



Woodland managers' understanding of resilience and their future information needs

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Government policy across the UK seeks to encourage woodland owners, both commercial and non-commercial, to implement resilient management of their forests and woodlands. However, there are significant barriers to the uptake of resilient forestry practice, for instance, uncertainty about the efficacy of action, the costs involved, and the perceived difficulty in doing things differently. By presenting data from an evidence review, a national survey, workshops and semi-structured interviews, this Research Note provides an investigation into private woodland owners' and managers' understanding of resilience in regard to forest and woodland management in the UK. It describes the four different components of resilience, resistance, recovery, adaptation and transformation, and explains how each could be linked to management decision-making, planning and implementation of resilience actions. Categorising different kinds of woodland manager, reveals the motivations and preferences which influence each type, and how they conceive resilience differently depending on their beliefs, management objectives, their understanding of forest ecology, and perceptions of risk and uncertainty. The results show changing management practice relies on providing relevant information in a way which impacts owners' and managers' beliefs and responses to uncertainty. Future knowledge-transfer strategies must tailor advice specifically for each type of woodland manager.

Introduction

In the UK, concern about the sustainability of forests and woodlands has recently been heightened by the increasing incidence of tree pests and diseases, environmental stresses such as pollutant deposition, and the increase in occurrence of extreme events which have been linked to climate change, for example, high winds, periods of summer drought and winter flooding.

Consequently, the forestry sector has recognised the need to understand and promote actions and measures focused on maintaining or building resilience into forests and woodlands. Resilience is defined as '[t]he ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self-organisation, and the capacity to adapt to stress and change' (Forestry Commission, 2017). There is a consensus that woodland owners and managers need to change their practice and behaviours if greater resilience is to be achieved (Climate Change Accord, 2015).

However, land managers are a heterogeneous group, with varying degrees of awareness, understanding and intention to respond to resilience issues, each of which has an impact on their decision-making and subsequent woodland and forest management behaviours.

This Research Note summarises a study (see Ambrose-Oji *et al.*, 2018) reporting land managers' decision-making with regard to resilience, and addresses the following key questions:

1. Do woodland owners and managers in the UK recognise and understand the concept of resilience and, if so, how?
2. Which resilience practices are woodland managers aware of and already undertaking?
3. What barriers might prevent woodland managers implementing measures to support resilience?

Background

Linking resilience with landowner decision-making

Recent studies by Fuller and Quine (2016) and Bone *et al.* (2016) conclude that land managers should define what resilience means in the context of their own woodland, the components of their woodland that should be resilient in regard to specific pressures, and for whom this resilience is important. This definition should provide the basis for their

decision-making, planning and implementation of resilience actions. Fuller and Quine (2016) suggest four different components of resilience that forest managers need to consider in their decision-making:

