

# Differentiating between land managers for understanding of “resilience”, and factors influencing decision making

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## Acknowledgements

This report has been prepared as an output for Programme 3 in Forestry Commission's Science and Innovation Strategy 2015-2019. The research described was co-ordinated by Dr Bianca Ambrose-Oji, but also involved collaboration and inputs from colleagues within Forest Research, and with other sector partners.

The authors would like to acknowledge Dr Gabriel Hemery, Sylva Foundation and Dr Gillian Petrokofsky, University of Oxford as the lead organisers and co-ordinators of the British Woodlands Survey 2015 (BWS2015), and the British Woodlands Survey 2017 (BWS2017). BWS2015 was a collaborative project between Sylva, University of Oxford, Forestry Commission England and The Woodland Trust. BWS2017 was a collaborative project between Sylva, University of Oxford, Forest Research and The Woodland Trust, led by Sylva with support from the Scottish Forestry Trust, and Forestry Commission Scotland.

Collaborative working with Sylva Foundation and Oxford University led to the extended analysis of the BWS2015 data, and qualitative research material from workshops organised as part of the BWS2017 development process.

Dr Jack Forster undertook the extended statistical analysis of the BWS2015 dataset.

Dr Suzanne Raum undertook some of the interviews with land managers.

Thanks are extended to all the individuals – private woodland managers, agents and others - who shared information in the research interviews and during the workshops.

An **appropriate citation** for this report is:

Ambrose-Oji, B., Atkinson, G., Pecurul-Botines, M., Petr, M., 2018, *Differentiating between land managers for understanding of "resilience", and factors influencing decision making*, Forest Research, Farnham, Surrey.

# Contents

<b>Executive summary</b> .....	<b>iii</b>
<b>1. Introduction</b> .....	<b>1</b>
1.1. Linking resilience concepts with land manager decision making .....	2
<b>2. Method</b> .....	<b>6</b>
2.1. Rapid Evidence Assessment .....	6
2.2. Additional analysis of the British Woodlands Survey 2015 dataset .....	7
2.3. Semi-structured interviews .....	8
2.4. Narrative evidence from workshops involving owners and managers.....	8
<b>3. Results</b> .....	<b>9</b>
3.1. Differentiating between land managers .....	10
3.2. Differentiating resilience perceptions and behaviours .....	11
3.3. Differentiating land managers and their understanding of resilience.....	12
3.4. Confirming a segmentation model .....	14
3.5. Insights from the empirical data.....	16
3.6. Barriers to changing practice .....	20
3.7. Perceptions of risk and management responses .....	21
3.8. Information, knowledge and communication needs.....	23
<b>4. Conclusions</b> .....	<b>25</b>
4.1. Understanding resilience .....	26
4.2. Resilient Practice .....	26
4.3. Barriers to action: Belief, knowledge, risk perception and confidence to act .....	27
4.4. Signposting information .....	28
<b>5. References</b> .....	<b>33</b>

## List of Figures

Figure 1. Influences on land manager decision-making affecting resilience outcomes .....	5
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## List of Tables

Table 1. SPICE framework and key words structuring evidence review .....	7
Table 2. Workshop participants by type and country .....	9
Table 3. Characteristics of the land managers interviewed applying a refined Eves <i>et al.</i> (2015) segmentation model.....	15
Table 4. UK land managers understanding of resilience and decision making factors differentiated using a modified segmentation model derived from Eves <i>et al.</i> (2015a) ..	17
Table 5. Signposting information about resilience issues of concern to different kinds of land manager .....	30

## Executive summary

Government policy in all countries of the UK seeks to encourage private land owners, both commercial and non-commercial, to implement resilient management of their forests and woodlands. However, the acceptance and uptake of resilient forestry practice presents a number of significant challenges to different kinds of woodland owners and managers. Research that can explain differences in owner/manager understandings of resilience and how this links with their management behaviours can provide an important insight in how best to influence their practice in the short (i.e. next 10 years) and medium (i.e. next 50 years) term. This Research Report details an investigation aiming to do this by addressing the following questions:

- 1 Do woodland owners/managers in the UK recognise and understand the concept of “resilience”? If so how?
- 2 What resilient practices are woodland managers aware of, or already undertaking?
- 3 What barriers might prevent woodland managers implementing measures to support resilience?

An evidence review, a national (UK) survey, workshops and semi-structured interviews with woodland owners and managers provide the evidence. These different data sources were synthesised and demonstrate how different types of owners and managers conceive of resilience in different ways depending on their management objectives, their understanding of forest ecology, and their interpretations and approaches to managing risk.

The review suggests that the key factors affecting land owner and manager behaviour in the context of resilience and resilient practice, are:

- their knowledge, information and understanding of forest resilience concepts and processes
- how these ideas relate to their woodland and forestry objectives
- their perceptions of the actual risks to their own forests
- their belief in their own capability to, and the likely effectiveness of their actions to manage risks (i.e. efficacy)
- the influence of peer social networks and communication
- the importance of a supportive economic, policy and legislative context in facilitating behaviour change.

An important issue to come through from the Rapid Evidence Assessment (REA) was the stress placed on characterising land managers as a way to manage the diversity and heterogeneity amongst them, and create a method for effectively analysing differences and similarities amongst groups that share attitudes, values, motivations and objectives.

Using land manager typologies or segmentation models in this way, has been successfully used to explore particular questions that better target policy development, legislation, and information and support aimed at particular kinds of land managers.

