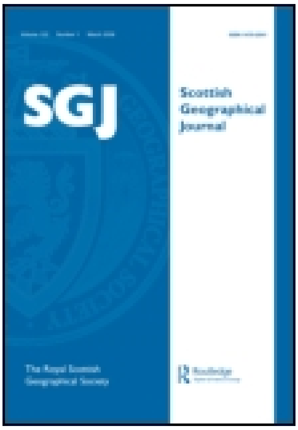
Rewilding - a new paradigm for nature conservation in Scotland?

Brown, Calum; McMorran, Robert; Price, Martin

Published in:
Scottish Geographical Journal

Publication date:
2011



Scottish Geographical Journal
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/rsgj20

Rewilding - A New Paradigm for Nature Conservation in Scotland?

Calum Brown [a], Robert Mcmorran [b] & Martin F. Price [b]
[a] CREEM, The Observatory, University of St Andrews, Buchanan Gardens, St Andrews, KY16 9LZ, UK
[b] Centre for Mountain Studies, Perth College, University of the Highlands and Islands, Crieff Road, Perth, PH1 2NX, UK

Available online: 09 Mar 2012

Scottish Geographical Journal
Vol. 127, No. 4, 288–314, December 2011

Rewilding – A New Paradigm for Nature Conservation in Scotland?

CALUM BROWN*, ROBERT MCMORRAN** & MARTIN F. PRICE**
**CREEM, The Observatory, University of St Andrews, Buchanan Gardens, St Andrews, KY16 9LZ, UK*
***Centre for Mountain Studies, Perth College, University of the Highlands and Islands, Crieff Road, Perth, PH1 2NX, UK*

ABSTRACT *Rewilding is a strategy for the conservation of complete, self-sustaining ecosystems, primarily involving the protection and, where necessary, reintroduction, of populations of keystone species in large, connected reserve networks. A potential method of preserving ecosystem functions and biodiversity, it is now receiving a great deal of practical and political attention, particularly in North America. In Scotland, where many native species have been extirpated in the relatively recent past, rewilding has clear relevance and may provide an overarching set of objectives for current programmes of native woodland restoration and species reintroductions. Nevertheless, rewilding is not widely used as a term or strategy in Scottish conservation. This review considers the development of the concept and its possible application in Scotland, and identifies substantial scope for rewilding, in terms of the restoration and protection of large areas of wild land, and of the reintroduction of native species which have been driven to extinction by human activity. As the environmental, social and economic benefits which are likely to result from a programme of rewilding in Scotland outweigh the potential drawbacks, the adoption of rewilding is recommended as one aim of environmental policy.*

KEY WORDS: conservation policy, environmental restoration, keystone species, rewilding, Scottish environment, trophic cascades

Introduction

The howl of the wolf is perhaps the most potent and widely-recognised symbol of wilderness in the northern hemisphere. As a result of habitat loss and long-term persecution of wolves, it is rarely heard outside large areas which are relatively untouched by human activity. Along with other emblematic species such as the lynx and brown bear, the wolf has long been absent from even the most remote and wild corners of the Scottish Highlands. However, considerable potential exists here to restore habitats and extinct species through an approach termed 'rewilding'. Despite having firm foundations in ecology, environmental philosophy and practical conservation, rewilding is yet to be widely adopted, as a term or concept, in

Correspondence Address: Calum Brown, CREEM, The Observatory, University of St Andrews, Buchanan Gardens, St Andrews, KY16 9LZ, UK. Email: calum@mcs.st-and.ac.uk

ISSN 1470-2541 Print/1751-665X Online
http://dx.doi.org/10.1080/14702541.2012.666261

Scotland. Nevertheless, its principles are highly applicable here and offer a valuable new perspective on Scottish environmental issues.

The formal theory of rewilding developed from the field of conservation biology in North America during the 1990s, and also has a longer and less distinct practical history in various countries including the UK. Its principal contention is that the conservation of biodiversity is best served through the protection of species at or near the top of the food chain in large, connected areas. This claim is justified through a number of established theories and, although controversial, has strong empirical support (e.g. Hobbs & Cramer 2008; Terborgh & Estes 2010).

Few investigations of the applicability of rewilding have been undertaken outside North America, especially where social or political conditions appear to preclude it. This is true in Scotland, where conservation is often allied instead to the concept of sustainable development, despite an independent practitioner-led rewilding movement influenced by evidence of extensive degradation of natural ecosystems and changes in the economic basis of current land uses. The focus of rewilding on the restoration of natural processes, along with its ultimate objective of establishing populations of large carnivores, may have a significant role to play in Scottish environmental management. In this article, we explore the philosophical and scientific foundations of rewilding and consider its relevance and meaning in Scotland.

Historical Context

Rewilding is often presented in the context of a long history of anthropogenic environmental disruption, the attempted reversal of which is one of its principal objectives. Undisturbed ecosystems are attributed inherent value, and human activity is regarded as inherently unnatural, to some extent at least (Soulé & Noss 1998; Taylor 2005). Justifications for this rely on evidence of anthropogenic environmental damage throughout human history, beginning with the extinctions of numerous (mainly large animal) species from each landmass following human colonisation (Brook & Bowman 2002; Foreman 2004).

These extinctions have long puzzled biologists; to Darwin they represented a 'most gratuitous mystery' (1859, p. 341); to Alfred Russell Wallace, a 'marvellous fact . . . that has hardly been sufficiently dwelt upon' (1876, p. 150). Despite much investigation during the intervening years, their causes remain unclear. Human hunting has become the favoured explanation, but because colonisation is difficult to date confidently and was often, by its nature, coincident with climate change, it has proved difficult to link decisively to species extinctions in most cases (Hoffecker *et al.* 1993; Grayson & Meltzer 2003; Barnosky *et al.* 2004; Borrero 2008; Pushkina & Raia 2008).

Nevertheless, strong circumstantial evidence exists, particularly where colonisation was relatively recent. This is the case in the islands of Oceania, where up to 2,000 bird species, for example, became extinct within centuries of the arrival of humans (Steadman & Martin 2003; Sutton *et al.* 2008). Such findings have led to broad agreement that Pleistocene extinctions were most likely caused by some combination of human activity and climate change, perhaps exacerbated by other factors

(Burney & Flannery 2005; Koch & Barnosky 2006). With the development of arable agriculture c.10,000 BP, however, far more dramatic anthropogenic environmental change began to occur; its early effects can still be discerned along the waterways and coasts by which agricultural practices spread from the Middle East (Thapar 1978; Neumann 2003; Willcox 2004; Séfériadès 2007; Shennan & Edinborough 2007; Atahan *et al.* 2008).

The development of the modern Scottish environment began at the end of the Pleistocene epoch, between 15,000 and 10,000 BP (Ballantyne *et al.* 1998; Currant & Jacobi 2001). In Scotland, the Holocene began with a predominant habitat of open tundra, which spread as the ice of the Devensian glaciation receded. This tundra quickly gave way to scrubland and woodland of pioneer species such as birch and, soon afterward, Scots pine (Froyd 2005). This flora gradually moved northwards along with mammals such as the Auroch, Beaver, Brown Bear, Lynx, Mountain Hare, Pika, Red and Arctic Fox, Red Deer, Reindeer, Saiga, Tarpan, Wolf, and Woolly Mammoth, although the extent to which some of these penetrated Scotland is unclear (Kitchener 1998; Yalden 1999).

Particular uncertainty surrounds human colonisation; the earliest evidence is found on the western coast and islands between 11,000 and 9,000 BP, contemporaneous with that from similar latitudes in Scandinavia (Edwards & Mithen 1995; Bang-Andersen 1996). It is thought likely that settlement occurred along the Atlantic seaboard between 10,000 and 8,000 BP, with the first definitive evidence coming from the island of Rum at 8,500 BP (Wickham-Jones & Pollock 1987; Wickham-Jones & Woodman 1998). Species present by the time of the formation of the English Channel c. 9.500–7,000 BP are now classed as native, and subsequent immigration was inevitably less intense. By the early Mesolithic, Britain contained an estimated 1.4 million Wild Boar, 100,000 Aurochs, 70,000 Elk, 35,000 Beavers, 20,000 Wolves, and 10,000 Lynx – some of the species that have since become extinct – alongside 2,000–3,000 humans (Yalden 1996, 1999).

Few environmental impacts are attributable to these people or their close descendants. A role in Machair formation, which began through natural processes in the Outer Hebrides 8,700 BP, has been theorised (Edwards *et al.* 2005a), and some intensive plant use bordering on agriculture may have taken place (Mithen *et al.* 2001). However, it was not until the Neolithic, beginning 6,500–5,000 BP, that significant anthropogenic change occurred. By this time, Scottish forests had reached their maximum extent, covering up to 80% of the country (Smout 2003). Their subsequent retreat under human pressure – a 'vast tale of wanton destruction' in the words of Frank Fraser Darling (Darling & Boyd 1964, p. 55) – provides the clearest evidence of changing land use. Once again the effects of simultaneous climate change, as Scotland became warmer and wetter, confuse the record and are thought by some to be solely responsible for widespread peat formation and the decline of forest cover (e.g. Fenton 2011). However, a clear pattern of woodland clearance emerged with the advent of agriculture, and continued for several millennia (Smout 1997, 2003).

Evidence of moderately intense agricultural activity in the Bronze Age (c. 4,500–2,500 BP) is found throughout Scotland, but especially in the Western and Northern Isles (Edwards *et al.* 2005b; Tipping *et al.* 2008). Woodland area declined steadily as a result, with arable and pastoral land being created through burning and clearing (e.g. Wilkins 1984). The Iron Age (c. 2,500–1,500 BP) saw an escalation of these practices, especially in the south (Davies 2007; Dumayne-Peaty 1998, 1999).

This large-scale forest clearance contributed to the first Scottish faunal extinctions that are clearly attributable to man – those of the Elk and the Lynx (Table 1). The Elk survived in Scotland until at least 4,000 BP, and the Lynx until at least 1,800 BP (and even more recently in England). It is likely that both species persisted for some time after these dates, but more recent remains have not been found. In any case, the climate was by then settled and similar to that of the present time, and species were primarily threatened by human hunting, habitat destruction and persecution, particularly when they posed a threat to domesticated livestock, as in the case of Lynx (Yalden 1999; Hetherington *et al.* 2005).

The Auroch (which became globally extinct in 1627) probably succumbed to habitat loss and hunting during the Neolithic, but may have been present throughout the Iron Age and perhaps into Roman times. The latest certain British specimen was found in England and dates to 3,200 BP (Kitchener 1998; Yalden 1999). The brown bear is thought to have survived until the 10th century (1,000 BP), although the most recent confirmed remains date to 2,700 BP (*ibid.*). Prior to its extinction, it was hunted (perhaps as a game animal) and used in Roman gladiatorial contests (Harting 1880; Yalden 1999).

Medieval Scotland was characterised by social, rather than environmental, change. Interactions between Scandinavian, Gael, Briton, Anglo-Saxon and Norman populations intensified, with dramatic effects (McDonald 1995). Coastal regions, particularly the west and the islands, became increasingly important as trading hubs (Barrett *et al.* 1999). Inland, diffuse settlement and stock grazing spread rapidly (Dodgshon 1993; Holl & Smith 2007). Conflict was the chief driver of environmental

Table 1. Scottish faunal extinctions of the Holocene directly attributable to man

Species	Date of extinction	Probable causes of extinction*
Elk	$<$4,000 BP	Hunting, habitat loss
Auroch	$\sim$2,000 BP (?)	Hunting, habitat loss
Lynx	$<$1,800 BP	Hunting, persecution, habitat loss
Brown Bear	10th century (?)	Hunting, persecution, habitat loss
Crane	$<$15th century (?)	Hunting, habitat loss
White Stork	15th century	Habitat loss
Beaver	16th century	Hunting, habitat loss
Great Bustard	16th century	Hunting, habitat loss
Wild Boar	17th century (?)	Hunting, habitat loss
Wolf	17th century	Hunting, persecution, habitat loss
Capercaillie	18th century	Hunting, habitat loss
Great Auk	19th century	Hunting, habitat loss
Bittern	19th century	Hunting, habitat loss
Red Squirrel	19th century (?)	Habitat loss
Great Spotted Woodpecker	19th century	Hunting, habitat loss
Red Kite	20th century	Persecution
Goshawk	20th century	Persecution
Spotted Crake	20th century	Habitat loss
Polecat	20th century	Persecution
Osprey	20th century	Persecution
Sea Eagle	20th century	Persecution

*Principal suspected causes of extinction are given (Kitchener 1998; Yalden 1999). '?' denotes dates over which there is particular uncertainty.

change, however, with extensive burning of woodland in the north and west (especially by the Vikings) and from the south-east (by various warring factions) (Darling & Boyd 1964).