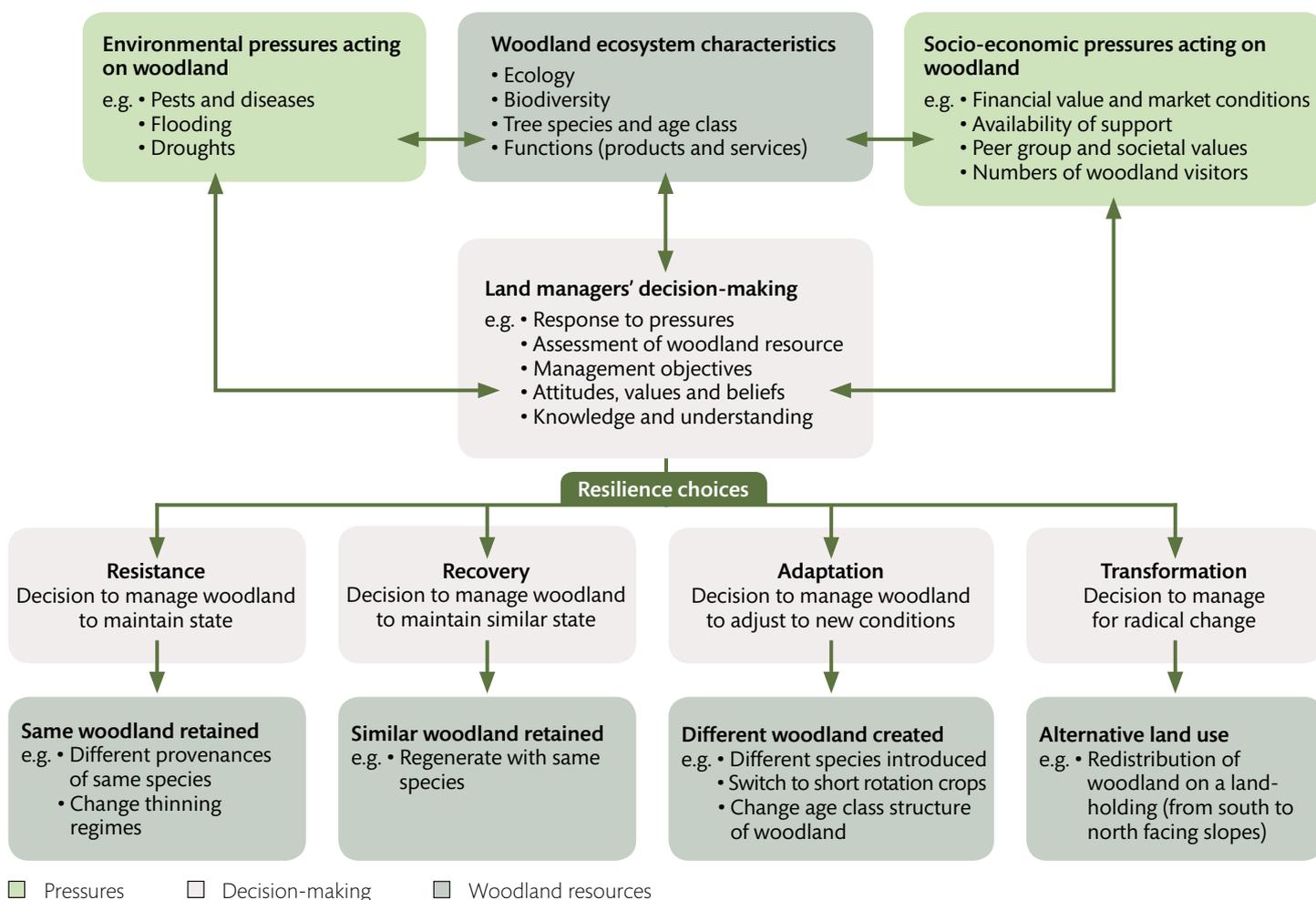
- **Resistance:** Instigating or improving defences against changes in order to withstand adverse conditions, for example by introducing biosecurity measures to prevent the arrival of a pest or disease.
- **Recovery:** Enabling the ecosystem to return to a healthy, normal state after a disturbance, for instance, regenerating a stand after windthrow in an attempt to maintain or recreate pre-disturbance conditions.
- **Adaptation:** Facilitating ecosystem adjustment to new conditions, working to keep the forest in place, for example by diversifying the species composition or age structure of a forest, changing the species mix or silvicultural system.
- **Transformation:** Facilitating a dramatic change in form, appearance or character of a forest ecosystem to a completely different ecosystem, for instance, from woodland to restored peatland, or from neglected woodland to actively managed woodland.

Regarding which of these four components of resilience a forest manager may pursue, and how each might mix or balance these in their management approach, depends on a wide range of different influences on their decision-making.

Dandy (2012) and others (see, for example, Blennow *et al.*, 2012, Karppinen, 2005, Karppinen and Berghäll, 2015) have shown the complexity of the factors involved in land managers' decision-making. These include assessment of the potential of woodland to provide specific products, services and benefits in line with their management objectives, their own attitudes and motivations, and other external factors such as the market conditions and availability of labour. Figure 1 summarises the key influences on land managers' decision-making with regard to the forest resilience concept (Ambrose-Oji *et al.* 2018).

In an ideal world, land managers will address most or all of the pressures acting on their woodlands and impacting upon resilience. These pressures can be environmental and ecological, but they may also emanate from the human, social and economic context. They could be pressures exerted over the long term, for instance, temperature increases, changing societal values such as increasing demand for access to woodland for recreation, or they could be shorter pulse events, for example, storms and windthrow events, or a drop in market prices for timber.

Figure 1 Influences on land managers' decision-making, leading to different resilience outcomes.