An adapted segmentation model (based on work by Eves *et al.* 2015) was successfully applied to the primary data, and demonstrated woodland owners and managers could be understood as: Multifunctional Managers, Timber Producers, Enterprise Focused Managers, Eco-centric Managers and Individualists. Land managers in each segment within this model were shown to have different understandings of resilience, different perceptions of risk and efficacy, and different approaches to woodland management, all of which structured the kind of information they found useful and legitimate and were willing to act on.

The majority of land managers recognise the word “resilience”. Regardless of segment membership, the word was generally understood to be about the sustainable management of forests and woodlands. The only component of resilience commonly discussed in explicit terms is adaptation. There is little explicit discussion of resistance, recovery and transformation. There is also little evidence that managers are clearly able to articulate detail about which aspects of their woodland need to be resilient. Land managers could however, clearly identify threats to their woodland from climate change factors and from tree pests and diseases. There was greater discussion and recognition of the environmental and ecological influences on resilience than the economic and social pressures.

The issue of whom resilience was for was largely linked to land managers’ own objectives. In the case of Timber Producers, Enterprise Focused Managers and some Multifunctional Managers resilience was linked with income generation. In the case of Eco-centric Managers, some Enterprise Focused Managers and some Multifunctional Managers it was also associated with their objectives for conservation of woodland biodiversity and natural heritage.

There are some clear differences in the approaches to management for resilience amongst the different land manager types affecting their decisions about which measures and practices they might adopt. Multifunctional Managers spoke of ‘good husbandry’, whilst Timber Producers referred to ‘proper forestry’, and Eco-centric Managers’ held that ‘ecological processes rather than actions’ were required.

The empirical evidence shows that there are specific resilience issues woodland managers and owners feel they need more information about, specifically:

- An explanation and justification of the need to manage for resilience, i.e. an overview of resilience issues, climate change projections and other material explaining why there is a need for change, how urgent this is, and what effect individuals can have by changing their practice

- An outline of the broadest set of silvicultural options for resilience and how to assess which is best adopted by a particular manager, as well as for a particular type of woodland
- Appropriate response strategies for tree pests and diseases and how to assess which is best for a particular manager and a particular type of woodland
- Information about the financial and economic aspects of implementing resilience measures
- Clear guidance about time scales and required lead time to make appropriate changes to forest management
- How to integrate resilience approaches into woodland management planning in the short and medium term.

Applying the segmentation model revealed three broad management approaches amongst groups of owners which 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” or “world views” if policy formulations and communication strategies are to effectively engage with managers of private woodland (see, for example, Feliciano *et al.*, 2017). It means that information and advice needs to be framed, packaged and communicated in ways that are tailored to specific types of woodland owners and managers. For example, advice to Eco-centric 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. It also means that different owners and managers will have confidence in, and recognise the legitimacy of, information sourced from a variety of organisations.

Furthermore, a desire to “do the right thing”, tempered with uncertainty and a fear of doing the wrong thing by acting on poor advice, leads many owners and managers to inaction. It is important for advice and information to present flexible or “no regret options” that can accommodate perceived uncertainties or the need to change approach if new information or new threats emerge.

The report ends by providing links to existing information and resources according to these issues and approaches, to signpost which existing resources produced by the Forestry Commission, Forest Research and other sector organisations might be of interest to different types of land managers.

# Differentiating between land managers for understanding of “resilience”, and factors influencing decision making

## 1. Introduction

In Britain concern about the sustainability of forests and woodlands has recently been heightened by the increasing incidence of tree pests and diseases such as *Phytophthora ramorum* and Chalara dieback of ash (*Hymenoscyphus fraxineus*), environmental stresses such as pollutant deposition, along with the increase in occurrence of extreme events, e.g. high winds, periods of summer drought or winter flooding, which have been linked to climate change (Read *et al.*, 2009, UK Government, 2013).

As a result, the concept of forest resilience has become prominent in forestry policy, research and practice as a response to these issues. Resilience is included within agreements at a global level, (e.g. United Nations Framework Convention on Climate Change (UNFCCC) Paris agreement in 2015 which aims to work against forest ecosystem vulnerability by building resilience through adaptation), and a European level, (e.g. commitments to protection of forests and their stability, resistance, regenerative and adaptive capability in a changing climate by signatories to Forest Europe, Madrid, 2015). A European level working group has begun to explore adaptive forest management strategies, practices and tools leading to forest resilience as a practical response to realising policy aims improving the outlook for forests in Europe (Lindner, 2017). The consensus across leading UK forestry sector organisations is that positive action is required in support of more resilient woodlands. In 2015 more than 30 organisations signed the Climate Change Accord, ‘A call for resilient forests, woods and trees’ (Climate Change Accord, 2015). It states:

*We believe that it is necessary to act now to provide a secure future for our forests, woods and trees, that significant changes are required to widely-accepted and practiced systems of management to make them resilient, and we are committed to help realise the vision set out in this Accord.*

In the same year, the 2015 British Woodlands Survey revealed that the current resilience of the UK’s forests was poor. Results from the survey identified a need for

clearer communication of risk to stakeholders, and guidance on addressing these risks. Developing scientific understanding of resilience related to the silviculture, management and ecology of forests and woodlands<sup>1</sup> should help to respond to projected and experienced challenges. However, it is only recently becoming clear what forest resilience means in either theoretical or in practical terms (Benson and Garmestani, 2011, Fuller and Quine, 2016, Newton and Cantarello, 2015, Rist and Moen, 2013). In a general sense the resilience of woodlands has been shown to be linked with the adaptive capacity of species, habitats and silvicultural regimes to respond to environmental changes (Bone *et al.*, 2016). By contrast, many forest policies, particularly those related to tree health and biosecurity emphasize the use of technology and management prescriptions to prevent and control invasive species and other forestry conditions, which closely links resilience to resistance rather than adaptive strategies (Potter and Urquhart, 2017). Furthermore, the issues of temporal scale (i.e. short, medium and long term) and spatial scale (i.e. species, forest stand, landscape) mean that translation of general concepts into practical prescriptions presents particular challenges. Recent work by Bellamy *et al.* (2018), focuses on an exploration of the ecological resilience of woodland ecosystems, linking woodland and environmental characteristics with positive influences on biodiversity that support resilience across a range of scales. Bellamy *et al.* (2018) take this one step further and go on to include a brief summary of the implications for woodland management actions and practice. By and large the provision of explicit advice for land managers that encapsulates these multiple dimensions of resilience remains limited.