The resulting loss of habitat, together with over-hunting, led to the extinction of the Beaver during the 16th Century (Kitchener & Conroy 1996). The White Stork and, possibly, the Crane had already succumbed to habitat loss; the Great Bustard followed (Kitchener 1998). The Wild Boar is thought to have died out in the early 17th Century for similar reasons, although the species persisted as domesticated stock and was repeatedly reintroduced to English game forests (Ritchie 1920; Yalden 1999). Destruction of woodland was also detrimental to Wolf populations and, after centuries of persecution had 'failed to compass their entire destruction', they were 'effectively extirpated' by 'cutting down or burning whole tracts of the forests which harboured them' (Harting 1880, p. 116). This almost certainly occurred during the 17th Century, despite the legendary killing of Scotland's last wolf in 1743 (Darling & Boyd 1964; Yalden 1999).

By the mid-18th century, only around 4% of Scotland was wooded (Stewart, in Smout 2003). Human populations, grazing (which intensified dramatically with the advent of large-scale sheep farming) and industrial activity all increased during the next century, while the failed Jacobite Rebellion of 1745–1746 led to yet more woodland burning and dramatic social change. The clearance of tenant crofters and farmers from Scottish estates remains an infamous episode from this period, and marked a shift away from the diverse if intensive environmental management practiced by these people, towards extensive grazing regimes (Smout & Watson, in Smout 1997; Davidson 2004).

The Red Squirrel was almost or entirely lost from Scotland during this time (but was quickly reintroduced) (Yalden 1999). Many bird species also fell victim to habitat loss and hunting – the Capercaillie in the late 18th Century; Bittern, Great Auk, and Great Spotted Woodpecker in the 19th; and the Spotted Crake in the early 20th (Bourne 1972; Kitchener 1998).

Sporting estates proliferated during the 19th century and used reintroductions to bolster the populations of species which had acquired new value as game, perhaps even saving some from extinction. These included the Red Fox (even as attempts were made to extirpate it elsewhere), Otter, Red and Roe Deer (Yalden 1999; Fairnell & Barrett 2007). Many other species were less fortunate, however - particularly those classified and intensively persecuted as vermin. Species such as the Pine Martin and Wild Cat suffered enormous declines, almost following the Polecat to extinction (Hubbard *et al*. 1992). The Osprey, White-Tailed Sea Eagle, Red Kite and Goshawk were also lost (Kitchener 1998).

Philosophical and Scientific Basis for Rewilding

By this point, the development of the modern conservation movement in the United States of America was well underway. Its origins are often linked to the émigré Scotsman John Muir, who would become one of the foremost campaigners for the protection of North America's apparently pristine environments. Although environmental restoration was a long-established practice in western Europe, it often focused on preserving the anthropogenic, mainly agricultural (often referred to as 'cultural') landscapes that had developed over millennia of relatively consistent land use (Hall 2005). The long-term moulding of nature to suit the purposes of arable and pastoral agriculture had left relatively few areas of true wilderness, and the protection or enhancement of these was a small, if important, facet of European conservation. The 'New World', in contrast, contained environments that appeared untouched to European colonists, suggesting a new paradigm for environmentalism in which the effects of human activity were to be actively reversed (ibid.; Abensperg-Traun *et al.* 2004).

Muir was a leading proponent of the preservationist view, which achieved prominence with the designation of Yosemite National Park in 1872 and emphasised the aesthetic and spiritual (and hence largely anthropocentric) value of spectacular natural areas (Runte 1987; Muir 1996). At around the same time, the Progressive Movement helped to popularise a concept of the environment as a common resource requiring protection for the benefit of all (Scott 1959; McDonagh 1992) – later labelled as 'limited socialism in the public interest' (Bates 1957, p. 30). Those most associated with this concept include Republican President Theodore Roosevelt and the first Chief of the US Forest Service, Gifford Pinchot (Meyer 1997; Miller 2004), who argued that 'the first principle of conservation is development, the use of the natural resources . . . for the benefit of the people' (Pinchot 1910, p. 43).

The preservation of natural resources for their ongoing exploitation was already an established practice both within North America and beyond. This was particularly true of forestry, wherein 'sustained yield' approaches provided the basis for management on both sides of the Atlantic from the early 19th century (Farrell *et al.* 2000; Papaik *et al.* 2008). In Scotland, sporting estates also traditionally practiced resource management of woodlands and, increasingly, species classed as game. Beyond such public and private approaches to resource management, the concept of common ownership of, and rights to, environmental resources has been a fundamental aspect of many indigenous cultures around the world (Berkes 1999; Colding & Folke 2001; Campbell & Butler 2010). This has often resulted in deliberate attempts to achieve sustainable relationships with the environment, as apparent in traditional patterns of resource use and recognised in conceptions of Traditional Ecological Knowledge (Pierotti & Wildcat 2000, Turner *et al.* 2000; Davis & Ruddle 2010). In late 19th century North America, however, the prominence afforded to the idea of common ownership of environmental resources by Pinchot was far more unusual.

Equally influential was the emerging field of ecology, famously given a moral element in Aldo Leopold's 'land ethic' (Leopold 1966). This championed the inherent value of ecological systems, and contributed to the establishment of ecological restoration as a practical process (Hall 2005). Notably, it also stated that humans are integral members of the ecological community (Skolimowski 1984; Taylor 1991). Once again, this was extensively presaged by belief systems around the world which represented humankind as one member of an inter-reliant ecological system (Egerton 2001; Swearer 2001; Watson *et al.* 2003; Martin *et al.* 2010). These systems were often geographically delimited, for example corresponding to specific watersheds (Berkes *et al.* 1998). Leopold's philosophy had more immediate roots in the burgeoning environmental and Deep Ecology movements, typified by the writings of Arne Naess, Rachel Carson and Paul Ehrlich (e.g. Carson 1962;

Ehrlich 1968; Naess 1973). In bridging the gap between scientific and ethical fields of ecology, however, it proved particularly influential.

Scientifically, ecology led to a repudiation of protection on purely aesthetic grounds, promoting biological significance as an alternative focus for conservation effort (Soulé 1985; Kuzmiak 1991). Biological conservation subsequently developed as an attempt to maintain diversity, initially stressing the accepted importance of wilderness areas and the presence of large carnivores within them (e.g. Shelford 1933). Practical efforts became increasingly targeted at specific species, habitats or areas, however – exemplified in the controversial identification and protection of global biodiversity 'hotspots' (Olson *et al*. 2001; Bartolino *et al*. 2011; Thomassen *et al*. 2011). The consequent risk of habitat fragmentation, genetic impoverishment and species loss was a motivating factor in the development of rewilding (Macarthur & Wilson 1967; Hanski & Gilpin 1991).

Keystone Species

Of equal importance to rewilding was the development of the theory of keystone species. These are defined as species which have a structural role in their community disproportionate to their abundance, and are often large, wide-ranging predators (e.g. Power *et al*. 1996). The putative 'regulatory role of large predators', based on this theory, is central to the concept of rewilding. Here it is presented in a tripartite form in which such species suppress herbivores through predation, suppress smaller mesopredators through competition, and consequently limit competition between prey species (Soulé & Noss 1998).

While proponents of rewilding regard these effects as proven (Soulé & Noss 1998) debates about their nature and extent continue (Paine 1995; Isasi-Catala 2011). Nevertheless, strong empirical support for the existence of keystone species does exist. The maintenance of diversity through predation is implied by Gause's (1934) competitive exclusion principle, which follows Darwin (1859) and Grinnell (1917, 1924) in suggesting that individuals best fitted to their biotic and abiotic environment are able to drive competitors to extinction in the absence of some mediating process. Predation upon these superior competitors may fulfil this role, so enabling a greater number of species to persist (Slobodkin 1961, 1964). This was confirmed by Paine (1966), who found that 'local species diversity is directly related to the efficiency with which predators prevent the monopolization of the major environmental requisites by one species' (p. 65), and subsequently labelled such predators 'keystone' in respect of their stabilising influence on community function (Paine 1969).

In the intervening years, similar effects have been observed in a wide range of ecological communities. In tropical rainforests – some of the most diverse ecosystems on Earth – plant resources which sustain animal populations may be regarded as keystone (Terborgh 1986), as may animal or plant species upon which others depend (Hubbell & Foster 1986). The search for keystone species in these and other environments has been intensive (e.g. Wright *et al*. 1994; Peres 2000; del Castillo *et al*. 2009, Jordán 2009).

An important implication of the theory of keystone species is that species removal may result in a 'trophic cascade' of further species loss (Terborgh & Estes 2010). This too has been observed on numerous occasions (*ibid*., Crooks & Soulé 1999;

Schmitz *et al.* 2000; Jackson *et al.* 2001; Shurin *et al.* 2002; Ripple & Beschta 2008), particularly where forest fragments or islands have been left devoid of predators (Terborgh *et al.* 2001). Conversely, ecosystem function can recover following the return of keystone species. After wolves recolonised Banff National Park in Canada in 1986, cascading effects were identified on elk survival rates and population density, aspen and willow recruitment, beaver density, and riparian songbird diversity and abundance (Jones 2002; Hebblewhite *et al.* 2005). Similarly, the programme of wolf reintroduction to Yellowstone National Park had dramatic effects on the population and movement of elk, leading to the recovery of aspen, beaver and riparian habitats (Ripple & Beschta 2003, 2006, 2007; Beschta & Ripple 2010). Conditions following these changes appear to approximate conditions prior to wolf extirpation (Halofsky & Ripple 2008). Other ecosystems have shown a similar recovery of prior structure (Mittelbach *et al.* 1995; Hobbs & Cramer 2008), and smaller-scale equivalents are found with variation in predator density (e.g. McLaren & Peterson 1994). It has also been argued that biotic resources and processes which benefit humans (known as ecosystem services) are enhanced by the presence of keystone species; these may include the provision of clean air and water, pollination of agricultural crops, nutrient cycling and storage, and the mitigation of the ecological effects of climate change (Hooper *et al.* 2005; Fischer *et al.* 2006; Larson & Paine 2007).

The protection of keystone species may have additional indirect effects. Many such species are wide-ranging and sensitive to disturbance, requiring large, relatively pristine habitats which also support many other species. The conservation of such species can therefore have an 'umbrella' effect of conferring wider indirect protection. The efficacy of this approach does remain under debate, however (Lambeck 1997; Roberge & Angelstam 2004; Isasi-Catala 2011).

Single species may also be used to justify the connection of protected areas in order to provide space for viable populations (Hilty *et al.* 2006). Other potential benefits of this include increases in diversity and new opportunities for economically productive land uses (Kerley *et al.* 2003; Chave & Norden 2007). While debate continues over the design and efficacy of corridors for particular species (Haddad *et al.* 2003; Van Dyck & Baguette 2005), these general effects are increasingly well-documented (Gilbert-Norton *et al.* 2010). The establishment of connections between protected areas has consequently been identified as a global priority for conservation (Crooks & Sanjayan 2006; Worboys *et al.* 2010).

Theory of Rewilding

The first detailed definition of rewilding traced its development through Muir's monumentalism and the associated 'wilderness movement', the science of biological conservation and targeted species protection, and the discoveries of island biogeography (Soulé & Noss 1998). Foreman (2004) highlights the precedent of ecological restoration in identifying the need – if not the means – for restoring ecosystem health. Soulé and Terborgh (1999) argue that ecological restoration is more concerned with small-scale recovery of ecological process, while Simberloff *et al.* (in Soulé and Terborgh 1999) further contend that it requires, by definition, an implicit acceptance of a prior state to which restoration is directed. The selection of this prior state, they argue, is 'fundamentally normative rather than scientific' (p. 65). Rewilding differs in that its target – the presence of keystone species – is 'both an end (because of our duty to repair past mistakes in management) and a means by which the viability of conservation units is achieved' (Soulé and Terborgh 1999, p. 11).

