Forest Resilience in British Forests, Woods & Plantations

4. Forestry practice and 21st century challenges

In the final part of this series on resilience in forestry, **Jonathan Spencer** and **Alison Field** consider the part to be played by practice and policy in the future.

We have explored ecological aspects of resilience, its establishment within conifer plantations, the long-term changes to forest composition throughout the history of British forests in the face of changing climatic conditions and the contingent nature of our forest tree communities. This final article considers how forest resilience might best be reflected in forestry practice:

- How should forest production be balanced with other ecosystem services to ensure resilience against climate change and increasing numbers of new insect pests and fungal diseases?

- How should forest resilience be promoted in existing or newly planted woods and forests?

This article recommends that competing interests in the management of woods, such as those of soils and wildlife, should be reappraised to support the needs of forest resilience and calls for an urgent review of current policy, notably for ancient woodland and plantations on ancient woodland sites (PAWS).

Definitions

Two particular, if slightly contradictory, definitions help clarify the role of forest resilience in this regard:

- “*The capacity of a forest to withstand or absorb external pressures and return, over time, to its pre-disturbance state.*” (Holling, 1973; Walker and Salt, 2006).

- “*The capacity of the forest to continue to provide most, or all, of the ecosystem services, even if the composition and structure are permanently altered by disturbances*.” (CBD Technical Series No.43, 2009).

(For other definitions see Convention on Biological Diversity, 2009)

Both definitions require sustained genetic and biological diversity above and below ground although the second definition accepts changes in species composition over time.

For centuries it has been a central tenet of woodland management that it should sustain the flow of benefits, which are not eroded by immediate demands or excessive exploitation. Traditionally this has been expressed as the sustainable yield of timber and other wood products. ‘Sustainable forest management’ now applies this concept to the much wider range of goods and services provided by woods and forests. In the 21st century the values that society ascribes to the different goods and services derived from woods and forests should drive forest policy regardless of whether they can be monetised and traded.

‘Natural Capital’ and ‘Ecosystem Services’ are terms that describe the attributes of woodland and forest that 21st century society recognises as important. Both concepts acknowledge that certain conditions must be maintained for these benefits to flow from forests and other natural systems. Methodologies ascribe a ‘common currency’ of value to services so that benefits may be fairly compared, alongside the maintenance of a ledger of assets and an account of services received (the ‘Natural Capital Account’).

Methodologies are emerging as the practice of natural capital accounting becomes more widely adopted (Natural Capital Committee, 2014; Eftec et al., 2015) and they will be central to future attempts to quantify and monitor forest resilience and its effectiveness. This will require society to view trees, woodlands and forests as 'natural capital assets', managed to maintain and enhance the flow of both private (commercial) and public (non-commercial) benefits from forests and woods. Management designed to yield a sustained flow of multiple benefits is now widely established as the norm in 21st century forestry practice.

Issues for forest policy and practice

Forest resilience depends on establishing:

- Genetic variation within species.
- Species diversity within forests or stands.
- Structural diversity within and between stands.
- Intact, functioning forest soils that drive nutrient and water cycling.
- An acceptance of change to species composition and stand structure to address prevailing environmental circumstances (see Spencer, 2018a).

Although much can be achieved through compliance with current forestry standards, notably the UK Woodland Assurance Standard and the UK Forestry Standard (UKWAS, 2017; UKFS, 2017), there are critical shortcomings that constrain delivery of forest resilience. The next section explores how we might address these concerns to build confidence in our ability to improve woodland resilience, and considers variations in approach according to woodland origin.

Ancient semi-natural woodland

Ancient woodlands are given primary importance in UK woodland and forest conservation policy, in large part because they are refugia for forest biodiversity. They are the repository for both genetic variation within our native tree species and diversity in forest soil biota, notably mycorrhizal and other forest soil fungi. Species diversity is seldom an issue as it is already well-established within most woods and restoration and management plans will normally seek to restore native woodland tree communities. The impact of Chalara on ash-dominated woods and of droughts in woods dominated by beech now present major challenges and recovery and restoration of such woods will require careful thought and considered action.