However, in reality, land managers' understanding of forestry and how comprehensively they are able to assess their woodland resource and identify the pressures acting upon it will determine how they decide to manage it. Their decisions will be influenced by their awareness and understanding of resilience, and their wider values and beliefs, such as those concerning issues to do with climate change. These factors play a key role in how they view and balance the perceived risks facing their woodlands with decisions regarding appropriate management responses, and ultimately which (if any) of the components of resilience are acted upon.

The research reported here reviews the influences on woodland owners' and managers' decision-making to better understand and characterise their information needs, encouraging resilient management practices.

Methods

This study drew on findings from four sets of evidence and empirical data:

- (i) A Rapid Evidence Assessment (REA) of published research about land managers' understanding of forest resilience and decision-making in North America, Europe and the UK conducted between August 2016 and November 2017, synthesising findings from 78 appropriate studies.
- (ii) Quantitative data from an extended analysis of the British Woodlands Survey 2015 dataset using a subset isolating the 1009 owners and agents who manage woodland.
- (iii) Qualitative data from semi-structured interviews conducted between August 2016 and January 2017 with 44 owners and managers of private woodlands across the UK.
- (iv) Qualitative data collected at four workshops organised between February and July 2017 in partnership with Sylva Foundation and Oxford University as part of the 360° research and consultation process used to develop the British Woodlands Survey 2017. Evidence was collected from 25 private woodland owners and managers, and 11 representatives from organisations representing landowners and managers.

Results

Differentiating among types of land managers

The REA revealed that key to understanding more about land managers' decision-making is recognising the importance of differentiating among them. Segmentation models, typologies or characterisations have all been used to group woodland owners and managers by shared features and preferences. Using such groupings as a basis for analysis has provided insights into the perceptions, attitudes and factors affecting the decision-making and behaviours of particular types of land manager. This has enabled the delivery of more targeted and persuasive communication, appropriate information, support and incentives aimed at influencing the behaviour of specific types of woodland manager. More recently, different behavioural frameworks, in particular the Theory of Planned Behaviour and the Theory of Reasoned Action, have been applied to such characterisations and segmentation as a way of exploring the reasons for differentiated responses to forest resilience. The published evidence indicates that the key factors affecting land managers' decision-making and behaviours in a forestry context are:

- their knowledge, understanding of forest resilience concepts and processes, and the information available to them;
- how these ideas relate to their woodland and forestry objectives;
- their perceptions of the actual risks to their own forests and woodlands;
- their belief in their own capability to manage risks, and the likely effectiveness of any actions undertaken (i.e. efficacy);
- the influence of peer social networks and communication.

Furthermore, the REA revealed the importance of a supportive economic, policy and legislative context to facilitate resilience-focused behaviour.

Characterising land managers in the UK

A recognition that owners and managers of woodland in the UK can be very different has provided important insights into how they might be characterised and grouped, in particular according to their varying objectives and motivations for woodland management and woodland creation, and by their behaviours related to uptake of forestry incentives and advice (Hopkins *et al.*, 2017, Howley, 2013, Lawrence and Dandy, 2014, Lawrence and Marzano, 2012, Thomas *et al.*, 2015, Urquhart and Courtney, 2011).

Recent research focusing specifically on resilience uncovers: (i) how understanding of resilience influences decision-making at

a sector level (Marzano *et al.*, 2015, Young *et al.*, 2018); (ii) how land managers respond to threats from tree pests and diseases (Marzano *et al.*, 2017); (iii) how forest managers' perceptions of risks vary around different climate change threats (Petr *et al.*, 2014); and (iv) differences between forestry sector stakeholders' and land managers' awareness of forest resilience and their intentions to act (Hemery *et al.*, 2015).

The research differentiating among types of woodland owners and managers has proven to be useful for developing policy support tools. However, such characterisations have not been used in relation to resilience behaviours.

Applying a segmentation model

In an effort to overcome this limitation, a segmentation model developed by Eves *et al.* (2015) was used to classify different types of woodland manager. Segmentation models are widely used in business to improve the effectiveness of product marketing by identifying groups of people who share particular consumer characteristics or product needs; they are designed to identify, understand and target specific groups of customers and change their behaviours. Applying a segmentation model approach to woodland owners and managers helps reveal the motivations and preferences of each group so that the resources and services supporting woodland management can be targeted most effectively. The work done by Eves *et al.* (2015) grouped together woodland owners and managers by factors such as their management objectives, the degree to which they managed their woodland, the type and size of their woodlands, and whether they had a management plan. The process of applying the segmentation model to the data from the interviews showed that the Eves *et al.* (2015) model was not a perfect fit, so several adaptations were made to it (Table 1). This modified scheme provided the basis for subsequent analysis.