## 1.1. Linking resilience concepts with land manager decision making

It is clear that how the concept of resilience is understood and then communicated by scientists, policy makers, stakeholders and land managers is critically important. How resilience science is translated into practical recommendations and how this is described and presented is likely to shape response strategies and management practices of woodland owners and land managers in different ways.

Fuller and Quine (2016) make the point that differences in approaches to understanding resilience in a forestry context by scientists, policy makers and others mean that the concept is not only complex, but no single definition of resilience is really sufficient, nor easy to communicate. Definitions are commonly structured by the ecological context, by forest type and characteristics, and by the spatial and temporal scale being considered. They go on to say that resilience is better defined by forest and woodland managers

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<sup>1</sup> A distinction is often made between 'forests' and 'woodlands', where forests are understood to be larger, denser areas of often coniferous species of trees, compared with woodlands which are smaller, more open and more often contain broadleaved or mixed broadleaves and conifer species. The terms are used interchangeably in this report because the owners and managers interviewed discussed their understanding of resilience as it relates to their management of larger plantations as well as smaller woodlands.



*themselves*, because they are best able to refer to their specific forest system, the specific scale they operate at, and understand the important environmental and socio-economic issues influencing their particular woodland. Even though the issues of time and spatial scale in resilience responses are highlighted as being particularly important, the focus of Fuller and Quine (2016) remains at the stand or woodland scale. Working through resilience issues at the scale of woodland components (e.g. species), woodland holdings (i.e. woodland blocks or management units), and the landscape remains problematic (cf Bellamy *et al.* 2018). Bone *et al.* (2016) present similar views to Fuller and Quine (2016), but recognise the need to clearly define scale, and woodland components, and emphasise that forest managers need to be very clear about what aspects of their forest need to be resilient, what these need to be resilient against, and for whom this resilience is important.

Fuller and Quine (2016) suggest four different components of resilience that forest managers will need to take into account in their decision making, which are:

- **Resistance:** Management that introduces or improves defenses in an attempt to withstand adverse conditions, e.g. work to stop or to slow the establishment of, or to eradicate, invasive species or forest pests and diseases.
- **Recovery:** Management that enables the ecosystem to return to a healthy, normal state after a disturbance; e.g. regenerating a stand after wind throw in an attempt to maintain relatively similar conditions to before the disturbance.
- **Adaptation:** Management actions that facilitate and assist the ecosystem to adjust to new conditions and allow the forest to respond to changing conditions, but which work to keep the forest in place, e.g. diversify species composition and age structure of a forest, change the species mix or silvicultural system of a stand subject to windthrow.
- **Transformation:** Facilitating dramatic change in form, appearance or character of a forest ecosystem or transforming forest to a different ecosystem, e.g. putting in place an alternative land use for instance changing from upland forest to open heathland, or from woodland to housing development.

Which of these four components of resilience a forest owner or manager might pursue, and how they might mix or balance these in their management approach is subject to a wide range of different factors that feed into their decision making. Dandy (2012) has already shown the complexity of the contributing factors involved in land managers decision making. This includes assessment of the potential of their woodland to provide specific products, services and benefits in line with their management objectives, as well as the influence of other external factors such as market conditions and availability of labour.

In terms of decision making around resilience, in an ideal world land managers will be taking account of all or most of the pressures acting on their woodlands that impact on resilience. These pressures might be environmental and ecological, but may also

emanate from the human, social and economic context. They might be pressures which act over the long term, e.g. temperature increases, changing societal values such as the increasing demand for access to woodland for recreation, or shorter pulse events, e.g. storms, or a sudden drop in market prices for timber.