Most ancient semi-natural woods have supplied timber and other wood products for centuries and their continued role as such is necessary if their historic character is to be maintained and structural diversity within and between stands restored. More, rather than less, active and extensive management would support future resilience. Much could be achieved if future policy explicitly recognised the role of ancient woodland in supporting a shift to the low carbon economy by supplying 21st century markets for cellulose and fuel.

Maintaining and restoring soil health has become a major concern across the land-based sectors. The soils of ancient woodland are some of the most intact and best protected in the country. However, the thinning or coppicing of ancient woodland to restore light, biodiversity and structural diversity cannot be at the expense of intact, functioning soils. Not only should investment be encouraged in low impact technology for harvesting round wood but harvesting must also be encouraged in the dry months of the year from April through to September, when work is less likely to cause damage to soils. Once ancient woods are again light, open and dynamic tree and shrub communities, populations of species such as dormice will also thrive. There is an urgent need to prioritise soil conservation in forest management practice and within UKFS guidelines and re-draft habitat legislation to secure a shift away from protection of individuals of rarer species towards much greater protection of the woodland ecosystem as a whole and the promotion of populations of woodland species associated with early succession and stand diversity.

Plantations on ancient woodland sites

Plantations on ancient woodland sites (PAWS) also feature strongly as a focus for woodland conservation. They also act as refugia for genetic variation and for the conservation of wider woodland wildlife and biodiversity. Ancient woodland policy is particularly conservative with respect to their composition in the face of future environmental challenges (Forestry Commission England, 2005). There are frequently few native timber tree options in many PAWs sites, species new to the site are reluctantly accepted in restoration proposals and there is a failure to address practical challenges in the face of vigorous conifer regeneration (often of valued timber tree species). These issues restrict the establishment of greater species diversity in woods to promote forest resilience. PAWS restoration to native woodland has been pursued since the 1980s (effectively since the FC Broadleaves Policy of 1985 was adopted).

Since 2005 policy on PAWS management in England has widely presumed that conversion back to an analogue of former native woodland will be implemented at the earliest opportunity (Forestry Commission England, 2005). Where site conditions and the owner's management objectives clearly favour a return to native trees and shrubs the restoration of PAWS may progress relatively smoothly and has been widely adopted. However, for owners of larger and more actively managed PAWS the loss of timber production potential may be financially unsustainable. Unsurprisingly this can generate a conflict of interests between production forestry and nature conservation, and PAWS restoration has essentially stalled. Future policy for PAWS management needs to place more emphasis on balancing competing interests in a way that favours sustained ecological function and the delivery of ecosystem services, the enhancement of existing remnant and resurgent ancient woodland features, and should embrace native tree species beyond their current UK range and temperate tree species from elsewhere in Europe. There should be more emphasis on process (natural regeneration, soil conservation and enhancement planting to establish stand diversity) and less emphasis on native species composition as a proxy for restoration. Restoration needs to shift to new integrated policy ambitions where PAWS fully contribute to both biodiversity conservation and the supply of 21st century markets for timber, fibre, cellulose and fuel.

Ancient woodland policy

A thorough review of ancient woodland and PAWS policy to develop more progressive and forward looking management is overdue. Their past management was more dynamic than is generally appreciated (Rackham, 2006; Barnes and Williamson, 2015). Widening the native species range beyond those dominant in the late 20th century may be desirable in response to the need to establish forest resilience in ancient woodland. This would address the past simplification of species composition to supply historic markets in many woods, and the implicit species constraints

