrated in Fig. 4, such partnerships that support carbon sequestration and hydro power schemes, as well as introducing early forest timber products through regional woodfuel production could be crucial in generating a renewed forest culture in the Highlands. This paper uses an innovative mixed-methods approach to expand the understanding of spatial resilience from the perspective of individual land managers. As demonstrated in Sections 4.1 and 4.2 this produces useful maps that could be valuable for decision-makers at all levels to understand local practice, perceptions and potential routes to locally based ecosystem approaches. Such maps and supporting collaborative evidence built upon local adaptation inform relevant actions and capacity building that could improve not only individual understanding of resilience but provide potential paths to implement resilience strategies for the benefit of both policy and practice.

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