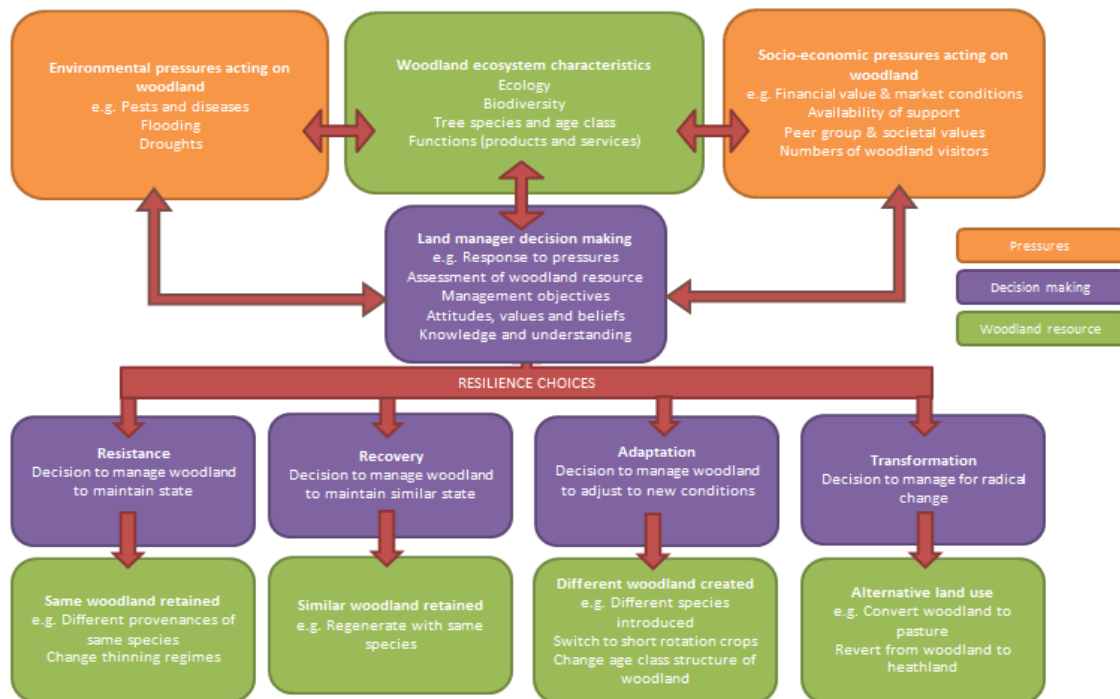
Amongst the human and social pressures will also be factors internal to the land manager, not only their more obvious management objectives, but their knowledge, their values and beliefs. A significant influence on decision making will be land manager beliefs about climate change; what if any threats are perceived to be important to their woodlands; their knowledge about forestry and woodland management and the concept of resilience; their ability and capacity to stay up to date with any advances in research and advice; and their ability to interpret and apply this.

Equally important is the *interplay* between knowledge, values and belief. Some beliefs around resilience issues are particularly powerful. For example, a study of private forest owners across Europe (Blennow *et al.* 2012) reported that a model of adaptation to climate change based on two personal variables had significantly higher predictive power than several variables related to structural information. The two variables “strength of belief in local effects of climate change” and “strength of belief in having perceived climate change” almost completely explained measures taken to adapt forest management to climate change. The authors concluded that “*when forest owners believe in, and see the effects of climate change they are more likely to take measures to adapt to climate change*”. Factors external to land managers but impacting on their perspectives may include social and cultural factors such as, family, neighbours’, communities’ and the public’s expectations about woodland access for recreation, habitat provision for wildlife or landscape aesthetics. Economic factors include local demand for the production of particular products and services, alongside judgements about access to investment support, timber prices and expectations that historic timber yields and productivity will continue into the future. These factors each have a role in how land managers assess and react to the pressures acting on themselves and their woodland, and the type and intensity of management action and woodland practice they opt to adopt (Blennow *et al.*, 2012, Dandy, 2012, Dandy, 2016, Karppinen, 2005, Karppinen and Berghäll, 2015, Novais and Canadas, 2010, Wilson *et al.*, 2011).

Figure 1 presents a conceptual summary of these influences acting on land managers and their decision making process, and shows the different resilience outcomes that may come about as a result.

This figure draws attention to the key focus of this Research Report which is understanding more about land manager decision making around resilience, i.e. the central box in the summary diagram. Of particular interest is land managers’ knowledge and understanding of resilience, and how this is incorporated with the other components of their decision making, including assessment and response to the pressures acting on their woodland, i.e. the driving pressures on either side at the top of the diagram.

**Figure 1. Influences on land manager decision-making affecting resilience outcomes**



The research reported here focuses on private owners and managers of woodlands and forests. Forest and woodland ownership in Britain reflects the situation over much of Europe and North America where the majority, around three quarters by area, is owned and managed by private owners (Forestry Commission, 2017). Most of these private holdings, around 90%, are below 10 hectares in size (Forest Europe, 2015). There is a clear relationship between ownership and the quality, structure and function of forests (Lidestav *et al.*, 2017). In Britain small privately owned woodlands have diverse functions, and there is a general perception that many of these smaller woodlands are undermanaged and therefore of poorer quality and more likely to be vulnerable to the socio-ecological pressures acting on woodland (Forestry Commission, 2012). In other words, smaller privately owned and undermanaged woodlands are less resilient and as these make up a significant proportion of total woodland cover this is a significant concern. Consequently, the promotion of forest resilience as a key policy aim means it is crucially important to understand how private land managers, particularly owners of small woodlands, understand and perceive forest resilience. Better understanding of land owners' views could help to identify strategies and mechanisms that facilitate their management practice and help build forest resilience.

Whilst there is some research exploring the socio-economic drivers of change acting on woodlands, how these pressures are factored in to land manager decision making and their actual behaviour, and whether land owners think about resilience at all, and if or how they incorporate such concepts into their decision making processes is very poorly evidenced or understood (Lawrence and Gillet, 2011, Quine *et al.*, 2012). There is

limited evidence specifically exploring what encourages resilient practice amongst managers, or what challenges and barriers they may experience in implementing more resilient woodland management practice and behaviours.

The social research described in this Research Report aimed to fill this gap by undertaking an evidence review, as well as primary and secondary empirical research to investigate the following questions:

- 1 Do woodland owners/managers in the UK recognise and understand the concept of “resilience”? If so how?
- 2 What resilient practices are woodland managers aware of, or already undertaking?
- 3 What barriers might prevent woodland managers implementing measures to support resilience?