Reporting on PAWS Restoration Progress

Reporting on PAWS restoration has lost momentum. In 1992 the extent of PAWS across England was estimated at circa 135,000ha, within a total area of 341,000ha of ancient woodland (Spencer and Kirby, 1992). Summary reports by the Woodland Trust in 2011 and 2018 quoted exactly the same figures (Atkinson and Townsend, 2011; Woodland Trust, 2018) failing to acknowledge progress achieved over some 30 years. Forestry England (formerly Forest Enterprise England) has completed restoration of at least 4,000ha with a further 30,000ha in progress and the Woodland Trust has some 3,800ha under restoration and is facilitating a further 22,600ha of ancient woodland restoration elsewhere (Woodland Trust, 2018). Restoration of privately-owned woodlands is also extensive but poorly recorded. Given the importance of ancient woodland restoration in all current conservation policies, updated national figures are urgently required.

Soil surface damage following rhododendron clearance in wet weather, Bury and Redlands Forest, Surrey, February 2017. Conservation operations also impose damage to forest soils when undertaken in wet weather. The free draining soils here are on sandy gravels and consequently should recover fairly quickly. (Photo: Jay Doyle, Forestry England)

Soil damage to forest soils following forest operations on heavy Wealden clay soils, Chiddingfold Forest, West Sussex, winter 2013/14. The compaction and rutting on such clays takes many decades to recover, if at all. The inset shows sallow thickets that arose from similar operations on compacted Wealden clays in 1987. Planted oaks and other species failed and the soils have still yet to recover from the compaction. (Photo: Matthew Woodcock, Forestry Commission England)

locked into the descriptions found within woodland type classifications such as the Peterken Stand Type classification (Peterken, 1981), or the National Vegetation Classification (Rodwell et al., 1991) may also require re-examination.

20th century forests

The heavy reliance on conifer species of known timber quality and with well understood silvicultural characteristics presents challenges to the establishment of forest resilience measures. The foundation of resilience in contemporary plantations was explored in Part 2 of this series (Spencer, 2018b). The widespread adoption of Forest Development Types (see below) for guiding change in both established plantations and plantations on ancient woodland sites and developing 'future natural' woods and forests (see Peterken, 1981) should lead to two broad forest types:

- Warm temperate lowland forest models comprised of: European high forest species (oak/hornbeam; beech/silver fir in old forests and extensive beech woods; Norway spruce, Douglas fir in appropriate locations) and pine/birch as clearfell on podsols and nutritionally poor soils.

- Upland cool temperate forest models comprised of: North American 'production' high forest species (spruces or Douglas fir), and shade bearing associates (western hemlock, western red cedars, with birches, aspens and minor species as appropriate).

Species choice and appropriate associations should be governed by local site conditions and site history, and guided by the Ecological Site Classification (see Pyatt et al., 2001) and the emerging Forest Development Types (Haufe and Kerr, in prep). Establishing resilience in existing plantations will require bold action, establishing mixed and 'naturalistic' stands of complementary species. Forestry practice needs to actively promote better soil conservation with forest policy acting to alleviate operational constraints on summer working to avoid wet conditions (that are expected to become far more frequent in future winters) when soils are at their most vulnerable.

The use of large machines, inappropriate working practice, contractual constraints forcing the pace of activity and no thin practices in conifer stands (leading to raw humus/peat accumulation; Jens Haufe pers. comm.) all contribute to the impairment of forest soil development. Similarly, the wide acceptance of large-scale clear-felling, particularly in the uplands, can militate against the development, conservation and careful management of forest soils.

21st century afforestation

Establishing resilience on woodland creation sites presents different challenges. Open ground and soils of recent agricultural origin can be unfavourable for many tree species until forest conditions and forest soils are established. Afforestation, particularly in Northern Britain, remains wedded to spruces, and an operational methodology for establishing genetic variation in future afforestation projects, particularly in the main timber producing conifer species, has yet to emerge. The increasingly warm summers and milder winters are still punctuated by wet cool periods and occasional harsh frosts.