Soulé and Noss (1998) also suggest that rewilding has a strong moral justification linked to Aldo Leopold's land ethic, under which the deliberate and often officially sanctioned extirpation of species must be reversed. This commitment is extended by others to include species unintentionally eliminated by human action and other anthropogenic environmental damage, albeit in relation to the conceptual focus on keystone predators (e.g. Foreman 2004; Taylor 2005). Aesthetically, wilderness is linked with the presence of large predators, echoing Muir's assertion that 'none of Nature's landscapes are ugly so long as they are wild' (Muir 1901, p. 4). Many treatments of rewilding give this as its principal extra-scientific rationale despite its subjective nature (e.g. Meyer 1997; Noss *et al.*, in Soulé & Terborgh 1999; Trombulak & Royar, in Klyza 2001; Foreman 2004; Taylor 2005).

In Britain, a less conspicuous but largely independent rewilding movement developed through practical conservation and restoration projects (Featherstone 1997; Ethos 2008; Taylor 2011). Partly as a result, it is avowedly more loosely defined and less clearly differentiated from other restorative strategies; something that is itself regarded as a defining characteristic (Taylor 2011). Nevertheless, it shares the overarching aim of protected and connected 'core' areas of wild land – inspired here by the practicalities of conservation in a densely populated island nation – with the North American concept, differing most clearly in the initial steps required for the reintroduction of species (Featherstone 2004; Ethos 2008). A spiritual justification is more often employed by British than North American commentators – ironically based to some extent on Native American environmental philosophy (e.g. Taylor 1996, 2005; Featherstone 1997).

Pinchot's philosophy of resource conservation is less often employed, and direct socio-economic returns of rewilding generally remain unspecified. This contrasts with the extensive literature relating to the effect on ecosystem services of other conservation strategies (e.g. Baron *et al.* 2002; Lomas *et al.* 2008; Norgaard & Jin 2008). Whether this stems from an ethical unwillingness to entertain an anthropocentric case for rewilding or from uncertainty that the case could be made is unclear, and may vary between commentators. Nevertheless, greater consideration does appear to have been given to the economic consequences of rewilding in the British movement than the North American (e.g. Taylor 2005, 2007).

In North America, according to Soulé and Noss, 'the greatest impediment to rewilding is an unwillingness to imagine it' (1998, p. 26); in Britain, Taylor similarly argues that 'as with all paradigm shifts . . . the most resistant force . . . is bureaucratic' (2009, p. 1). However, these authors also acknowledge practical problems in establishing wilderness areas, particularly in populated or highly degraded regions. Soulé and Noss suggest that socioeconomic objectives cannot be incorporated in a realistic conservation plan; a potentially problematical contradiction of sustainable development theory and of suggestions that ecological restoration should incorporate social and cultural interests (e.g. Robinson 2011). Taylor, in contrast, identifies the lack of natural vegetation and grazing regimes in Britain as a greater difficulty, requiring remedial steps to be taken in preparation for full rewilding.

Further difficulties relate to reintroductions. The opinions of both the public and landowner have been found to have a decisive effect (perhaps equal to biological factors) on the feasibility of reintroduction programmes, to which they are often opposed (Clark *et al*. 2002; Ostergren *et al*. 2008; Worthington *et al*. 2010). Keystone species are often viewed especially negatively and persecuted as ‘pests’ or ‘vermin’, despite their roles in sustaining ecosystem functions from which people benefit both directly and indirectly (Delibes-Mateos *et al*. 2011). This has been successfully addressed in some countries, however, through informed discussion and a legal framework to provide justification and compensation for losses sustained (Dyar & Wagner 2003; Meadow *et al*. 2005).

Nevertheless, more fundamental objections to the theory can be made. The ethical case for rewilding may be viewed as subjective in its emphasis on moral obligations to repair anthropogenic environmental damage over moral obligations to provide for expanding or impoverished human populations (West & Brechin 1991; Fabricius *et al*. 2004), although proponents argue, as above, that it is not its function to stress the latter. Attempts to balance the two have been made in a Scottish context and inform the Scottish Government’s attempted amalgamation of environmental and socio-economic objectives in a programme of sustainable development (Scottish Government 2011). The claim that rewilding can achieve both by producing healthier and more robust ecosystems (e.g. Daily 1997) relies on empirical evidence that, while strong, is not conclusive. In particular, reintroductions of species identified as keystones have occurred so rarely that their detailed impacts on environmental and socio-economic conditions remain hard to predict; a significant difficulty for a theory that places so much emphasis on them.

Conservation Philosophies and Environmental Realities in Scotland

Whilst the foundations of rewilding were being laid in North America, the Scottish environment was subject to continuing changes in human land use. Much of the 20th century was characterised by exploitative practices and attitudes. These were perhaps most evident in the management of Scottish woodlands after the First World War, when demand for timber led to widespread felling and to the establishment of the Forestry Commission in 1919 (Dunlop, in Smout 1997). Within 20 years, almost 200,000 ha of commercial forestry – mainly comprising exotic species – had been planted in Scotland (Holmes 1975). Little of this ‘strategic reserve’ had reached maturity by the time of the Second World War, and so the bulk of the 92,000 ha felled between 1939 and 1945 comprised pre-existing forest (Foot, in Smout 2003).

At the same time, conservation movements were developing throughout the UK. The ‘environmental revolution’ of the 1960s affected attitudes in Britain, but the increasing appeal of conservation here may be more accurately viewed as part of the legacy of the Romantic reaction to industrialisation (Kuzmiak 1991; Veldman 1994). The advent of widespread car ownership and air travel, which greatly increased access to remote and natural areas, may also have stimulated public awareness of environmental issues (Bloom 1995; Turner 2002). Membership of environmental groups grew significantly and a range of statutory and non-governmental advisory and advocacy groups were established (Adams 1997).

Another important current in British environmentalism was – and remains – respect for agriculture. As elsewhere in Europe, a long history of agricultural land use has generated widespread association of agricultural objectives with social, and even environmental, benefit (Bills & Gross 2005; Soliva *et al.* 2008). In Highland Scotland, the legacy of the 'Clearances' has bolstered the perceived cultural significance of the crofting system, and prompted its statutory protection (Moisley 1962). Together with domestic and European monetary support such as that generated by the Common Agricultural Policy (CAP), and a prevailing anti-regulatory political climate, these factors have ensured that agriculture has become increasingly associated with – yet often detrimental to – the British natural environment (Donald *et al.* 2001). This has motivated a number of policy reforms, including changes to the CAP designed to favour less intensive and more diverse agricultural practices, exemplified by the introduction of the Single Farm Payment scheme in 2005 (Europa 2009; Scottish Government 2010b).

In upland Scotland, the principal form of agriculture since the 18th century has been sheep farming (Dodgshon & Olsson 2006). In recent years, however, subsidies to the industry have declined, and the area under sheep grazing fell by over 1 million ha between 2004 and 2009, to just under 7 million ha excluding common grazing. The average net farm income reached a low in 2006/07 of just £1,932, while average subsidies of £23,702 were maintained by the classification of 84% of Scotland – and over 90% of grazing land - as agricultural 'Less Favoured Areas' (Scottish Executive 2006, 2007a,b; Scottish Government 2008, 2010a). Scotland does have populations of native herbivores, and low- to moderate-intensity grazing can have demonstrable environmental benefits, particularly in terms of floral diversity (Humphrey & Patterson 2000; Marriott *et al.* 2009; Whyte 2010). This is especially true of large native herbivores such as wild cattle and wild boar (Armstrong & Bullock 2004; Hancock *et al.* 2010). However, no grants exist to support the establishment of natural grazing regimes (Taylor 2009), while intensive grazing of the kind often produced by modern farming practices is highly detrimental to diversity and ecological function (Dennis *et al.* 2008; Newton *et al.* 2009).

The majority of Scottish estates are managed for sport hunting, particularly of deer and grouse. The economic basis of these industries is also precarious, and estates generally require financial support by their owners – 608 of whom possess half of Scotland's land in estates typically of 5,000–8,000 ha, representing the highest concentration of large-scale private land ownership in the world (Wightman 1999; Price *et al.* 2002; MacMillan *et al.* 2010). A major consequence of the estate system is high densities of deer: over the past 30 years, it is estimated that deer numbers in Scotland have doubled, to well over 300,000 (Clutton-Brock *et al.* 2004; Nilsen *et al.* 2007). Increased levels of culling in recent years have resulted in red deer populations stabilising or declining in certain areas, but their grazing and browsing (particularly when combined with that of sheep) continue to have detrimental localised impacts on upland ecosystems, particularly through the inhibition of semi-natural native woodland regeneration (Côté *et al.* 2004; Albon *et al.* 2007). Management for grouse shooting appears to have mixed effects depending upon its nature, maintaining large areas of heather moorland (some of which represent internationally significant habitats) and benefiting certain species as a result, but also preventing natural reforestation and proving detrimental to other species, particularly those which predate on grouse and are therefore often persecuted (Thompson *et al.* 1995; Thirgood *et al.* 2000; Tharme *et al.* 2001) However, economic pressures and changes in estate-owner motivations are leading to diversification in land use, with several estates conducting conservation or restoration projects (e.g. The Corrour Trust 2010; Alladale Wilderness Reserve 2011).

The unique history and structure of land use in Scotland means that conservation must take place alongside other forms of active management. The philosophical basis of conservation is consequently rather different to that in North America, as reflected in the emphasis of conservation designations. The UK's basic form of statutory protection, the Site of Special Scientific Interest (SSSI), is intended to 'conserve the total national . . . range of variation in habitats, with their associated flora and fauna' (JNCC 2011b, p. B-1.2), and is applied to almost 13% of Scotland's land area in 1,456 different sites (Joint Nature Conservation Committee (JNCC) 2011a; Scottish Natural Heritage (SNH) 2011b). However, where potentially damaging activities are proposed within sites, Scottish Natural Heritage must balance environmental considerations against 'the needs of agriculture, fisheries and forestry; social and economic development; . . . and the specific interests of owners and occupiers and local communities' before giving or withholding consent (SNH 2004). National Parks, meanwhile - the first of which was designated in 2002– aim, in part, to 'promote the sustainable use of the natural resources of the area . . . [and] sustainable social and economic development of the communities of the area' (SNH 2011c). This differs notably from US National Park objectives to 'preserve unimpaired . . . natural and cultural resources . . . for the enjoyment, education, and inspiration of this and future generations' (National Park Service, NPS 2011).

In these respects, something like Pinchot's natural resource ethic is recognisable in Scottish environmental thinking, with protection generally provided on the basis of ongoing resource use, albeit 'sustainable'. What appears to be lacking is an underlying principle of equitable distribution. There is, however, an independent Scottish tradition of universal access to environmental benefits, apparent in the convention of 'open access' to the countryside which became a legal right under the *Land Reform (Scotland) Act 2003*. In fact, practical conservation projects in Scotland often have more in common with rewilding theory than official management policies suggest, even avowedly eschewing anthropocentric justifications in favour of those that assign inherent value to wild land (e.g. National Trust for Scotland 2002; Carrifran Wildwood 2011; Trees for Life 2011).

A strong aesthetic tradition also informs conservation in Scotland. While agricultural landscapes are valued, those perceived as 'wild' are attributed even greater significance, with the great majority of the Scottish public regarding their presence and protection as very important (McMorran *et al.* 2006; SNH 2008). They are consequently recognised in Scottish Government policy (SNH 2002; Scottish Government 2009) and in the objectives of several conservation charities concerned with land management (e.g. Carrifran Wildwood 2011; John Muir Trust 2011; Trees for Life 2011). General agreement also exists that, although subjective, the phrase 'wild land' implies a lack of human artefacts (McMorran *et al.* 2008). Furthermore, the mapping of wildness as a landscape characteristic, using GIS techniques, has taken place in both of Scotland's national parks and is underway at the national level by Scottish Natural Heritage (Carver *et al.* 2008, 2012).

Despite this recognition of the importance of wild land in Scotland and a growing emphasis on species reintroductions, neither Scottish Government nor Scottish Natural Heritage policy statements refer to the concept of rewilding. In addition, the landscape-based Scottish concept of 'wild land' has yet to be meaningfully linked with large-scale approaches to ecological restoration or rewilding, although recent reports to the Scottish and UK governments recommend policies directed to this end (Fisher *et al.* 2010; Lawton *et al.* 2010). This is likely a consequence of the management-oriented approach to conservation in Scotland, and a general perception that rewilding is inapplicable here due to environmental and political conditions. Perhaps for similar reasons, an intrinsic land ethic is also apparently lacking in Scottish conservation theory, despite being afforded great significance by some practitioners and commentators (Featherstone 1997; Taylor 2005). It is perhaps most discernible in scientific arguments for biodiversity conservation, but normally remains implicit and so, at best, indefinitely and subjectively understood (Fischer & Young 2007).