## 2. Method

The research synthesised findings from four sets of evidence and empirical data, as follows:

- i Rapid Evidence Assessment of published evidence about land manager understanding of forest resilience and decision making in Britain, Europe and North America.
- ii An extended analysis of the British Woodlands Survey 2015 dataset, using data from 1,009 woodland owners and managers.
- iii Qualitative primary data from semi-structured interviews conducted with 44 individuals representing different types of private woodland and forest owners and managers across Britain between autumn 2016 and summer 2017.
- iv Qualitative primary data in the form of narrative evidence collected at five workshops involving more than 50 woodland owners, land managers and other forestry stakeholders involved in the development of the British Woodlands Survey 2017.

### 2.1. Rapid Evidence Assessment

A Rapid Evidence Assessment (REA) was undertaken to search for relevant published<sup>2</sup> material: An REA is a systematic method developed to review and synthesise evidence to answer specific questions in public policy research (Government Social Research, 2010). A set of key words related to the research questions was generated following the systematic SPICE conceptual framework (Booth and Brice, 2004, Booth, 2006). This was used to search academic journals and other documents via Science Direct, Scopus and

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<sup>2</sup> i.e. predominantly journal articles and a limited number of significant reports published on websites of bone fide organisations referenced by Google Scholar

Google Scholar to locate evidence published in the last fifteen years, and which related to the UK, Europe and North America (see Table 1). The search was undertaken twice, once in August 2016 and again in November 2017, and yielded 78 studies with evidence directly related to the three research questions. These studies were used to develop the interview guides, data coding and interpretation frameworks.

**Table 1. SPICE framework and key words structuring evidence review**

Setting	Population/Perspective	Interest	Comparison	Evaluation (measure)
forest* (i.e. to cover forest, forests, forestry)	farm* (to cover farmer, farmland, farm, farming)	resilien* (to cover resilience, resilient)	Climate change	attitude*
wood* (i.e. to cover wood, woods, woodland)	owner	adapt* (to cover adapt, adaptation, adaptations)	Pest*	motivation*
silvicultur* (to cover silviculture, silvicultural)	manager	uncertainty	Disease*	perception*
	business	risk	Flooding	objective*
	estate		Wind* (to cover windy, windiness, wind blow)	behaviour
				management
				practice
An example search expression would be: ((forest* OR wood* OR silvicultur*) AND (resilien* OR adapt* OR uncertainty OR risk)) coupled with combinations of the remaining words, which might be used within results of the search using the initial expression				

## 2.2. Additional analysis of the British Woodlands Survey 2015 dataset

The British Woodlands Survey 2015 (BWS2015) used an on-line questionnaire to explore private woodland owners'/managers', awareness, action and aspiration relating to environmental change and aspects of resilience. The survey was framed around the adaptation elements of the UK Forestry Standard (UKFS), and asked private woodland owners; forestry agents, other tree and forestry professionals (e.g. NGO staff, forestry contractors) and tree nursery businesses about their intended and actual behaviours relating to resilience. Responses were received from across the whole of the UK: A total of 1509 individuals responded to the survey including: 827 private woodland owners; 182 forestry agents; 235 other tree and forestry professionals. The results of the survey were published as a report (Hemery *et al.*, 2015).

Additional statistical analyses were undertaken on a subset of this dataset which isolated the 1,009 owners and forestry agents who manage woodland. In this subset most private woodland owners were located in England, while agents proportionally represented more properties than owners in Scotland and Wales. The respondents

represented an area of woodland, managed by owners or their agents, covering 247,891 ha; equal to 11% of all privately-owned woodlands in the UK. The R statistical programme functions were used to test for: associations between owner/manager motivations, woodland size class and woodland type; and differences in understanding of resilience and implementation of resilient practice between different kinds of owners/managers (a full report of the analyses and tests applied is given in Forster, 2016).

### 2.3. Semi-structured interviews

A total of 44 semi-structured interviews were conducted with woodland owners and managers over the telephone. The majority of interviewees were recruited using a database of respondents who stated they were willing to take part in further research about woodland resilience as a follow-on from participation in BWS2015. Key information about each of the respondents collected as part of BWS2015 allowed the sample to be codified using the segmentation model for woodland managers developed by Eves et al. (2015a). Some of this data answered six of the “golden questions” i.e. the key variables which explained Eves et al.’s segmentation model. Interviewees were selected according to country location, and by their inferred segment membership. This membership was based on 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 semi structured interviews were undertaken between August 2016 and January 2017 and explored with respondents: their management objectives and forestry background; their understanding of resilience and any translation of this knowledge into practice; and what measures or information sources influenced their perceptions and their behaviour, including their social networks and knowledge sources. The interviews lasted between 40 minutes and 2 hours and were digitally recorded and transcribed verbatim, then coded in Nvivo using a coding framework. Two different researchers coded the data. Consistency of interpretation between researchers was tested, and returned a Kappa value of >0.7 which was considered an acceptable level of consistency. Queries were generated in Nvivo to discover patterns in perceptions, understandings and behaviour common to the land owner and land manager groupings in the segmentation model.

### 2.4. Narrative evidence from workshops involving owners and managers

Five workshops across England, Scotland and Wales were organised in partnership with the Sylva Foundation and Oxford University as part of the 360 degree research and consultation process that was used to develop the next in the series of British Woodlands Surveys, i.e. BWS2017 (Hemery et al., 2018). Active listening (Given, 2008) was undertaken at these workshops to collect additional evidence about owners/managers

understanding of resilience and their associated behaviours. Active listening is a technique used in psychology and behavioural sciences, and aims to focus on the speaker in a research encounter, accurately hearing and interpreting their verbal and nonverbal communication. Using participant observation and close listening to the content and meaning of conversations, the active listener records key themes and phrases against a predefined set of questions (Given, 2008). Active listening data were collected by a team of between four and six researchers at the 360 degree workshops held between February and July 2017. The active listening notes recorded the emerging themes amongst different kinds of land managers, distinguishing between which type of participant expressed particular views. The active listening notes were coded for key phrases and concepts using Nvivo and following a coding framework related to the research questions. The land manager and land owner sample in this qualitative dataset was 25, and representatives from organisations representing land owners and managers was 11 (see Table 2).