Forest establishment should focus on the rapid creation of forest conditions, using familiar pioneer species such as pine and birch, Sitka spruce and green alder (*Alnus viridis*). These can be followed with later underplanting of a much wider variety of tree species less tolerant of frost, drought or desiccating exposure to sun and wind. Drought resistance may well be a key requirement of future afforestation projects and the early establishment of forest conditions can mtigate against soil waterlogging and drought, particularly on compacted former agricultural soils. New planting may provide opportunities for the use of species most suited to future climate projections (IPCC, 2018) once forest conditions are established.

The practicalities of 'climate adapted' woodland creation have yet to be established in practice. They will need to be designed to guide the creation of forest 'natural capital assets' that provide both ecosystem services for the benefit of society and private goods for the benefit of landowners. They are very likely to include species currently unfamiliar to

Forest Development Type 122. An uneven aged, complex structured Norway spruce stand, Germany. Other similar FDTs might combine timber bearing conifers, such as Sitka spruce with western hemlock, or accept an admixture of broadleaves in the understorey (such as birch or rowan). (Photo: Dr Jens Haufe, Forest Research)

Forest Development Type 512. An uneven aged, simple-structured mixture of pedunculate oak (as the primary species) with an understorey of beech (as a secondary species). Other similar FDTs might combine oak with birch, lime, hornbeam and minor species such as rowan or cherry depending on location and soils. New Forest. (Photo: Dr Jens Haufe, Forest Research)