The Potential and Justification for Rewilding in Scotland

The scientific justification for rewilding may be expected to have universal applicability. The hypothesised regulatory role of large predators and predicted and observed trophic cascades are not site- or country-specific and may be viewed as naturally-occurring processes in Scotland. Moreover, herbivores in Scotland, free of all large natural predators, are present in densities more than capable of supporting viable populations of all extirpated native carnivores (Wilson 2004; Hetherington & Gorman 2007). Scotland does differ from North America in the extent of remaining habitat available to such species. Nevertheless, studies have found ample scope for many missing species.

Beaver reintroduction is seen as feasible, and is the subject of an ongoing trial (South *et al.* 2000; Vines 2007; Scottish Wildlife Trust 2010). It can also be expected to generate considerable economic and environmental benefits, particularly in terms of diversity in riparian habitats (Campbell *et al.* 2007; Rosell *et al.* 2005). A viable population of Wild Boar could survive in Scottish woodland – as one does in southern England – and this species is also the subject of a trial reintroducution (Leaper *et al.* 1999; Trees for Life 2009). Scotland could also support a successful and relatively large population of Lynx (Hetherington & Gorman 2007; Hetherington *et al.* 2008), and a smaller but viable number of wolves (Yalden 1986; Panaman 2002; Nilsen *et al.* 2007). Both species would have significant effects on deer populations and movement, likely generating beneficial trophic cascades similar to those observed in Yellowstone and elsewhere (Johnson 2010; Melis *et al.* 2010).

Furthermore, Yalden (1986, 1999) has proposed that Aurochs and Tarpan could be 'reconstituted' from existing wild and semi-wild horse and cattle populations. Their reintroduction would be relatively simple, and beneficial to natural woodland habitats (Kirby 2004). Earlier successful reintroductions of Capercaillie and Sea Eagles could be repeated if necessary (as they might be for Capercaillie given high numbers of fatalities in deer fences) (Love & Ball 1979; Moss 2001; Marshall & Edwards-Jones 2004). One exception is the Brown Bear, for which insufficient habitat is probably available at the present time, and which is not thought to play a keystone role (Taylor 2005).

Another consideration in Scotland is that many relevant species were eradicated several hundred years ago, so that ecological relationships between surviving species may have become altered in their absence. Such timescales may allow for some ecological and evolutionary change, but are unlikely to have resulted in transformed ecological relationships (Callicot 2002; Carroll *et al.* 2007). In addition, the well-documented recovery of varied environments following decreases in grazing intensity in Britain and elsewhere suggests that prior ecological structure may be spontaneously re-established (e.g. Welch & Rawes 1964; Virtanen *et al.* 2002; Bowen *et al.* 2007).

While interventionist management techniques would be necessary to implement rewilding, these do not necessarily differ from those already in use for species reintroductions and habitat restoration (e.g. Trees for Life 2009; Scottish Wildlife Trust 2010), or designated area management (SNH 2011b,c). The principal Scottish upland land uses which are not connected to conservation also require extensive management, be it for grouse shooting, forestry and woodland management, deer stalking or sheep farming (Thirgood *et al.* 2000; Price *et al.* 2002). As such, the great majority of uplands in Scotland are under ongoing human management at a level which rewilding may initially match, but would only decrease in the long term. The implied preclusion of other conservation projects in core areas may be viewed as a disadvantage, but this stems partly from their expected redundancy in healthy ecosystems and partly from scepticism about the efficacy of species-specific approaches to conservation (Soulé *et al.* 2005; Early & Thomas 2007).

Not only is rewilding possible in Scotland, but it may be expected to provide numerous ancillary benefits. Perhaps the most obvious of these is the further development of nature-based tourism, which is currently worth at least £1.4 billion annually to the Scottish economy, and supports 39,000 full-time jobs (Bryden *et al.* 2010). Tourism associated with Sea Eagles on the island of Mull generates an estimated £2 million annually; dolphin-watching off the east coast another £4 million (ibid.). Reintroductions could be similarly profitable: it has been estimated, for example, that a beaver release site could be worth £2 million to the local economy (Campbell *et al.* 2007). The identification of scenery as the principal attraction for tourists who visit Scotland (VisitScotland 2008) further suggests that the diverse and natural landscapes produced by rewilding could be an important economic resource. Research in Scotland also suggests that local economic benefits of rewilding projects, including the number of full-time jobs sustained, are up to 5 times greater than those of traditional land uses (Taylor 2007).

Precedents exist in other countries for the economic benefits of rewilding, where restored habitats and wild populations of species such as beaver, lynx and wolf add dramatically to tourism revenue. The reintroduction of wolves to Yellowstone National Park, for example, resulted in a 25% increase in visitor numbers within three years, bringing estimated extra revenue to the local economy of \$35.5 million annually – offset only by depredation losses of between \$11,000 and \$64,000 (Switalski *et al.* 2002; Duffield *et al.* 2006). The very act of protecting lynx habitat in

Canada has also been found to have a net positive economic effect (Kroeger & Casey 2006). Scotland's hunting industry, itself worth an estimated annual £136 million (Bryden *et al.* 2010), also stands to gain. The diversification of game hunting to species such as elk, lynx and boar is already occurring profitably in other European countries, and improved habitats would allow current game species such as deer to command higher prices (Matilainen & Keskinarkaus 2010).

General environmental benefits would also result from rewilding. Considerable evidence suggests that protection of large areas – especially at the scale of entire ecosystems – is the most effective method of preserving biological diversity, especially under climate change (Hilty *et al.* 2006; Cantú-Salazar & Gaston 2010; Rands *et al.* 2010). Not only is this a global priority (United Nations 2011), but the Scottish Biodiversity Strategy explicitly advocates linked and large-scale habitat conservation to this end (Scottish Executive 2004). In England, the protection and connection of fragmented environments has been identified as the best method of ensuring ecosystem resilience and stemming declines in biodiversity (Lawton *et al.* 2010). This is reflected in recent UK Government policy which aims to expand and link protected areas in order to mitigate the effects of climate change on native species (HM Government 2011).

Efforts to create links between areas of wild land in Scotland may require greater recognition of core wild areas and of existing or potential wild corridors between them. A recently published report commissioned by the Scottish Government seeks to address these issues by considering policy responses across Europe, and suggests that clearly defined, zoned and linked protected areas of the kind required under rewilding are indeed necessary for long-term conservation (Fisher *et al.* 2010). Some designations, such as those of the International Union for Conservation of Nature (IUCN), already capture much of Europe's wildest land and are highly compatible with the diverse environmental and socio-economic consequences of rewilding (*ibid.*). Specifically, categories Ia, Ib would be suitable for large 'core' areas, category IV for areas under restoration, and categories II, V and VI for buffer and surrounding regions where increasing levels of human activity occur. The IUCN has already initiated an expansion of the coverage of its protected-area management categories across the UK (International Union for Conservation of nature (IUCN) 2011). Emergent national maps of wildness in Scotland developed by SNH represent a potential starting point for the strategic recognition and protection of core wild areas and corridor zones (see Carver *et al.* 2008, 2012).

The potential of rewilding to increase the resilience of Scottish species and ecosystems to climate change would also have important consequences for the provision of ecosystem services (e.g. Lawton *et al.* 2010). A recent assessment of these underlines their importance, identifying them as including natural resources such as grass, timber, fruit, meat and water; processes such as carbon storage, protection from erosion and floods and the provision of clean air; and recreational opportunities such as wildlife watching, hunting, fishing and walking (SNH 2011a). Finally, rewilding satisfies the frequently-identified moral obligation to reverse anthropogenic environmental damage – particularly that which has been caused deliberately, as in the case of targeted species extirpations (Rolston 1985; Foreman 2004). This is recognised in British and European law, under which the Scottish

Government is committed to considering the reintroduction of extinct native species (Council of Europe 1979; Rees 2001).

Conclusion

In North America, the concept of rewilding was born of the precipitate environmental change generated by European colonisation of the continent and the strongly preservationist conservation movements that resulted. In the UK, a convergent yet largely independent movement grew from practical restoration projects which highlighted the far more gradual, though fundamental, ecological effects of human activity. Despite their different backgrounds, both formulations agree on the necessity of protecting large, connected areas within which self-sustaining populations of keystone species may survive.

In practice, rewilding must be a longer-term and initially less ambitious strategy in countries which lack a large proportion of their native large mammal species and natural habitats. Neither the British nor North American concepts, however, limit the methods by which their objectives may be achieved. Indeed, the principal virtue of rewilding may be its identification of a clear philosophical and scientific objective, often only implicit in alternative strategies, which does not require didactic and site-specific definition. As such, it represents a logical extension of the principles of nature conservation and an important regulative ideal.

Rewilding could therefore make an invaluable contribution to conservation philosophy and practice in Scotland. Its implementation here would be based on a coherent and scientifically defensible series of steps that would quickly provide wider benefits. In order to initiate this, the following key overarching aims are proposed for the adoption of rewilding as a conservation strategy in Scotland:

- The inclusion of rewilding as a term and objective in government policy, and further detailed review of the concept's environmental and economic implications by key stakeholders such as Scottish Natural Heritage.
- The identification and designation of large core areas of semi-natural habitat with surrounding buffer zones, to allow the expansion and linking of existing protected areas – for example through utilisation of forest habitat networks and riparian corridors. Existing protected-area designations may be particularly suitable for this purpose.
- The development of a long-term strategy for the full rewilding of these areas, including any necessary initial restoration, subsequent management activities and, eventually, species reintroductions. This strategy should combine land acquisition plans, specific management strategies, and stakeholder partnerships.
- Widespread sustainable management of deer populations and landscape-scale ecological processes which encourage natural regeneration of woodland habitats and the creation of ecotonal habitats across Scotland.
- The reintroduction and protection (through stakeholder partnerships) of viable populations of a number of keystone species including beaver, elk, lynx, wild boar, and polecat, along with currently threatened species such as the wildcat. Programmes of protection and reintroduction can begin immediately in many

cases, with certain species (e.g. wolf and bear) requiring longer-term plans involving large-scale habitat restoration.

- Programmes of education and interpretation by a range of stakeholders to present the rationale and benefits of rewilding and reintroductions to the widest possible audience.

References

Abensperg-Traun, M., Wrbka, T., Bieringer, G., Hobbs, R., Deininger, F., Main, B. Y., Milasowszky, N., Sauberer, N. & Zulka, K. P. (2004) Ecological restoration in the slipstream of agricultural policy in the old and new world, *Agriculture, Ecosystems & Environment*, vol. 103, pp. 601–611.

Adams, W. M. (1997) Rationalization and conservation: ecology and the management of nature in the United Kingdom, *Transactions of the Institute of British Geographers*, vol. 22, pp. 277–291.

Albon, S. D., Brewer, M. J., O'Brien, S., Nolan, A. J. & Cope, D. (2007) Quantifying the grazing impacts associated with different herbivores on rangelands, *Journal of Applied Ecology*, vol. 44, pp. 1176–1187.

Alladale Wilderness Reserve (2011) *Alladale Wilderness Reserve*, [Online] Available at: http://www.alladale.com/ (accessed 18 April 2011).

Armstrong, H. & Bullock, D. (2004) Stock grazing in woodland, in Qulne, C., Shore, R. & TROUT, R. (Eds.) *Managing Woodlands and their Mammals* (Edinburgh: Forestry Commission), pp. 81–86.

Atahan, P., Itzstein-Davey, F., Taylor, D., Dodson, J., Qin, J., Zheng, H. & Brooks, A. (2008) Holocene-aged sedimentary records of environmental changes and early agriculture in the lower Yangtze, China, *Quaternary Science Reviews*, vol. 27, pp. 556–570.

Ballantyne, C. K., McCarroll, D., Nesje, A., Dahl, S. O., Stone, J. O. (1998) The last ice sheet in North-West Scotland: reconstruction and implications, *Quaternary Science Reviews*, vol. 17, pp. 1149–1184.

Bang-Andersen, S. (1996) Coast/inland relations in the Mesolithic of southern Norway, *World Archaeology*, vol. 27, pp. 427–443.

Barnosky, A. D., Koch, P. L., Feranec, R. S., Wing, S. L. & Shabel, A. B. (2004) Assessing the causes of late Pleistocene extinctions on the continents, *Science*, vol. 306, pp. 70–75.