A full analysis of the information needs of the workshop participants from this dataset is reported in (Atkinson and Ambrose- Oji, 2017).

**Table 2. Workshop participants by type and country**

	England	Scotland	Wales	TOTAL
Woodland owners	7	4	3	14
Forestry managers and businesses	6	2	3	11
Sector organisations	5	3	3	11
Government	1	1	2	4
Researchers	1	2	2	5
Other	1	1	1	3
<b>TOTAL</b>	<b>21</b>	<b>13</b>	<b>14</b>	<b>48</b>

## 3. Results

The following sections report on the results of the different elements of the research beginning first with the evidence review investigating factors influencing land manager decision making and their understanding of resilience, and how these might affect their forestry management practice and behaviours.

The empirical research including the interview data, data from the land manager workshops and the additional BWS 2015 data analyses are then used to explore the following research questions:

- 1 What do woodland owners and managers in Britain know and understand about resilience according to land manager type (i.e. segment)?
- 2 What management actions are different types of land managers (i.e. segments) already implementing or what would they consider doing to manage for resilience?

And the final section reports on research question 3 looking at the main barriers to changing practice experienced by different types of land manager. These results are organised following the two key themes which emerged from the data, i.e. barriers related to:

- 3.a How perceptions of risk influences decision making and management responses.
- 3.b The importance of knowledge and information related to land managers understanding of forestry and forest resilience to their decision making.

### 3.1. Differentiating between land managers

The evidence reviewed in the REA stresses the need to distinguish between different kinds of land owners and managers when considering their decision making because land managers differ greatly in their personal characteristics, and the forestry context in which they operate. Research clearly documents the differences between private owners' behaviour and practice which is related to their varying individual objectives, motivations, attitudes and knowledge as much as the different kinds of woodland and forest they manage (see for example Blanco *et al.*, 2015, Feliciano *et al.*, 2017, Ficko and Boncina, 2013, Ficko *et al.*, 2017, Finley and Kittredge Jr, 2006, Finley *et al.*, 2006, Hallikainen *et al.*, 2010, Ingemarson *et al.*, 2006, Lidestav *et al.*, 2017). The existing studies have used a variety of methods to differentiate between land managers, the most common of which are: large sample surveys which have been used to produce segmentation models by applying cluster or factor analysis; or smaller sample in-depth qualitative research to produce typologies or characterisations that group owners by shared features and preferences. Whatever the method, such groupings help to provide specific insights into the perceptions, attitudes or other factors associated with specific groups of land managers around particular forestry and woodland management issues or policy questions.

The benefit of techniques based on large sample surveys is that they can perform multi-variate analyses to generalise amongst the diversity of management objectives, behaviours and practice across a broad spectrum of different land managers. Some studies have tested the quality and reliability of these classification approaches, particularly the segmentation models, and the interpretation frameworks applied to them. They have been shown to be powerful techniques within the limits of the modelling assumptions, and the research suggests that they do reveal important patterns as a basis for policy and operational level action (Blanco *et al.*, 2015, Dayer *et al.*, 2014, Ficko and Boncina, 2013, Ficko and Bončina, 2014, Caplenor *et al.*, 2017). In North America and some other parts of Europe, researchers have applied segmentation models as a way of developing and delivering tactical tools design to influence the behaviour of very specific groups of land managers, particularly those smaller non-industrial woodland owners. This has included for example: targeted communication and messaging strategies aimed at particular types of woodland owner by identifying closely what different owner "segments" want to know about, and taking into consideration their



views and values when framing the justification and need for uptake of particular woodland management actions and strategies (Boon *et al.*, 2004, Butler *et al.*, 2016, Häyriinen *et al.*, 2015, Kuipers *et al.*, 2013, Surendra *et al.*, 2009); and, the identification of appropriate extension services, knowledge brokers and media channels perceived as legitimate, credible and accessible by particular woodland owner segments (Karppinen and Berghäll, 2015, Kittredge, 2004, Metcalf *et al.*, 2016, Richter and Lewis, 2007, Salmon *et al.*, 2006, Starr *et al.*, 2014, Surendra *et al.*, 2009, Steiner Davis *et al.*, 2015, Tian *et al.*, 2015).

## 3.2. Differentiating resilience perceptions and behaviours

Most recently, research combining segmentation models with different behavioural science frameworks (particularly the Theory of Planned Behaviour – TpB - and the Theory of Reasoned Action - TRA) has started to explore aspects of land manager's response to forestry issues that are related to resilience. A large proportion of these studies explore forest resilience related to climate change impacts, either the belief in and general understanding that different kinds of forest owners have about climate change risks (Laakkonen *et al.*, 2018, Eriksson, 2014, Blennow *et al.*, 2012), or how this understanding does or might influence their differentiated forestry behaviours (see for example Andre *et al.*, 2017, Khanal *et al.*, 2017, Oakes *et al.*, 2016, Sousa-Silva *et al.*, 2016, Eriksson, 2014).