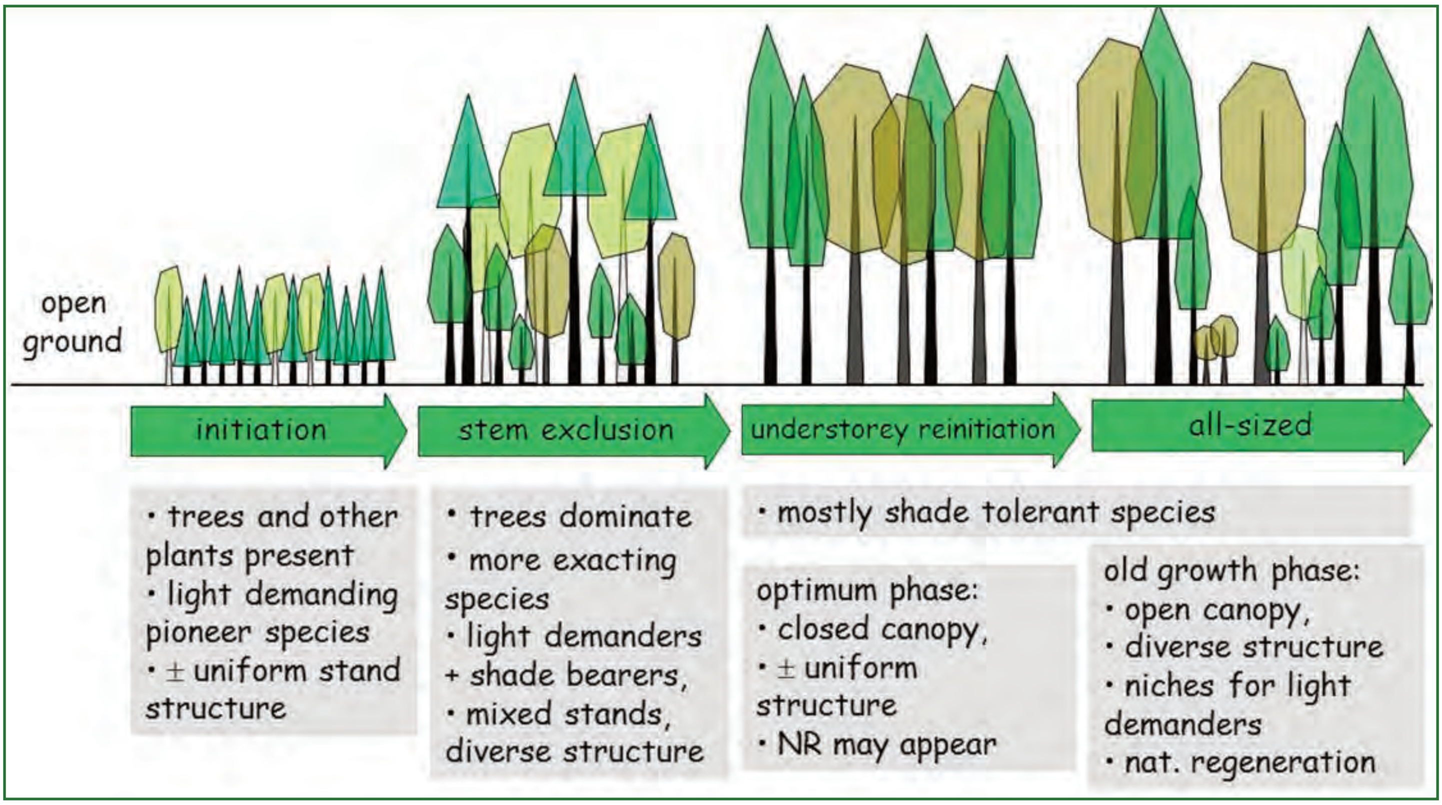

Figure 1. The development of woodland structure and composition over time.
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the professional forester. Combining familiar pioneer species (in the establishment of forest conditions) with later underplanting could introduce a level of diversity in forest species that could significantly enhance resilience. Tree communities once native in earlier warm interglacials or the late Tertiary in Britain may provide models for the planning of 'future natural' forests which might become close analogues of ancient 'past' natural forests.

Genetic variation and age class diversity in forests

Genetic variation in native tree species is already high and likely to remain so wherever natural regeneration from vegetative regrowth or seed fall is used in forest re-establishment. Conversely, restocking established 20th century plantations managed as production forests rarely considers intimately mixed stands, nor strays far from a small number of fast-growing productive species of conifer. There are also risks of diminishing genetic variance in plantation forest stands as a result of tree breeding programmes that select solely for performance. This needs careful consideration alongside the future needs of resilience.

Varying the age of stands within forests is well established and widely adopted by practitioners as a way to smooth the flow of both income and management activity. Whilst 'adjacency' guidelines require neighbouring stands to differ in age by at least five years, this approach has delivered only modest structural diversity between, and almost none within, forest stands particularly in the uplands. Over several rotations the age diversity between stands will, in theory, slowly increase but this risks delivering too little too late if we are to establish resilient and sustainable upland forests.