Baron, J. S., Poff, N. L., Angermeier, P. L., Dahm, C. N., Gleick, P. H., Hairston, N. G., Jr., Jackson, R. B., Johnston, C. A., Richter, B. D. & Steinman, A. D. (2002) Meeting ecological and societal needs for freshwater, *Ecological Applications*, vol. 12, pp. 1247–1260.

Barrett, J. H., Nicholson, R. A. & Cerón-Carrasco, R. (1999) Archaeo-ichthylogical evidence for long-term socioeconomic trends in Northern Scotland: 3500 BC to AD 1500, *Journal of Archaeological Science*, vol. 26, pp. 353–388.

Bartolino, V., Maiorano, L. & Colloca, F. (2011) A frequency distribution approach to hotspot identification, *Population Ecology*, vol. 53, pp. 351–359.

Bates, J. L. (1957) Fulfilling American democracy: the conservation movement, 1907 to 1921, *The Mississippi Valley Historical Review*, vol. 44, pp. 29–57.

Berkes, F. (1999) *Sacred Ecology – Traditional Ecological Knowledge and Resource Management* (London: Taylor & Francis).

Berkes, F., Kislalioglu, M., Folke, C. & Gadgil, M. (1998) Minireviews: exploring the basic ecological unit: ecosystem-like concepts in traditional societies, *Ecosystems*, vol. 1, pp. 409–415.

Beschta, R. L. & Ripple, W. J. (2010) Recovering Riparian plant communities with wolves in Northern Yellowstone, U.S.A., *Restoration Ecology*, vol. 18, pp. 380–389.

Bills, N. & Gross, D. (2005) Sustaining multifunctional agricultural landscapes: comparing stakeholder perspectives in New York (US) and England (UK), *Land Use Policy*, vol. 22, pp. 313–321.

Bloom, D. E. (1995) International public opinion on the environment, *Science*, vol. 269, pp. 354–358.

Boitani, L., Falcucci, A., Maiorano, L. & Rondinini, C. (2007) Ecological networks as conceptual frameworks or operational tools in conservation, *Conservation Biology*, vol. 21, pp. 1414–1422.

Borrero, L. A. (2008) Extinction of Pleistocene megamammals in South America: the lost evidence, *Quaternary International*, vol. 185, pp. 69–74.

Bourne, W. R. P. (1972) The decline of Auks in Great Britain, *Biological Conservation*, vol. 4, pp. 144–146.

Bowen, M. E., McAlpine, C. A., House, A. P. N. & Smith, G. C. (2007) Regrowth forests on abandoned agricultural land: a review of their habitat values for recovering forest fauna, *Biological Conservation*, vol. 140, pp. 273–296.

Brook, B. W. & Bowman, D. M. J. S. (2002) Explaining the Pleistocene megafaunal extinctions: models, chronologies, and assumptions, *Proceedings of the National Academy of Sciences*, vol. 99, pp. 14624–14627.

Bryden, D. M., Westbrook, S. R., Burns, B., Taylor, W. A. & Anderson, S. (2010) Assessing the economic impacts of nature based tourism in Scotland. Scottish Natural Heritage Commissioned Report No. 398. Inverness: Scottish Natural Heritage.

Burney, D. A. & Flannery, T. F. (2005) Fifty millennia of catastrophic extinctions after human contact, *Trends in Ecology and Evolution*, vol. 20, pp. 395–401.

Callicott, J. B., (2002) Choosing appropriate temporal and spatial scales for ecological restoration, *Journal of Biosciences*, vol. 27, pp. 409–420.

Campbell, R., Dutton, A. & Hughes, J. (2007) *Economic Impacts of the Beaver* (Oxford: University of Oxford).

Campbell, S. K. & Butler, V. L. (2010) Archaeological evidence for resilience of Pacific Northwest Salmon populations and the socioecological system over the last ~7,500 years, *Ecology and Society*, vol. 15, [Online].

Cantú-Salazar, L. & GASTON, K. J. (2010) Very large protected areas and their contribution to terrestrial biological conservation, *BioScience*, vol. 60, pp. 808–818.

Carrifran Wildwood (2011) *Our mission statement*, [Online] Available at: http://www.carrifran.org.uk/about/our-mission-statement/ (accessed 10 November 2011).

Carroll, S. P., Hendry, A. P., Reznick, D. N. & Fox, C. W. (2007) Evolution on ecological time-scales, *Functional Ecology*, vol. 21, pp. 387–393.

Carson, R. (1962) *Silent Spring* (Boston: Houghton Mifflin).

Carver, S., Comber, L., Fritz, S., McMorran, R., Taylor, S. & Washtell, J. (2008) *Wildness Study in the Cairngorms National Park* (Leeds: University of Leeds).

Carver, S., Comber, L., McMorran, R. & Nutter, S. (2012) A GIS model for mapping spatial patterns and distribution of wild land in Scotland, *Landscape and Urban Planning*, vol. 104, pp. 395–409.

Chave, J. & Norden, N. (2007) Changes of species divrsity in a simulated fragmented neutral landscape, *Ecological Modelling*, vol. 207, pp. 3–10.

Clark, J. D., Huber, D. & Servheen, C. (2002) Bear reintroductions: lessons and challenges: invited paper, *Ursus*, vol. 13, pp. 335–345.

Clutton-Brock, T. H., Coulson, T. & Milner, J. M. (2004) Red deer stocks in the Highlands of Scotland, *Nature*, vol. 429, pp. 261–262.

Colding, J. & Folke, C. (2001) Social taboos: "invisible" systems of local resource management and biological conservation, *Ecological Applications*, vol. 11, pp. 584–600.

Côté, S. D., Rooney, T. P., Tremblay, J. P., Dussault, C. & Waller, D. M. (2004) Ecological impacts of deer overabundance, *Annual Review of Ecology, Evolution and Systematics*, vol. 35, pp. 113–147.

Council of Europe (1979) *Convention on the Conservation of European Wildlife and Natural Habitats* (Bern: Council of Europe).

Crooks, K. R. & Sanjayan, M. A. (eds.) 2006 *Connectivity Conservation* (Cambridge: Cambridge University Press).

Crooks, K. R. & Soulé, M. E. (1999) Mesopredator release and avifaunal extinctions in a fragmented system, *Nature*, vol. 400, pp. 563–566.

Currant, A. & Jacobi, R. (2001) A formal mammalian biostratigraphy for the Late Pleistocene of Britain, *Quaternary Science Reviews*, vol. 20, pp. 1707–1716.

Daily, G. C. (1997) *Nature's Services: Societal Dependence on Natural Ecosystems* (Washington, DC: Island Press).

Darling, F. F. & Boyd, J. M. (1964) *Natural History in the Highlands and Islands* (London: Bloomsbury Books).

Darwin, C. (1859) *The Origin of Species by Means of Natural Selection, or the Preservation of Favoured Races in the Struggle for life*, 1st Collier Books edn (New York: Collier Books).

Davidson, N. (2004) The Scottish path to capitalist agriculture 2: the capitalist offensive (1747–1815), *Journal of Agrarian Change*, vol. 4, pp. 411–460.

Davies, A. L. (2007) Upland agriculture and environmental risk: a new model of upland land-use based on high spatial-resolution palynological data from West Affric, NW Scotland, *Journal of Archaeological Science*, vol. 34, pp. 2053–2063.

Davis, A. & Ruddle, K. (2010) Constructing confidence: rational skepticism and systematic enquiry in local ecological knowledge research, *Ecological Applications*, vol. 20, pp. 880–894.
Del Castillo, R. F., Trujillo, A. S. & Cuauhtémoc, S. R. (2009) Pinus chiapensis, a keystone species: genetics, ecology and conservation, *Forest Ecology and Management*, vol. 257, pp. 2201–2208.
Delibes-Mateos, M., Smith, A. T., Slobodchikoff, C. N. & Swenson, J. E. (2011) The paradox of keystone species persecuted as pests: A call for the conservation of abundant small mammals in their native range. *Biological Conservation*, vol. 144, pp. 1335–1346.
Dennis, P., Skartveit, J., McCraken, D.I., Pakeman, R.J., Beaton, K., Kunaver, A. & Evans, D.M. (2008) The effects of livestock grazing on foliar arthropods associated with bird diet in upland grasslands of Scotland. *Journal of Applied Ecology*, vol. 45, pp. 279–287.
Dodgshon, R. A. & Olsson, G. A. (2006) Heather moorland in the Scottish Highlands: the history of a cultural landscape, 1600–1880, *Journal of Historical Geography*, vol. 32, pp. 21–37.
Dodgshon, R. A. (1993) West Highland and Hebridean landscapes: have they a history without runrig? *Journal of Historical Geography*, vol. 19, pp. 383–398.
Donald, P. F., Green, R. E. & Heath, M. F. (2001) Agricultural intensification and the collapse of Europe's farmland bird populations. *Proceedings: Biological Sciences*, vol. 268, pp. 25–29.
Duffield, J., Neher, C. & Patterson, D. (2006) *Wolves and People in Yellowstone: Impacts on the Regional Economy* (Missoula: Department of Mathematical Sciences, University of Montana).
Dumayne-Peaty, L. (1998) Human impact on the environment during the Iron Age and Romano-British times: palynological evidence from three sites near the Antonine wall, Great Britain, *Journal of archaeological science*, vol. 25, pp. 203–214.
Dumayne-Peaty, L. (1999) Late Holocene human impact on the vegetation of southeastern Scotland: a pollen diagram from Dogden Moss, Berwickshire, *Review of Palaeobotany and Palynology*, vol. 105, pp. 121–141.
Dyar, J. A. & Wagner, J. (2003) Uncertainty and species recovery program design, *Journal of Environmental Economics and Management*, vol. 45, pp. 505–522.
Early, R. & Thomas, C. D. (2007) Multispecies conservation planning: identifying landscapes for the conservation of viable populations using local and continental species priorities, *Journal of Applied Ecology*, vol. 44, pp. 253–262.
Edwards, K. J. & Mithen, S. (1995) The colonization of the Hebridean Islands of western Scotland: evidence from the palynological and archaeological records, *World Archaeology*, vol. 26, pp. 348–365.
Edwards, K. J., Whittington, G. & Ritchie, W. (2005a) The possible early role of humans in the early stages of machair evolution: palaeoenvironmental investigations in the Outer Hebrides, Scotland, *Journal of archaeological science*, vol. 32, pp. 435–449.
Edwards, K. J., Whittington, G., Robinson, M. & Richter, D. 2005b. Paleoenvironments, the archaeological record and cereal pollen detection at Clickimin, Shetland, Scotland. *Journal of Archaeological Science*, vol. 32, pp. 1741–1756.
Egerton, F. N. (2001) A history of the ecological sciences: early Greek origins, *Bulletin of the Ecological Society of America*, vol. 82, pp. 93–97.
Ehrlich, P. (1968) *The Population Bomb* (New York: Ballantine Books).
Ethos (2008) *Cores and Connectivity: A Wildlands Manifesto for Britain* (Walton Hill, Somerset: Ethos).
Europa (2009) *Reform of the Common Agricultural Policy (CAP)*, [Online] Available at: http://europa.eu/legislation_summaries/agriculture/general_framework/l60002_en.htm (accessed 11 November 2011).
Fabricius, C., Koch, E., Magome, H. & Turner, S. (eds.) (2004) *Rights, Resources and Rural Development* (London: Earthscan).
Fairnell, E. H. & Barrett, J. H. (2007) Fur-bearing species and Scottish islands, *Journal of Archaeological Science*, vol. 34, pp. 463–484.
Farrell, E. P., Führer, E., Ryan, D., Andersson, F., Hüttl, R. & Piussi, P. (2000) European forest ecosystems: building the future on the legacy of the past. *Forest Ecology and Management*, vol. 132, pp. 5–20.
Featherstone, A. W. (1997) The wild heart of the Highlands, *ECOS*, vol. 18, pp. 48–61.
Featherstone, A. W. (2004) Rewilding in the north-central Highlands – an update, *ECOS*, vol. 25, pp. 4–10.
Fenton, J. (2011) *Towards a new paradigm for the ecology of Northern and Western Scotland: a synthesis of issues*, [Online] Available at: http://www.james-hc-fenton.eu/page19.html (accessed 4 July 2011).