Other examples include aligning owner understanding of climate change by owner type with their specific management concerns, and from this identifying their information needs to support improved practice (Andre *et al.*, 2017, Khanal *et al.*, 2017, Mostegl *et al.*, 2017, Oakes *et al.*, 2016); understanding more about how different kinds of owners and managers respond to tree pests and diseases, and what kind of messaging about these issues is most effective for different types or land manager 'segments' (see for example Caplenor *et al.*, 2017, Surendra *et al.*, 2009, Marzano *et al.*, 2017a); and distinguishing more clearly the components of owner decision making and behaviour around fire risk and fire resilient forestry (see for example Charnley *et al.*, 2017).

What this body of work suggests is that the key factors affecting land owner and manager behaviour in the context of resilience and resilient practice, are:

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

- and the importance of a supportive economic, policy and legislative context.

### 3.3. Differentiating land managers and their understanding of resilience

Information about how the owners and managers of woodlands in the UK perceive and understand resilience is far less comprehensive. A review by Lawrence and Dandy (2014) showed what research there is about land manager decision making for forestry has concentrated, for the most part, on assessing behaviour in response to specific policy tools and measures, particularly economic measures such as forestry grants. For example: Crabtree *et al.* (1998) applied an econometric model on data about farmers as a means to predict the likelihood of them entering into farm woodland schemes; John Clegg Consulting (2007) reported on land owner attitudes to woodland planting scheme in the national forest, England; Ambrose-Oji *et al.* (2012) looked at land manager motivations for taking up woodland management grants in Wales; Ambrose-Oji (2016) investigated land manager and small scale forest business responses to knowledge dissemination and outreach events associated with forestry and land management schemes incentivising active woodland management activity; and most recently, working in Scotland, Hopkins *et al.* (2017) conducted a survey of 1,735 farmers and categorised them into three groups examining their likelihood to create and manage woodland using 51 variables impacting on decision making derived from Dandy (2012).

Thomas *et al.* (2015), looking at the issue of woodland expansion in Scotland, make the point that decision making research should be applying theories of behaviour change to quantitative and qualitative studies if more robust insights about land managers are to be developed. Although there are no found studies of British land managers that apply behaviour change theories, there have been a number of studies that investigate attitudes and motivations as a basis for characterising land managers and providing general insights into the behaviours of specific groups. For example, Firn Crichton Roberts Ltd (1990) conducted a survey of 110 landowners found five distinct groups based on their investment decisions in forestry and woodland creation; Sutherland *et al.* (2011) used a large scale survey and qualitative interviews to identify five attitudinal land manager types and demonstrate different responses to landscape level land use change; Urquhart, Courtney and Slee (2012) working in England were able to characterise woodland managers using Q methodology and factor analysis to identify four different perspectives of woodland ownership and management related to the concept of multifunctional woodlands; and Wavehill Consulting (2009) in Wales were able to identify different responses to woodland management amongst farmers.

Similarly, there are some larger scale quantitative surveys that have used more formal statistical techniques to develop “segmentation models” that group owners and managers by their actual and expected behaviours. For example: Urquhart and Courtney (2011) in England used factor and cluster analysis to distinguish a segmentation model with six different owner types in relation to production,

consumption and protection values they associated with their woodlands; and Howley (2013) working in Ireland used principal component analysis to identify three core motivations for forest ownership based on economic, lifestyle and multifunctional benefits. One of the most recent segmentation models in England, sponsored by Defra and the Forestry Commission, was developed to explore differences and similarities between private owners and the likely measures that might influence their behaviour around forest management and woodland creation (Eves *et al.*, 2014, Eves *et al.*, 2015a, Eves *et al.*, 2015b).

There has been some work uncovering the understanding that UK forestry sector stakeholders have of resilience and how this influences decision making at strategic and policy level (Marzano *et al.*, 2015, Young *et al.*, 2018). The few studies that examine resilience explicitly within land manager decision making are limited to response to the threat of tree pests and diseases (Marzano *et al.*, 2017b), and an examination of forest managers perceptions and understanding of risks associated with different forestry threats related to climate change and associated management strategies (Petr *et al.*, 2014).

The most significant piece of work focusing specifically on resilience at a UK level was the British Woodlands Survey 2015 coordinated by the Sylva Foundation in support of the Climate Change Accord (Hemery *et al.*, 2015). Results revealed that there was a very high degree of uncertainty amongst private woodland owners about whether or not future climate change would affect their forests (55% either felt climate change would not have substantial impact, or were uncertain about the impact of climate change on their woodlands). Rating factors which were most important in managing for woodland resilience, owners and agents overwhelmingly recognised the threat and need to control tree pests and diseases. The survey also revealed that woodland owners and agents understanding of resilience was dominated by concerns around woodland pests and diseases. The results of the British Woodlands Survey 2015 clearly identify that practical action for resilience will not be embraced by private owners until their uncertainty about how to respond is countered by better information and understanding about the risks posed by environmental change and their inaction. This relies on better more clearly communicated tailored guidance on how to address those risks being provided by relevant organisations. The risk perspective study by Petr *et al.* (2014) exploring the issue of uncertainty among forest managers in the UK, showed that they perceived climate change risks to be of high concern, they had a better understanding of risks relating to pests, drought and wind, but much less appreciation of the economic and social risks and pressures, and they understood that appropriate forest practice could mitigate some risks where it was supported by forest policies and policy tools. Lawrence and Marzano (2012) also explored attitudes to climate change and changing behaviour amongst forest managers and found that more general beliefs about climate change framed their notions of resilience, with available information and market demands/conditions constraining their action.

What is missing from the UK studies compared with the others encountered in the REA is a clear connection between woodland owner/manager characterisations and segmentation models and the differentiated understanding of resilience and resilience behaviours.