Insights from the empirical data

Table 1 summarises key findings from the empirical data using the segmentation model to distinguish among different groups of woodland owners and managers. The main decision-making factors emerging from the data are highlighted, including how resilience is understood by different owners and managers, which of the perceived risks impact upon their intentions to act, and the barriers to changing their management practices (i.e. their behaviours).

Understanding of resilience

Regardless of segment membership, the majority of land managers recognised the word resilience and related it to ensuring the sustainability of their woodlands. However, the

Table 1 UK land managers' understanding of resilience and decision-making factors differentiated using a modified segmentation model derived from Eves *et al.* (2015).

Land manager segment (% of sample)	Decision-making factors			Exemplary quotes
	Understanding of resilience	Perspectives on risk	Barriers to action	
Multifunctional managers (41%) Average land holding ~51 ha	<p>Definitions and potential actions are a combination of resistance (e.g. planting resilient species), recovery (e.g. natural regeneration) and adaptive (e.g. diversification species, age class, stand structure and Continuous Cover Forestry) measures.</p> <p>Belief that good land husbandry is the best way to manage for resilience.</p> <p>May have a formal or informal management plan.</p>	<p>Risks closely associated with known threats, particularly pests and diseases. Most willing to act on this issue.</p> <p>Long planning horizons mean risks of acting or not acting are difficult to judge.</p> <p>Willing to experiment to test future actions/responses as part of risk mitigation strategy.</p>	<p>Uncertainty about how best to plan long term for multiple benefits is the main barrier to action.</p> <p>Not knowing what the right management measures are.</p> <p>Uncertainty over which tree species present functional alternatives to those under threat from climate change or from pests and diseases.</p> <p>Uncertainty how action now will support woodland in the future.</p> <p>Do not feel available advice suits their circumstances.</p> <p>Difficulty in finding contractors with the skills to enable changing practice.</p>	<p>'It's about creating opportunities for diversity within the forest which allows you to deal with a multitude of different potential outcomes going forward and giving you some spread of risk management in terms of those potential challenges that face you, or won't face me but might face my successors in future years.'</p> <p>'We work on a very different lifetime balance to a tree. A tree will live for 400/500 years, we won't even see the effects of what we're doing now, they'll be left to future generations. We won't see any benefits or adverse reaction to anything in our lifetime.'</p> <p>'It's about good land management... the less stress the tree has the more likely it is to be resilient against acute oak decline. There are certain things I could do, but it is limited.'</p>
Timber producers (20%) Average land holding ~69 ha	<p>Descriptions and potential actions are a combination of resistance (e.g. biosecurity) and adaptive (e.g. diversification species, age class and stand structure) measures.</p> <p>Belief that proper forest management is the best way to manage for resilience.</p> <p>Likely to have a formal woodland management plan which helps plan for resilience.</p>	<p>Focus on avoiding or reducing risk to the crop, and risk of loss of timber value and the financial implications of that. Most willing to act on this issue.</p> <p>Timescales are tied into shorter rotation cycles, so short-term risk perspectives lead to inaction or resistance strategies for conifers.</p> <p>Willing to experiment to test future actions/responses as part of risk mitigation strategy.</p>	<p>Unpredictable and uncertain market demands and timber prices.</p> <p>Uncertainty about future demands of the processing industry.</p> <p>Uncertainty about policy measures and tools, particularly post-Brexit (e.g. grant provision).</p>	<p>'...they keep saying "plant all these exotic species" but it's not backed up by the legislation and the funding, there's no scope for having planting mixtures and things without being financially penalised.'</p> <p>'We know how Sitka performs on certain site conditions, it's fairly reliable, why give that up, you've got to have a good economic reason for not planting Sitka spruce these days, especially with the improved stock around.'</p> <p>'We get in at an appropriate time for thinning, and ensure that maintaining the airflow with regards to those crops is quite critical, you've got to reduce the infection rate.'</p>
Enterprise-focused land managers' (16%) Average land holding ~40 ha	<p>Definitions and potential actions are mainly resistance (e.g. preventive management including novel species, biosecurity and improved thinning regimes) measures.</p> <p>Focus on avoiding risk to the crop.</p> <p>Very likely to have a formal woodland management plan which could help planning for resilience.</p>	<p>Risk is mainly associated with a loss of crop, and the social value and financial implications of that. Most willing to act on this issue.</p> <p>View risk across business portfolio so that woodland risks are balanced against risk of loss in other parts of the business.</p>	<p>Unpredictable and uncertain market demands and pricing for woodland products and services relative to others: will not act if it does not pay to do so.</p> <p>Do not feel available advice suits their circumstances: costs not fully explained.</p>	<p>'My judgement would be to plant single species and the risk may be that we lose the entire crop. Now if my only business was in forestry I might think differently, and the fact is we don't have enough area of woodland to spread the risk.'</p> <p>'No, I suppose the thing is, because the forestry provides such a small proportion of our income, the risks involved to us are not very significant to the overall business. Obviously if we were just in the business of forestry I would be a lot more concerned about the risks of climate change and how they would impact.'</p>