Fischer, A. & Young, J. C. (2007) Understanding mental constructs of biodiversity: implications for biodiversity management and conservation, *Biological Conservation*, vol. 136, pp. 271–282.

Fischer, J., Lindenmayer, D. B. & Manning, A. D. (2006) Biodiversity, ecosystem function, and resilience: ten guiding principles for commodity production landscapes. *Frontiers in Ecology and the Environment*, vol. 4, pp. 80–86.

Fisher, M., Carver, S., Kun, Z., McMorran, R., Arrell, K. & Mitchell, G. (2010) *Review of Status and Conservation of Wild Land in Europe*. Project commissioned by the Scottish Government, [Online] Available at: www.scotland.gov.uk/Resource/Doc/1051/0109251.pdf (accessed 28 February 2012).

Foreman, D. (2004) *Rewilding North America: A Vision for Conservation in the 21st Century* (Washington: Island Press).

Froyd, C. A. (2005) Fossil stomata reveal early pine presence in Scotland: implications for postglacial colonization analyses, *Ecology*, vol. 86, pp. 579–586.

Gause, G. F. (1934) *The Struggle for Existence* (Baltimore: Williams & Wilkins Company).

Gilbert-Norton, L., Wilson, R., Stevens, J. R. & Beard, K. H. (2010) A meta-analytic review of corridor effectiveness, *Conservation Biology*, vol. 24, pp. 660–668.

Grayson, D. K. & Meltzer, D. J. (2003) A requiem for North American overkill. *Journal of Archaeological Science*, vol. 30, pp. 585–593.

Grinnell, J. (1917) Field tests of theories concerning distributional control, *American Naturalist*, vol. 51, pp. 115.

Grinnell, J. (1924) Geography and evolution. *Ecology*, vol. 5, pp. 225–229.

Haddad, N. M., Bowne, D. R., Cunningham, A., Danielson, B. J., Levey, D. J., Sargent, S. & Spira, T. (2003) Corridor use by diverse taxa, *Ecology*, vol. 84, pp. 609–615.

Hall, M. (2005) *Earth Repair: A Transatlantic History of Environmental Restoration* (Charlottesville: University of Virginia Press).

Halofsky, J. & Ripple, W. (2008) Linkages between wolf presence and aspen recruitment in the Gallatin elk winter range of southwestern Montana, USA, *Forestry*, vol. 81, pp. 195–207.

Hancock, M. H., Summers, R. W., Amphlett, A., Willi, J., Servant, G. & Hamilton, A. (2010) Using cattle for conservation objectives in a Scots pine *Pinus sylvestris* forest: result of two trials, *European Journal of Forest Research*, vol. 129, pp. 299–312.

Hanski, I. & Gilpin, M. (1991) Metapopulation dynamics: brief history and conceptual domain, *Biological Journal of the Linnean Society*, vol. 42, pp. 3–16.

Harting (1880) *British Animals Extinct within Historic Times, with Some Account of the British Wild White Cattle* (London: Trubner).

Hebblewhite, M., White, C. A., Nietvelt, C. G., Mckenzie, J. A., Hurd, T. E., Fryxell, J. M., Bayley, S. E. & Paquet, P. C. (2005) Human activity mediates a trophic cascade caused by wolves, *Ecology*, vol. 86, pp. 2135–2144.

Hetherington, D. A. & Gorman, M. L. (2007) Using prey densities to estimate the potential size of reintroduced populations of Eurasian lynx, *Biological Conservation*, vol. 137, pp. 37–44.

Hetherington, D. A., Lord, T. C. & Jacobi, R. M. (2005) New evidence for the occurrence of Eurasian lynx (Lynx lynx) in medieval Britain, *Journal of Quaternary Science*, vol. 21, pp. 3–8.

Hetherington, D. A., Miller, D. R., Macleod, C. D. & Gorman, M. L. (2008) A potential habitat network for the Eurasian lynx *Lynx lynx* in Scotland, *Mammal Review*, vol. 38, pp. 285–303.

Hilty, J. A., Lidicker, W. Z. Jr., Merenlender, A. M. (eds.) (2006) *Corridor Ecology: The Science and Practice of Linking Landscapes for Biodiversity Conservation* (Washington: Island Press).

HM Government (2011) *The Natural Choice: Securing the Value of Nature* [White Paper] (London: The Stationery Office Limited).

Hobbs, R. J. & Cramer, V. A. (2008) Restoration ecology: Interventionist approaches for restoring and maintaining ecosystem function in the face of rapid environmental change, *Annual Review of Environment and Resources*, vol. 33, pp. 39–61.

Hoffecker, J. F., Powers, W. R. & Goebel, T. (1993) The colonization of Beringia and the peopling of the New World, *Science*, vol. 259, pp. 46–53.

Holl, K. & Smith, M. (2007) Scottish upland forests: history lessons for the future, *Forest Ecology and Management*, vol. 249, pp. 45–53.

Holmes, G. D. (1975) History of forestry and forest management, *Philosophical Transactions of the Royal Society of London, Series B, Biological Sciences*, vol. 271, pp. 69–80.

Hooper, D. U., Chapin, F. S., Ewel, J. J., Hector, A., Inchausti, P., Lavorel, S., Lawton, J. H., Lodge, D. M., Loreau, M., Naeem, S., Schmid, B., Setälä, H., Symstad, A. J., Vandermeer, J. & Wardle, D. A. (2005) Effects of biodiversity on ecosystem functioning: a consensus of current knowledge, *Ecological Monographs*, vol. 75, pp. 3–35.

Hubbard, A. L., Mcoris, S., Jones, T. W., Boid, R., Scott, R. & Easterbee, N. (1992) Is survival of European wildcats *Felis silvestris* in Britain threatened by interbreeding with domestic cats? *Biological Conservation*, vol. 61, pp. 203–208.

Hubbell, S. P. & Foster, R. B. (1986) Commonness and rarity in neotropical forest: implications for tropical tree conservation, in Soulé, M. E. (Ed.) *Conservation Biology – The Science of Scarcity and Diversity* (Sunderland, MA: Sinauer Associates, Inc.), pp. 205–231.

Humphrey, J. W. & Patterson, G. S. (2000) Effects of late summer cattle grazing on the diversity of riparian pasture vegetation in an upland conifer forest, *Journal of Applied Ecology*, vol. 37, pp. 986–996.

International Union for Conservation of Nature, IUCN (2011) *Putting nature on the map*, [Online] Available at: http://www.iucn-uk.org/Projects/ProtectedAreas/tabid/65/Default.aspx (accessed 9 November 2011).

Isasi-Catala, E. (2011) Indicator, umbrellas, flagships and keystone species concepts: use and abuse in conservation ecology, *Interciencia*, vol. 36, pp. 31–38.

Jackson, J. B. C., Kirby, M. X., Berger, W. H., Bjorndal, K. A., Botsford, L. W., Bourque, B. J., Bradbury, R. H., Cooke, R., Erlandson, J., Estes, J. A., Hughes, T. P., Kidwell, S., Lange, C. B., Leniham, H. S., Pandolfi, J. M., Peterson, C. H., Steneck, R. S., Tegner, M. J. & Warner, R. R. (2001) Historical overfishing and the recent collapse of coastal ecosystems, *Science*, vol. 293, pp. 629–637.

JNCC (Joint Nature Conservation Committee) (2011a). *UK Protected Sites* (London: JNCC), [Online] Available at: http://www.jncc.gov.uk/page-4 (accessed 25 April 2011).

JNCC (Joint Nature Conservation Committee) (2011b). *Guidelines for selection of biological SSSIs* (London: JNCC), [Online] Available at: http://www.jncc.gov.uk/page-2303 (accessed 25 April 2011).

John Muir Trust (2011) *About the John Muir Trust*, [Online] Available at: http://www.jmt.org/about-the-john-muir-trust.asp (accessed 10 November 2011).

Johnson, C. N. (2010) Red in tooth and claw: how top predators shape terrestrial ecosystems, *Journal of Animal Ecology*, vol. 79, pp. 723–725.

Jones, K. R. (2002) *Wolf Mountains: A History of Wolves along the Great Divide* (Calgary: University of Calgary Press).

Jordán, F. (2009) Keystone species and food webs, *Philosophical transactions of the Royal Society B: Biological Sciences*, vol. 365, pp. 1733–1741.

Kerley, G. I. H., Pressey, R. L., Cowling, R. M., Boshoff, A. F. & Sims-Castley, R. (2003) Options for the conservation of large and medium-sized mammals in the Cape Floristic Region hotspot, South Africa, *Biological Conservation*, vol. 112, pp. 169–190.

Kirby, K. (2004) Rewilding and the role of large herbivores, *ECOS*, vol. 25, pp. 59–62.

Kitchener, A. C. & Conroy, J. (1996) The history of the beaver in Scotland and the case for its reintroduction, *British Wildlife*, vol. 7, 156–161.

Kitchener, A. C., 1998. Extinctions, introductions and colonisations of Scottish mammals and birds since the last ice age, in Lambert, R. A. (Ed.) *Species History in Scotland* (Edinburgh: Scottish Cultural Press), pp. 63–92.

Klyza, C. M. (ed.) (2001) *Wilderness Comes Home – Rewilding the Northeast* (Hanover, NH: University Press of New England).

Koch, P. L. & Barnosky, A. D. (2006) Late quaternary extinctions: state of the debate, *Annual Review of Ecology, Evolution and Systematics*, vol. 37, pp. 215–250.

Kroeger, T. & Casey, F. (2006) Economic impacts of designating critical habitat under the U.S. endangered species act: case study of the Canada Lynx (*Lynx Canadensis*), *Human Dimensions of Wildlife: An International Journal*, vol. 11, pp. 437.

Kuzmiak, D. T. (1991) The American environmental movement, *The Geographical Journal*, vol. 157, pp. 265–278.

Lambeck, R. J. (1997) Focal species: a multi-species umbrella for nature conservation, *Conservation Biology*, vol. 11, pp. 849–856.

Land Reform (Scotland) Act 2003 (asp 2) (London: HMSO), [Online] Available at: http://www.opsi.gov.uk/legislation/scotland/acts2003/asp_20030002_en_1 (accessed 25 April 2011).

Larson, A. J. & Paine, R. T. (2007) Ungulate herbivory: indirect effects cascade into the treetops, *Proceedings of the National Academy of Sciences (PNAS)*, vol. 104, pp. 5–6.

Lawton, J. H., Brotherton, P. N. M., Brown, V. K., Elphick, C., Fitter, A. H., Forshaw, J., Haddow, R. W., Hilborne, S., Leafe, R. N., Mace, G. M., Southgate, M. P., Sutherland, W. J., Tew, T. E., Varley, J. & Wynne, G. R. (2010) *Making Space for Nature: A Review of England's Wildlife Sites and Ecological Network* (London: Department for Environment Food and Rural Affairs). Report to DEFRA.

Leaper, R., Massei, G., Gorman, M. L. & Aspinall, R. (1999) The feasibility of reintroducing Wild Boar (*Sus scrofa*) to Scotland, *Mammal Review*, vol. 29, pp. 239–259.

Leopold, A. (1966) *A Sand County Almanac with Essays on Conservation from Round River* (New York: Ballantine Books).

Lomas, P. L., Álvarez, S., Rodríguez, M. & Montes, C. (2008) Environmental accounting as a management tool in the Mediterranean context: the Spanish economy during the last 20 years, *Journal of Environmental Management*, vol. 88, pp. 326–347.

Love, J. A. & Ball, M. E. (1979) White-tailed sea eagle *Haliaeetus albicilla* reintroduction to the Isle of Rhum, Scotland, 1975–1977, *Biological Conservation*, vol. 16, pp. 23–30.

Macarthur, R. H. & Wilson, E. O. (1967) *The Theory of Island Biogeography* (Princeton, NJ: Princeton University Press).

Macmillan, D. C., Leitch, K., Wightman, A. & Higgins, P. (2010) The management and role of Highland sporting estates in the early Twenty-First Century: the owner's view of a unique but contested form of land use, *Scottish Geographical Journal*, vol. 126, pp. 24–40.

Marriott, C. A., Hood, K., Fisher, J. M. & Pakeman, R. J. (2009) Long-term impacts of extensive grazing and abandonment on the species composition, richness, diversity and productivity of agricultural grassland, *Agriculture, Ecosystems & Environment*, vol. 134, pp. 190–200.