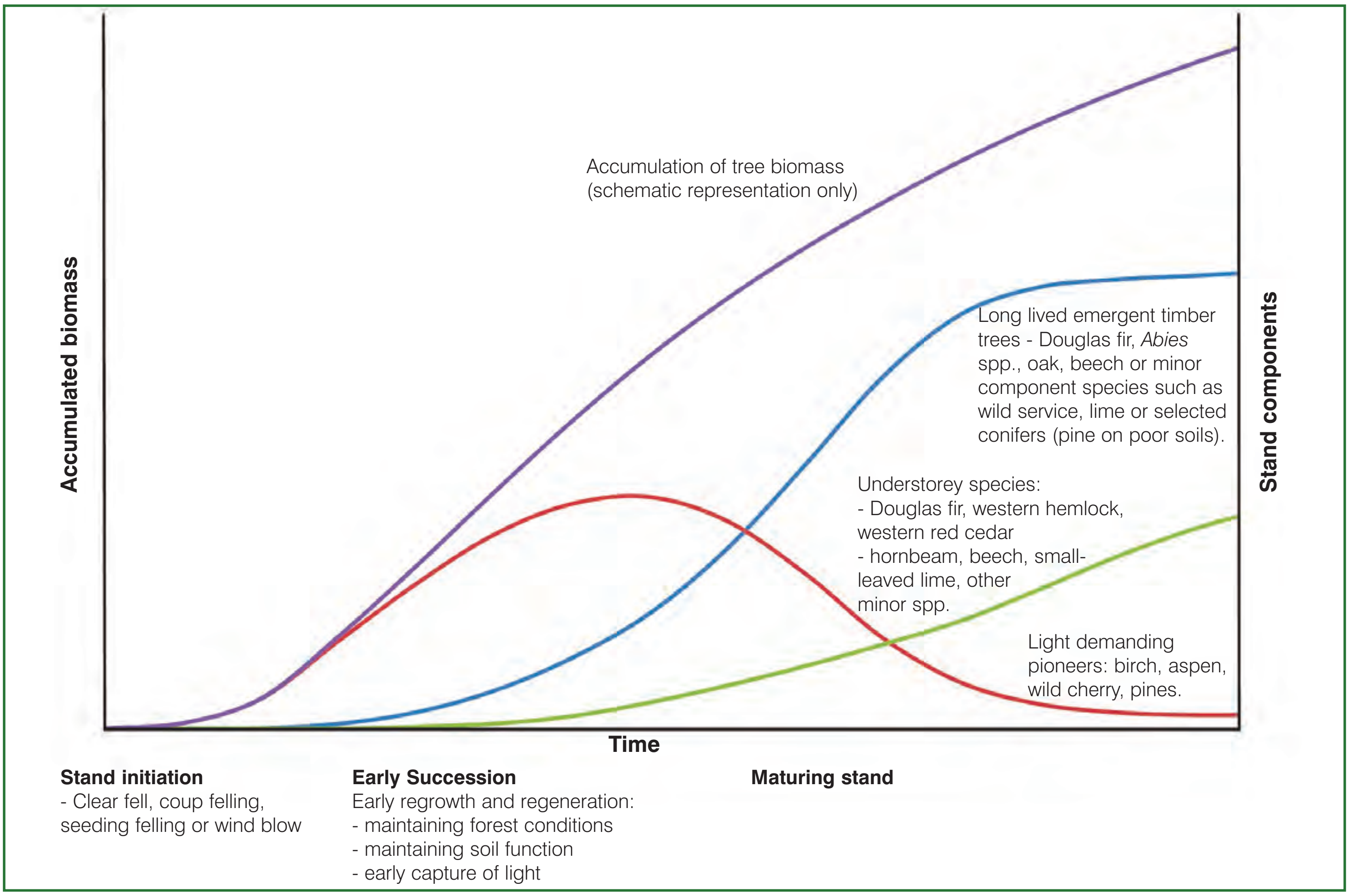

Figure 2. Schematic representation of forest stand development in more 'naturalisitic' forest stands of conifers and native broadleaves, showing the proportion of trees in early and later development. The diagram aims to emphasise the role of early successional species in the maintenance of forest conditions and soil function, alongside their role in increasing the capture of light and soil resources and their contribution to the overall accumulation of tree biomass over time. Later on in stand development their role diminishes and is replaced by shade tolerant understorey species, many of which have the potential to become timber species depending on silvicultural choices exercised throughout stand development. Species that function well together are the subject of the Forest Development Types programme being developed by Forest Research.

Functional diversity and the role of Forest Development Types

Functional diversity in our forests refers to the varying roles that tree species have evolved to exploit the available resources of light, water and nutrients as the stand develops over time and under varying soil and climatic conditions. Trees establish themselves as components throughout a stand's history through vegetative regrowth or natural regeneration, and these trees act in a complementary fashion sustaining both forest function and performance, and most importantly, imparting forest resilience. Respacing and thinning interventions change the composition of such tree associations promoting trees favoured by foresters. Stand development over time is illustrated in Figure 1.

Most temperate forest ecosystems consist of two or more tall emergents (usually species valued in timber production; a product of their evolved structure and competitive apical dominance), a small number of shade tolerant understorey species capable of performing below the emergent canopy trees, and two or more early pioneers, most often birch on mineral soils with aspens and willows on wetter and heavier soils. Pioneer species rapidly establish forest conditions and exploit the light and space available within well-lit early successional conditions.