Table 1 (continued).

Land manager segment (% of sample)	Decision-making factors			Exemplary quotes
	Understanding of resilience	Perspectives on risk	Barriers to action	
Ecocentric managers ² (14%) Average land holding ~6 ha	Descriptions and potential actions consist of recovery and adaptive approaches (e.g. promoting natural regeneration). Belief in ecological processes over efficacy of human action in finding resilient forest composition and structure.	Resilience not framed as risk management but as the natural capability of forest to survive and adapt. Risk framed as long-term risk to woodland within the landscape, the risks of acting or not acting are therefore difficult to judge.	Uncertainty about the right thing to do and conflicting advice leads to inaction. Would rather not act than do the wrong thing. See natural processes as adaptive change agent rather than themselves, so uncertain about the efficacy of changing practice. Do not feel available advice addresses their approach to woodland management.	'I don't see what plans I can make for the wood until I know how it affects it, and that doesn't worry me because I always think that woods' timescale is very different from mine.' 'I'm a great believer in letting nature take its course, so we'll adapt to any changes taking place rather than trying to influence changes.' 'I do believe in resilience, I believe more in the regeneration of the wood, to adapt to what's happening around it, so we act to encourage regeneration.'
Individualists ³ (9%) Average land holding ~10 ha	Combination of resistance measures (e.g. pest control and biosecurity, genetically resistant tree species/cultivars) and transformation approaches (e.g. changing land use into/out of forestry).	Views of risk differ. May not believe in climate/environmental change so may perceive little risk.	Focus on immediate threats, not long-term or diffuse threats. Do not feel it is necessary/or they have no efficacy for acting (e.g. against climate change).	'Climate change has been so much wetter that trees are thriving really. I don't feel that the climate change, I do believe that climate change is a real thing but I don't particularly feel either of my woods are currently at risk. Squirrels are the real threat in the Midlands.'

1. 'Profit-seeking guardians' in Eves *et al.* (2015) model 2. 'Disengaged Conservationists' in Eves *et al.* (2015) model 3. 'Aspiring manager' in Eves *et al.* (2015) model

empirical data clearly showed a very high degree of uncertainty and variability as to what resilience means in terms of detailed, practical and applied silvicultural and woodland management. Land managers generally linked resilience to adaptation. They did not talk about the components of transformation, resistance and recovery in explicit terms.

There was minimal evidence to suggest that managers were able to articulate which aspects of their woodland needed to be resilient. All land managers were able to describe what they believed their woodlands needed to be resilient against. The pressures that land managers recognised were primarily ecological and environmental. There was little recognition of the socio-economic dimensions of resilience, other than those links which timber producers, enterprise-focused managers and some multifunctional managers made to markets and the financial value of timber crops. As to who resilience was for was largely considered to be a matter related to the individual objectives of woodland owners and land managers. In the case of timber producers, enterprise-focused managers and some multifunctional managers, resilience was about realising personal and business objectives for income generation. In the case of ecocentric managers, some enterprise-focused managers and some multifunctional managers, resilience concerned realising their objectives for conservation of

woodland biodiversity and natural heritage, benefiting environment and society.