Marshall, K. & Edwards-Jones, G. (2004) Reintroducing capercaillie (*Tetrao urogallus*) into southern Scotland: identification of minimum viable populations at potential release sites, *Biodiversity and Conservation*, vol. 7, pp. 275–296.

Martin, J. F., Roy, E. D., Diemont, S. A. W. & Ferguson, B. G. (2010) Traditional Ecological Knowledge (TEK): Ideas, inspiration, and designs for ecological engineering, *Ecological Engineering*, vol. 36, pp. 839–849.

Matilainen, A. & Keskinarkaus, S. (2010) *The Economic Role of Hunting Tourism – Examples from Northern Areas. Report 64* (Helsinki: University of Helsinki Ruralia Institute).

McDonagh, E. L. (1992) Representative democracy and state building in the progressive era, *The American Political Science Review*, vol. 86, pp. 938–950.

McDonald, R. A. (1995) Matrimonial politics and core-periphery interactions in twelfth- and early thirteenth-century Scotland, *Journal of Medieval History*, vol. 21, pp. 227–247.

McLaren, B. E. & Peterson, R. O. (1994) Wolves, moose, and tree rings on Isle Royale, *Science*, vol. 266, pp. 1555–1558.

McMorran, R., Price, M. F. & McVittie, A. (2006) *A Review of the Benefits and Opportunities Attributed to Scotland's Landscapes of Wild Character*. Scottish Natural Heritage commissioned report no. 194 (ROAME no. F04NC18) (Inverness: Scottish Natural Heritage).

McMorran, R., Price, M. F., Warren, C. R. (2008) The call of different wilds: the importance of definition and perception in protecting and managing Scottish wild landscapes, *Journal of Environmental Planning and Management*, vol. 51, pp. 177–199.

Meadow, R., Reading, R. P., Phillips, M., Mehringer, M. & Miller, B. J. (2005) The influence of persuasive arguments on public attitudes toward a proposed wolf reintroduction in the southern Rockies, *Wildlife Society Bulletin*, vol. 33, pp. 154–163.

Melis, C., Basille, M., Herfindal, I., Linnell, J. D. C., Odden, J., Gaillard, J.-M., Hoegda, K.-.A. & Andersen, R. (2010) Roe Deer population growth and lynx predation along a gradient of environmental productivity and climate in Norway, *Ecoscience*, vol. 17, pp. 166–174.

Meyer, J. M. (1997) Gifford Pinchot, John Muir, and the boundaries of politics in American thought, *Polity*, vol. 30, pp. 267–284.

Miller, C. (2004) *Gifford Pinchot and the making of modern environmentalism* (Washington: Island Press).

Mithen, S., Finlay, N., Carruthers, W., Carter, S. & Ashmore, P. (2001) Plant use in the Mesolithic: evidence from Staosnaig, Isle of Colonsay, Scotland, *Journal of Archaeological Science*, vol. 28, pp. 223–234.

Mittelbach, G. G., Turner, A. M., Hall, D. J., Rettig, J. E., Osenberg, C. W. (1995) Perturbation and resilience: a long-term, whole-lake study of predator extinction and reintroduction, *Ecology*, vol. 76, pp. 2347–2360.

Moisley, H. A. (1962) The Highlands and Islands: a crofting region? *Transactions and Papers (Institute of British Geographers)*, vol. 31, pp. 83–95.

Moss, R. (2001) Second extinction of capercaillie (*Tetrao urogallus*) in Scotland? *Biological Conservation*, vol. 101, pp. 255–257.

Muir, J. (1901) *Our National Parks* (New York: Houghton, Mifflin and Company).

Muir, J. (1996) *John Muir – The Wilderness Journeys* (Edinburgh: Cannongate Books).

Naess, A. (1973) The shallow and the deep, long range ecological movement, *Inquiry*, vol. 16, pp. 95–100.

National Trust for Scotland (2002) *Wild land Policy*, [Online] Available at: http://www.nts.org.uk/conserve/downloads/wild_land_policy_2002.pdf (accessed 29 November 2011).

Neumann, K. (2003) New Guinea: a cradle of agriculture, *Science*, vol. 301, pp. 180–181.

Newton, A. C., Stewart, G. B., Myers, G., Diaz, A., Lake, S., Bullock, J. M. & Pullin, A. S. (2009) Impacts of grazing on lowland heathland in north-west Europe, *Biological Conservation*, vol. 142, pp. 935–947.

Nilsen, E. B., Milner-Gulland, E. J., Schofield, L., Mysterud, A., Stenseth, N. C., Coulson, T. (2007) Wolf reintroduction to Scotland: public attitudes and consequences for deer management. *Proceedings of the Royal Society B: Biological Sciences*, vol. 274, pp. 995–1002.

Norgaard, R. B. & Jin, L. (2008) Trade and the governance of ecosystem services, *Ecological Economics*, vol. 66, pp. 638–652.

NPS (National Park Service), (2011) *Mission*. US Department of the Interior, [Online] Available at: http://www.nps.gov/aboutus/mission.htm (accessed 25 April 2011).

Olson, D. M., Dinerstein, E., Wikramanayake, E. D., Burgess, N. D., Powell, G. V. N., Underwood, J. A., D'Amico, I. I., Strand, H. E., Morrison, J. C., Loucks, C. J., Allnut, T. F., Ricketts, T. H., Kura, Y., Lamoreux, J. F., Wettengel, W. W., Hedao, P. & Kassem, K. R. (2001) Terrestrial ecoregions of the world: a new map of life on Earth, *BioScience*, vol. 51, pp. 933–938.

Ostergren, D. M., Abrams, J. B. & Lowe, K. A. (2008) Fire in the Forest: Public Perceptions of Ecological Restoration in North-central Arizona, *Ecological Restoration*, vol. 26, pp. 51–60.

Paine, R. T. (1966) Food web complexity and species diversity, *The American Naturalist*, vol. 100, pp. 65–75.

Paine, R. T. (1969) A note on trophic complexity and community stability, *The American Naturalist*, vol. 103, pp. 91–93.

Paine, R. T. (1995) A conversation on refining the concept of keystone species, *Conservation Biology*, vol. 9, pp. 962–964.

Panaman, R. (2002) Wolves are returning, *ECOS*, vol. 23, pp. 3–8.

Papaik, M. J., Sturtevant, B. & Messier, C. (2008) Crossing scales and disciplines to achieve forest sustainability, *Ecology and society*, vol. 13, 30. [Online].

Peres, C. A. (2000) Identifying keystone plant resources in tropical forests: the case of gums from Parkia pods, *Journal of Tropical Ecology*, vol. 16, pp. 287–317.

Pierotti, R. & Wildcat, D. (2000) Traditional ecological knowledge: the third alternative (commentary), *Ecological Applications*, vol. 10, pp. 1333–1340.

Pinchot, G. (1910) *The Fight for Conservation* (Seattle: Washington University Press).

Power, M. E., Tilman, D., Estes, J. A., Menge, B. A., Bond, W. J., Mills, L. S., Daily, G., Castilla, J. C., Lubchenco, J. & Paine, R. T. (1996) Challenges in the quest for keystones, *Bioscience*, vol. 46, pp. 609–620.

Price, M. F., Dixon, B. J., Warren, C. R., Macpherson, A. R. (2002) *Scotland's Mountains: Key Issues for their Future Management* (Battleby: Scottish Natural Heritage).

Pushkina, D. & Raia, P. (2008) Human influence on distribution and extinctions of the late Pleistocene Eurasian megafauna, *Journal of Human Evolution*, vol. 54, pp. 769–782.

Rands, M. R. W., Adams, W. M., Bennun, L., Butchart, S. H. M., Clements, A., Coomes, D., Entwistle, A., Hodge, I., Kapos, V., Scharlemann, J. P. W., Sutherland, W. J. & Vira, B. (2010) Biodiversity conservation: challenges beyond 2010, *Science*, vol. 329. pp. 1298–1303.

Rees, P. A. (2001) Is there a legal obligation to reintroduce animal species into their former habitats? *Oryx*, vol. 35, pp. 216–223.

Ripple, W. J. & Beschta, R. L. (2003) Wolf reintroduction, predation risk, and cottonwood recovery in Yellowstone National Park. *Forest Ecology and Management*, vol. 184, pp. 299–313.

Ripple, W. J. & Beschta, R. L. (2006) Linking wolves to willows via risk-sensitive foraging by ungulates in the northern Yellowstone ecosystem, *Forest Ecology and Management*, vol. 230, pp. 96–106.

Ripple, W. J. & Beschta, R. L. (2007) Restoring Yellowstone's aspen with wolves, *Biological Conservation*, vol. 138, pp. 514–519.

Ripple, W. J. & Beschta, R. L. (2008) Trophic cascades involving cougar, mule deer, and black oaks in Yosemite National Park, *Biological Conservation*, vol. 141, pp. 1249–1256.

Ritchie, J. (1920) *The Influence of Man on Animal Life in Scotland* (Cambridge: University Press).

Roberge, J. M. & Angelstam, P. (2004) Usefulness of the umbrella species concept as a conservation tool, *Conservation Biology*, vol. 18, pp. 76–85.

Robinson, J. G. (2011) Ethical pluralism, pragmatism, and sustainability in conservation practice, *Biological Conservation*, vol. 144, pp. 958–965.

Rolston, H., III, (1985) Duties to endangered species, *Bioscience*, vol. 35, pp. 718–726.

Rosell, F., Bozsér, O., Collen, P. & Parker, H. (2005) Ecological impact of beavers Castor fiber and Castor canadensis and their ability to modify ecosystems, *Mammal Review*, vol. 35, pp. 248–276.

Runte, A. (1987) *National Parks: the American Experience*, 3rd ed (Lincoln, NE: University of Nebraska Press).

Schmitz, O. J., Hambäck, P. A. & Beckerman, A. P. (2000) Trophic cascades in terrestrial systems: a review of the effects of carnivore removals on plants, *American Naturalist*, vol. 155, pp. 141–153.

Scott, A. M. (1959) The progressive era in perspective, *The Journal of Politics*, vol. 21, pp. 685–701.

Scottish Executive (2004) *Scotland's Biodiversity: It's in Your Hands* (Edinburgh: Scottish Executive).

Scottish Executive (2006) *Agricultural Facts and Figures 2006* (Edinburgh: Scottish Executive), [Online] Available at: http://www.scotland.gov.uk/Publications/2006/06/07131531/17 (accessed 25 April 2011).

Scottish Executive (2007a) *Agricultural facts and figures 2007* (Edinburgh: Scottish Executive), [Online] Available at: http://www.scotland.gov.uk/Publications/2007/06/08165102/2 (accessed 25 April 2011).

Scottish Executive (2007b) *Key Scottish Environment Statistics 2007* (Edinburgh: Scottish Executive), [Online] Available at: http://www.scotland.gov.uk/Publications/2007/08/20165714/0 (accessed 25 April 2011).

Scottish Government (2008) *Agricultural Facts and Figures 2008* (Edinburgh: Scottish Government), [Online] Available at: http://www.scotland.gov.uk/Publications/2008/06/16141710/2 (accessed 25 April 2011).

Scottish Government (2009) *National Planning Framework for Scotland 2* (Edinburgh: Scottish Government).

Scottish Government (2010a) *Agricultural Facts and Figures 2010* (Edinburgh: Scottish Government), [Online] Available at: http://www.scotland.gov.uk/Resource/Doc/314320/0099836.pdf (accessed 2 February 2011).

Scottish Government (2010b) *Single Farm Payment Scheme* (Edinburgh: Scottish Government), [Online] Available at: http://www.scotland.gov.uk/Topics/farmingrural/Agriculture/grants/Schemes/SFPS/Introduction (accessed 11 November 2011).

Scottish Government (2011) *Sustainable Development: Overview* (Edinburgh: Scottish Government), [Online] Available at: http://scotland.gov.uk/Topics/Environment/SustainableDevelopment/7368 (accessed 11 November 2011).

Scottish Natural Heritage (2004) *Sites of Special Scientific Interest* (Battleby: Scottish Natural Heritage), [Online] Available at: http://www.snh.org.uk/publications/on-line/designatedareas/sssi2/default.asp (accessed 25 April 2011).

Scottish Natural Heritage (2008) *Public Perceptions of Wild Places and Landscapes in Scotland* (Edinburgh: Market Research Partners).

Scottish Natural Heritage (2011a) *Scotland's Natural Capital Asset (NCA) Index* (Inverness: Scottish Natural Heritage).