Pioneer tree species effectively accelerate the efficient capture of light and nutrients into the earlier years of stand development, and can be harvested for timber, woodfuel or fibre. In later stages of stand development the slow establishment of more shade tolerant species extends this efficiency by exploiting light and nutrients not captured by the tall overstorey of dominant trees. As the more shade tolerant species move into evolving stands they do so at the expense of the more light-demanding pioneers as these give way to the taller maturing forest dominants, including long lived early 'pioneers' such as pine or oak. If conditions remain undisturbed these too will also give way over time to the increased competition for light, nutrients and water and shade tolerant emergent trees such as Douglas fir, beech or lime may also come to dominate. Patterns of replacement are usually far from clear and much clouded by disruptive events (Peterken, 1996; Peterken and Mountford, 2017). Western hemlock, western red cedar and the younger stems of Douglas fir represent tree species from the North American cohort that can become functional elements of 'naturalistic' conifer forests in the UK in production forests of spruce and other conifers. The importance of these various elements was explored in Parts 1 and 2 of this series (Spencer, 2018a and 2018b).

Identifying groups of complementary species and understanding their silvicultural roles within UK forest management is a major challenge, but could become a key concept in establishing forest resilience (Larsen and Nielsen, 2007). In this regard the adoption of the UK Forest Development Types model (Haufe and Kerr, in prep) as a source of templates for both natural and 'naturalistic' forest types should be integrated within future forest policy and management guidance so that we can build greater resilience into our 20th century forests.

Conclusion

Policy is at its most effective when change is clearly justified, readily achieved and easily measured. Such statements are easy to make, but require wisdom and courage to be achieved. The next generation of trees and woodlands in England are facing unprecedented environmental challenges within their biological or economic lifespans and policy should focus on giving priority to underlying key outcomes, allowing the detail to emerge through networks of best practice. Indeed policy should ideally be neutral in the choice of management systems to be applied provided they deliver management aims (Kimmins, 2004).

The desire to achieve long-term sustainability and forest resilience has inevitably promoted interest in natural (or more naturalistic) approaches to forest management allowing forests to function in more dynamic and continuous cycles. This has been demonstrated by the growing commitment to continuous cover forest systems and the use of natural regeneration. Whilst much still needs to be shared about optimal thinning for continuous cover, re-spacing and enrichment planting to deliver resilient regeneration and the degree to which deer and other pests must be controlled, the principals are now widely acknowledged and best practice is steadily emerging. But if the ambition is to establish resilient forests then there is much that needs to change. If foresters are expected to embrace not just timber production as a primary objective but also the multiple outcomes of other ecosystem services then there will be a need to develop and apply new metrics in addition to familiar forecasting based on estimates by volume or weight against which to judge management options and outcomes.

This article argues that three priorities should be highlighted that enable forest resilience to sit consistently at the heart of future forestry practice. These are the need to:

- Reconsider species composition in our woods and forests, promoting species diversity and ecological process aimed at addressing the environmental conditions we expect to contend with in the early 22nd century.
- Shift existing plantation origin forests to a more naturalistic composition, function and structure.
- Give precedence to the conservation of soil integrity over and above other factors when planning and implementing forest operations.

The role of forests as 'natural capital assets' demands that they retain resilience against future impacts if they are to continue to deliver the wide range of environmental goods and services expected of them as we work towards the development of a low carbon economy. How the desired mix of goods and services is delivered, in locations of widely differing character, needs to be brought together into a new forestry rationale through discussion and debate at all levels across the forest sector. Such a rationale will require much greater appreciation of the importance of forest ecology and forest soil conservation and the role in forest resilience of non-tree species such as fungi, insects and birds. Investing in the deployment of Forest Development Types, and the development of a future forestry 'knowledge culture' (Tsouvalis, 2000) will be essential tools in building the resilience of 21st century forests.

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