Resilience measures and actions undertaken or considered

Strong sets of beliefs about woodland management approaches emerged for three of the land manager segments. Multifunctional managers spoke of good husbandry as the way to ensuring the resilience of individual trees and thus of woodlands (Figure 2). Providing the best conditions for trees to thrive, for example by reducing stress, was therefore expected to confer resilience. Timber producers were clear that proper forestry, that is following commercial silvicultural prescriptions to reach yield class potentials and maintain stand health, would confer resilience. Ecocentric managers held strong views about 'nature taking its course', believing that ecological processes rather than the actions of forest managers are the main drivers of adaptation most likely to result in resilient forests and woodlands. Beliefs regarding resilience had an influence on the decisions which managers made about practical measures already being taken, or which they would consider applying.

Table 1 lists the actions which different types of woodland owners and managers mentioned knowing, were willing to

Figure 2 Multifunctional managers spoke of good husbandry. Horse logging may help on sensitive sites.



apply, or were already using. To summarise, these were dominated by perceived risks from pests and diseases, and by the concept of diversification as follows:

- Adaptation actions, the most prominent of which were diversifying species choice in response to experienced and projected climate change, and diversifying stand structure, age and composition in response to perceived risks from pests and diseases. These actions were mentioned most often by multi-functional managers, timber producers and ecocentric managers.
- Resistance actions, the most prominent of which were those taken in response to perceived risks of pests and diseases, including the application of pest control measures and biosecurity (Figure 3), practising modified thinning regimes, planting with different strains/provenances of the same species, or choosing genetically tolerant trees. These actions were most frequently mentioned by timber producers and enterprise-focused managers.
- Recovery actions were mentioned less frequently, but these were responses to perceived risks from climate change, pests and diseases, and focused on replanting with different provenances or strains of the same species, or using natural regeneration from existing seed trees. These actions were mentioned by multifunctional managers and ecocentric managers.

Barriers to changing behaviour

The qualitative data suggested that two important factors created or reinforced barriers to changing management practice (i.e. behaviour); these were:

Figure 3 The application of pest control measures and biosecurity. Forest workers inspecting a sticky trap for signs of Pine Looper moth.



- (i) How land managers perceived risk and uncertainty in their decision-making, and their responses to those risks and uncertainties.
- (ii) The amount of information and knowledge which land managers had in order to be able to mediate their uncertainty and implement particular measures.

Perceptions of risk and management responses

Timber producers and enterprise-focused managers perceive risk in terms of the financial implications of any loss of value from their crops, and the risk of not producing what the market or value chain demands at a given time. Their time horizons were generally tied in with shorter rotation lengths of 35–55 years. This altered the way they balanced the costs and benefits of taking action or not. Within these segments some managers were willing to trade-off the uncertainty of changing practice for returns over the medium or longer term with the perceived level of risk associated with doing nothing, and still realising a return from the crop over the shorter term. Indeed, even if managers in these segments felt that action to improve the resilience of their forests might be necessary in principle, the financial costs of implementing measures for resilience, for example pest control or modified thinning, only made economic sense when there was clear added value to the likely end product. It was interesting to discover that across timber producers and enterprise-focused managers, around 35% mentioned conducting experiments with informal small scale test areas of novel species as a way to better observe possible suitability, performance and risks.

Multifunctional managers and ecocentric managers generally dealt with longer planning horizons associated with the broadleaves, which are an important component of their

woodlands. Multifunctional managers focused on two areas of risk: (i) the shorter term immediate risks of known threats, particularly pests and diseases; and (ii) the longer term risks of not practising good husbandry to address the largely unknown and uncertain future environmental and financial pressures acting on their forest resource. In their view, long-term risks were associated with applying adaptation and recovery approaches to resilience, in particular increasing the diversity of species, stand structure and function to increase biodiversity and also reduce stress on individual trees. Some multifunctional managers reported being concerned about the financial risks presented by loss of trees for timber and other products, but this was not a predominant concern for the segment as a whole. Many managers in this segment spoke of their fears of not implementing the right management and not having the right kind of information to facilitate changing practice. This concern was particularly strong when it came to assessing the best adaptation measures to ensure multiple benefits would continue to be provided over a long time horizon. Around 18% of the multifunctional managers mentioned planting small areas to test new species and species mixes in their woodlands (Figure 4).

Ecocentric managers did not describe risk as something they needed to proactively manage. For the majority, their belief in natural processes as the driver of change and adaptation meant they felt that woodland would survive and adapt to ecological and socio-economic pressures regardless of their actions. They did not seem to have a clear sense of why action by them might be necessary, and what difference they might make to the resilience of their woodland over longer time perspectives. In addition, ecocentric managers worried about the best action to take to support natural processes. There was considerable evidence that ecocentric managers monitor the changes in their woodlands very closely.