Scottish Natural Heritage (2011b) *Interactive Facts and Figures – Protected Areas* (Battleby: SNHi, Scottish Natural Heritage), [Online] Available at: http://gateway.snh.gov.uk/portal/page?_pageid=93,866334,93_884286&_dad=portal&_schema=PORTAL (accessed 25 April 2011).

Scottish Natural Heritage (2011c) *National Parks in Scotland* (Battleby: Scottish Natural Heritage), [Online] Available at: http://www.snh.gov.uk/about-snh/working-within-government/national-parks/ (accessed 25 April 2011).

Scottish Natural Heritage, SNH (2002) *Policy Statement: Wildness in Scotland's Countryside* (Battleby: Scottish Natural Heritage).

Scottish Wildlife Trust (2010) *Official Home of the Scottish Beaver Trial* (Edinburgh: Scottish Wildlife Trust), [Online] Available at: http://www.scottishbeavers.org.uk (accessed 02 February 2011).

Séfériadès, M. (2007) Complexity of the processes of Neolithization: tradition and modernity of the Aegean world at the dawn of the Holocene period (11-9 kyr), *Quaternary International*, vol. 167-168, pp. 177–185.

Shelford, V. E. (1933) The preservation of natural biotic communities, *Ecology*, vol. 14, pp. 240–245.

Shennan, S. & Edinborough, K. (2007) Prehistoric population history: from the Late Glacial to the Late Neolithic in Central and Northern Europe, *Journal of Archaeological Science*, vol. 34, pp. 1339–1345.

Shurin, J. B., Borer, E. T., Seabloom, E. W., Anderson, K., Blanchette, C. A., Broitman, B., Cooper, S. D., Halpern, B. S. (2002) A cross-ecosystem comparison of the strength of trophic cascades, *Ecology Letters*, vol. 5, pp. 785–791.

Skolimowski, H. (1984) Eco-ethics as the foundation of conservation, *The Environmentalist*, vol. 4, pp. 45–51.

Slobodkin, L. B. (1961) *Growth and Regulation of Animal Populations* (New York: Holt, Rinehart and Winston).

Slobodkin, L. B. (1964) Experimental populations of Hydrida, *The Journal of Animal Ecology*, vol. 33, pp. 131–148.

Smout, T. C. (ed.) (1997) *Scottish Woodland History* (Edinburgh: Scottish Cultural Press).

Smout, T. C. (ed.) (2003) *People and Woods in Scotland: A History* (Edinburgh: Edinburgh University Press).

Soliva, R., Rønningen, K., Bella, I., Bezak, P., Cooper, T., Flø, B. E., Marty, P. & Potter, C. (2008) Envisioning upland futures: stakeholder responses to scenarios for Europe's mountain landscapes, *Journal of Rural Studies*, vol. 24, pp. 56–71.

Soulé, M. E. & Noss, R. F. (1998) Rewilding and biodiversity conservation: complementary goals for continental conservation, *Wild Earth*, vol. 8, pp. 18–28.

Soulé, M. E. & Terborgh, J. (eds.) (1999) *Continental Conservation: Scientific Foundations of Regional Reserve Networks* (Washington, DC: Island Press).

Soulé, M. E. (1985) What is conservation biology? *BioScience*, vol. 35, The biological diversity crisis, pp. 727–734.

Soulé, M. E., Estes, J. A., Miller, B. & Honnold, D. L. (2005) Strongly interacting species: conservation policy, management, and ethics, *BioScience*, vol. 55, pp. 168–176.

South, A., Rushton, S. & Macdonald, D. (2000) Simulating the proposed reintroduction of the European beaver (*Castor fiber*) to Scotland, *Biological Conservation*, vol. 93, pp. 103–116.

Steadman, D. W. & Martin, P. S. (2003) The late Quaternary extinction and future resurrection of birds on Pacific islands, *Earth-Science Reviews*, vol. 61, pp. 133–147.

Sutton, D. G., Flenley, J. R., Li, X., Todd, A., Butler, K., Summers, R. & Chester, P. I. (2008) The timing of the human discovery and colonization of New Zealand, *Quaternary International*, vol. 184, pp. 109–121.

Swearer, D. K. (2001) Principles and poetry, places and stories: the resources of Buddhist ecology, *Daedalus*, vol. 130 (4, Religion and Ecology: Can the Climate Change?), pp. 225–241.

Switalski, T. A., Simmons, T., Duncan, S. L., Chavez, A. S. & Schmidt, R. (2002) Economic aspects of wolf recolonization in Utah, *Natural Resources and Environmental Issues*, vol. 10, pp. 6. [Online].

Taylor, B. P. (1991) Environmental ethics & political theory, *Polity*, vol. 23, pp. 567–583.

Taylor, P. (1996) Return of the animal spirits, *Reforesting Scotland*, vol. 15, pp. 12–15.

Taylor, P. (2005) *Beyond Conservation* (London: Earthscan).

Taylor, P. (2007) *Wildland Benefits – A Brief Survey of Schemes on the Wildland Network Database* (Walton Hill, Somerset: Wildland Network).

Taylor, P. (2009) Re-wilding the grazers: obstacles to the wild in wildlife management, *British Wildlife*, vol. 20, pp. 50–55.

Taylor, P. (ed.) (2011) *Rewilding: ECOS Writing on Wildland and Conservation Values* (Walton Hill, Somerset: Ethos/BANC).

Terborgh, J. & Estes, J. A. (2010) *Trophic Cascades: Predators, Prey, and the Changing Dynamics of Nature* (Washington, DC: Island Press).

Terborgh, J. (1986) Keystone plant resources in the tropical forest, in Soulé, M. E. (Ed.) *Conservation Biology – The Science of Scarcity and Diversity* (Sunderland, MA: Sinauer Associates, Inc), pp. 205–231.

Terborgh, J., Lopez, L., Nuñez, P., Rao, M., Shahabuddin, G., Orihuela, G., Riveros, M., Ascanio, R., Adler, G. H., Lambert, T. D., Balbas, L. (2001) Ecological meltdown in predator-free forest fragments, *Science*, vol. 294, pp. 1923–1926.

Thapar, B. K. (1978) Early farming communities in India, *Journal of Human Evolution*, vol. 7, pp. 11–22.

Tharme, A. P., Green, R. E., Baines, D., Bainbridge, I. P. & O'Brien, M. (2001) The effect of management for red grouse shooting on the population density of breeding birds on heather-dominated moorland, *Journal of Applied Ecology*, vol. 38, pp. 439–457.

The Corrour Trust (2010) *Deer Management & the Environment*, [Online] Available at: http://www.corrour.co.uk/content/template.asp?cID=32 (accessed 18 April 2011).

Thirgood, S., Redpath, S., Newton, I. & Hudson, P. (2000) Review: raptors and red grouse: conservation conflicts and management solutions, *Conservation Biology*, vol. 14, pp. 95–104.

Thomassen, H. A., Fuller, T., Buermann, W., Milá, B., Kieswetter, C. M., Jarrín-V. P., Cameron, S. E., Mason, E., Schweizer, R., Schlunegger, J., Chan, J., Wang, O., Peralvo, M., Schneider, C. J., Graham, C. H., Pollinger, J. P., Saatchi, S., Wayne, R. K. & Smith, T. B. (2011) Mapping evolutionary process: a multi-taxa approach to conservation prioritization, *Evolutionary Applications*, vol. 4, pp. 397–413.

Thompson, D. B. A., Macdonald, A. J., Marsden, J. H. & Galbraith, C. A. (1995) Upland heather moorland in Great Britain: a review of international importance, vegetation change and some objectives for nature conservation, *Biological Conservation*, vol. 71, pp. 163–178.

Tipping, R., Davies, A., McCulloch, R. & Tisdall, E. (2008) Response to late Bronze Age climate change of farming communities in north east Scotland, *Journal of Archaeological Science*, vol. 35, pp. 2379–2386.

Trees for Life (2009) *Dundreggan*, [Online] Available at: http://www.treesforlife.org.uk/dundreggan/news 200911.html (accessed 2 February 2011).

Trees for Life (2011) *Our Vision*, [Online] Available at: http://www.treesforlife.org.uk/tfl.visi.html (accessed 10 November 2011).

Turner, J. M. (2002) From woodcraft to 'Leave No Trace': wilderness, consumerism, and environmentalism in twentieth-century America, *Environmental History*, vol. 7, pp. 462–484.

Turner, N. J., Ignace, M. B. & Ignace, R. (2000) Traditional ecological knowledge and wisdom of aboriginal peoples in British Columbia, *Ecological Applications*, vol. 10, pp. 1275–1287.

United Nations (2011) Convention on biological diversity, [Online] Available at: http://www.cbd.int/ (accessed 23 April 2011).

Van Dyck, H. & Baguette, M. (2005) Dispersal behaviour in fragmented landscapes: routine or special movements? *Basic and Applied Ecology*, vol. 6, pp. 535–545.

Veldman, M. (1994) *Fantasy, the Bomb, and the Greening of Britain: Romantic protest, 1945–1980* (Cambridge: Cambridge University Press).

Vines, G. (2007) Don't fear the beaver, *New Scientist*, vol. 195, pp. 42–45.

Virtanen, R., Edwards, G. R. & Crawley, M. J. (2002) Red deer management and vegetation on the Isle of Rum, *The Journal of Applied Ecology*, vol. 39, pp. 572–583.

Visitscotland (2008) *The Visitor Experience 2008* (Edinburgh: Harris Interactive).

Wallace, A. R. (1876) *The Geographical Distribution of Animals – with a Study of the Relations of Living and Extinct Faunas as Elucidating the Past Changes of the Earth's Surface* (New York: Harper & Brothers).

Watson, A., Alessa, L. & Glaspell, B. (2003) The relationship between Traditional Ecological Knowledge, evolving cultures, and wilderness protection in the circumpolar North, *Conservation Ecology*, vol. 8, pp. 2–21.

Welch, D. & Rawes, M. (1964) The early effects of excluding sheep from high-level grasslands in the North Pennines. *The Journal of Applied Ecology*, vol. 1, pp. 281–300.

West, P. C. & Brechin, S. R. (1991) *Resident Peoples and National Parks: Social Dilemmas and Strategies in International Conservation* (Tucson: University of Arizona Press).

Whyte, A. (2010) Establishment of a mobile sheep flock to maintain and improve mesotrophic species-rich grasslands in Fife and Falkirk, Scotland, *Conservation Evidence*, vol. 7, pp. 44–51.

Wickham-Jones, C. R. & Pollock, D. (1987) Excavations at farm fields, Kinloch, Rhum 1984–85: a preliminary report, *Glasgow Archaeological Journal*, vol. 12, pp. 19–29.
Wickham-Jones, C. R. & Woodman, P. C. (1998) Studies on the early settlement of Scotland and Ireland, *Quaternary International*, vol. 49–50, pp. 13–20.
Wightman, A. (1999) *Scotland: Land and Power – The Agenda for Land Reform* (Edinburgh: Luath Press).
Wilkins, D. A. (1984) The Flandrian woods of Lewis (Scotland), *The Journal of Ecology*, vol. 72, pp. 251–258.
Willcox, G. (2004) Measuring grain size and identifying Near Eastern cereal domestication: evidence from the Euphrates valley, *Journal of Archaeological Science*, vol. 31, pp. 145–150.
Wilson, C. J. (2004) Could we live with reintroduced large carnivores in the UK? *Mammal Review*, vol. 34, pp. 211–232.
Worboys, G. L., Francis, W. L. & Lockwood, M. (eds.) (2010) *Connectivity Conservation Management* (London: Earthscan).
Worthington, T., Tisdale, J., Kemp, P., Williams, I. & Osborne, P. E. (2010) Public and stakeholder attitudes to the reintroduction of the burbot, Lota lota, *Fisheries Management and Ecology*, vol. 17, pp. 465–472.
Wright, S. J., Gompper, M. E. & Deleon, B. (1994) Are large predators keystone species in neotropical forests? The evidence from Barro Colorado Island, *Oikos*, vol. 71, pp. 279–294.
Yalden, D. W. (1986) Opportunities for reintroducing British mammals, *Mammal Review*, vol. 16, pp. 53–63.
Yalden, D. W. (1996) Historical dichotomies in the exploitation of mammals, in Taylor, V. J. & Dunstone, N. (eds.) *The Exploitation of Mammal Populations* (London: Chapman and Hall).
Yalden, D. W. (1999) *The History of British Mammals* (London: T & A D Poyser).