Figure 4 A small patch of improved sessile oak from the Loire Valley, experimenting for adaption to climate change in Hampshire.



Information, knowledge and communication needs

Most land managers felt that managing for resilience requires some specialist knowledge. This was less true for some ecocentric managers who felt that natural processes would drive forward adaptation regardless of human action. Timber producers and some enterprise-focused managers felt relatively well informed. Other respondents felt that the needs of non-professional woodland owners and owners of small woodland were largely overlooked. There was also a feeling that new research and advice was not translated into a form which land managers could usefully apply.

To overcome areas of uncertainty and increase confidence levels to the point at which they might take action, land managers wanted:

- **Information to explain and justify the need to manage for resilience**, that is, an overview of resilience issues, climate change projections and documents explaining why there is a need for change, how urgent this is, and what effect individuals can have. This was important for all land managers but particularly multifunctional managers and ecocentric managers not necessarily convinced that they should be acting to address resilience in their woodlands.
- An outlay of the **broadest set of silvicultural options** for resilience and how to assess which is best for a particular type of manager to adopt, as well as which is best to deploy for a particular type of woodland.
- Appropriate response **strategies for tree pests and diseases** and how to assess which is best for a particular type of manager to adopt, as well as which is best to deploy for a particular type of woodland.
- **Information about the financial aspects of various resilience approaches**: timber producers, enterprise-focused managers and multifunctional managers stated that one of the barriers to changing practice is the lack of knowledge which they can access about the financial costs of adaptation approaches to resilience. Enterprise-focused managers and multifunctional managers also wanted to understand more about how to assess the impact of changing tree species and their diversification on the value of the land and potential future revenue from timber/firewood. Timber producers wanted to better understand the business costs and benefits of either taking action or not.
- Information to help understand **timescales and required lead times** in order to make appropriate changes to forest management.

- Guidance regarding how to **integrate resilience approaches** into woodland management planning.

Conclusions

This Research Note has explored several of the factors key to land managers' decision-making and behaviours in the context of forest resilience. The application of a segmentation model has successfully demonstrated differences and similarities between groups of land managers, and revealed three broad management approaches to which particular segments subscribe. These approaches, namely 'proper forest management', 'good land husbandry' and 'let nature take its course' incorporate different woodland management objectives, different beliefs, planning timescales, risk perceptions and response to uncertainty. This reflects other research outlining the importance of understanding such cognitive models if policy formulations and communication strategies are to effectively engage with managers of private woodland (see, for example, Feliciano *et al.*, 2017).

This means that messages about resilience, and the way information and advice is framed, packaged and communicated, needs to be tailored to different types of land managers. There is no 'one size fits all' knowledge sharing and communication strategy. Advice and communication needs to speak to the interests and beliefs of different types of managers, and should also address their specific approaches to woodland management, perceptions of risk, and specific barriers to management action. For example, advice to ecocentric managers needs to build on their belief in the primacy of ecological process, and show how they can work with these to confer greater resilience.

Efficacy, that is, how far managers feel that they can affect or influence change (Oakes *et al.*, 2016, Sousa-Silva *et al.*, 2016), is fundamental to managers acting for resilience, and linked to this is their desire to do the right thing rather than implement actions which may have uncertain, unintended or negative consequences. It is important for advice and information to present flexible or 'no regret options' that can accommodate perceived and inherent uncertainties, and also the need to change the management approach if new information appears or new threats emerge. It is also important for forestry organisations to support moves towards adaptive management and 'learning-by-doing' approaches which encourage managers to try and test new resilient actions and practices, and then monitor and react to the results. There is an obvious need to describe and disseminate information about a far wider range of measures in response to perceived risks and pressures than is currently the case. Many of these require less technical expertise and are less drastic or costly when compared to the most widely recognised adaptation measure, that is, by changing species.

We have demonstrated that resilience thinking is already embedded in forest decision-making to some degree across different types of forest owners and land managers. However, an uptake of management actions supporting resilient forests is still developing. Therefore, the research and practice community should communicate information about forest resilience to different types of woodland owners and managers in a way that is tailored to their particular characteristics.

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