### 3.4. Confirming a segmentation model

In an effort to overcome this limitation, the research used a segmentation model developed by Eves *et al.* (2015a) to group together different kinds of woodland managers. Additional statistical analysis of the BWS2015 data showed that there was a clear association between size of woodland and owner/manager motivations or objectives for their woodland which closely reflected the categorisations in Eves *et al.*'s (2015) segmentation model of woodland managers. This close association confirmed the validity of applying the segmentation model to the interview data, and following through on the findings of the RAE confirming the validity and utility of applying characterisations.

During the course of conducting the interviews and coding the data by segment, it was clear that the Eves *et al.* (2015) model was not a perfect fit. Eves *et al.*'s (2015) "Aspiring Managers" category was not found in the data and a new category of "Individualists" was created. In addition, two of the land manager types were renamed to better reflect our understanding of the segments: "Profit Seeking Guardians" became "Enterprise Focused Managers", and "Disengaged Conservationists" became "Eco-centric Managers".

The characteristics of the land manager types after applying the refined Eves *et al.* (2015) model is shown in Table 3.

**Table 3. Characteristics of the land managers interviewed applying a refined Eves et al. (2015) segmentation model**

Land manager segment	Description of key characteristics	Exemplary quote from interview data	Woodland size class* (Ha)				TOTAL (%)
			0-6	6-15	15-50	50+	
Multifunctional Managers	Engage in some degree of active management of their woodlands for a broad range of private and social benefits. Woodland holdings include both small and relatively large size classes, and most are in long-term private ownership.	<i>"Well it's for various reasons, we have this for recreation, so we can walk our dogs there every day and as a source of firewood, and timber, and for a bit of landscape impact, and for the flora and fauna"</i>	8	3	2	5	18 (41)
Timber Producers	Main objective timber production. Desire to make a profit, 'break even' or to "manage woodland properly" are strong motives. Woodlands most likely to be large. Ownership private or in Trust.	<i>".... you get the satisfaction of having something where you've created some value because you have a crop that is useful"</i>			1	8	9 (20)
Enterprise Focused Managers <sup>1</sup>	Manage woodland for private and public goods and services. Woodland often part of larger land holding, e.g. estates or farms. Clearly aim to make a profit across the business, so may be cross-subsidisation with other land parcels.	<i>"The main business of the estate, it's integrated land management. So it is management to be sustainable and to make a profit, the woodland falls into that"</i>			2	5	7 (16)
Eco-centric Managers <sup>2</sup>	Value their woodland for many reasons, but tend to manage for ecological benefits or have strong views about "letting nature take its course". They are the least likely to engage in any income-generating activities. Their woodlands are the smallest average size and are privately owned.	<i>"I tend not to do anything much and when trees fall, I just let them fall where they fall or whatever. And, so it's... I suppose what a forester would call it, unmanaged"</i>	3	2	1		6 (14)
Individualists <sup>3</sup>	Many are relatively new to woodland ownership, and may have low levels of management other than tree planting. Their attitudes suggest they are keen to be woodland managers, but they have poor forestry knowledge and lower skill levels. Their woodlands are small, and relatively recently purchased or inherited.	<i>"Number one I hate regulation, number two I love grants because if that will enable me to plant more trees I want to take up a grant. In the county of Rutland the county emblem is the acorn, so I try to grow as many Oak trees as possible. But I like variety so we have Lime trees as well for the bees, and I grow walnut"</i>	2		2		4 (9)
<b>TOTAL</b>			<b>13</b>	<b>5</b>	<b>8</b>	<b>18</b>	<b>44</b>

\* The uneven intervals in woodland size are related to the Eves *et al* (2015) segmentation model which draws an association between segment and woodland size class and was an association confirmed by the additional analysis of the BSW2015 data (Forster, 2016)

<sup>1</sup> Renames "Profit-seeking guardians" in Eves *et al* (2015) model

<sup>2</sup> Renames "Disengaged Conservationists" in Eves *et al.* (2015) model

<sup>3</sup> Reclassifies "Aspiring manager" in Eves *et al.* (2015) model

It is important to note differences by size class of woodland held by the different segments as those owners and managers of smaller woodlands are so important. There is a trend within the BWS 2015 data as well as the qualitative data for the greater proportion of the smallest and medium sized woodlands (i.e. 0-6, 6-15, and 15-50 hectares) to sit amongst the Multifunctional Managers and the Eco-centric Managers, whereas Timber Producers and Enterprise Focused Managers hold proportionately more of the larger woodland holdings (50-500 hectares). However, it should be noted though that medium sized woodlands are also associated with some of the Timber Producers and Enterprise Focused Managers.

### 3.5. Insights from the empirical data

Table 4 provides a summary of the empirical data from the semi-structured interviews. The table highlights the key aspects of resilience understanding and the key factors playing a part in the decision making of land managers falling into each of the segments in the adapted model based on Eves et al. (2015a).

The majority of land managers, regardless of the segment to which they belonged, recognised the word “resilience” and related it to ensuring the sustainability of their woodlands. Consequently, all land managers agreed that resilience was an important concept for forestry. However, all three sets of empirical data (i.e. interview data, workshop narratives and BWS 2015 data) clearly showed a very high degree of uncertainty and variability amongst land managers about what resilience means in detailed, practical and applied silvicultural and woodland management terms. The qualitative data showed that woodland owners and managers were able to speak about “adaptation” explicitly. They did not talk about transformation, resistance and recovery in explicit terms. However, when describing the actions they do take, or those they would take to maintain or build forest resilience, they did describe practices which would fit under any one of these other three resilience components.

However, there was not a consistent understanding of adaptation across the segments and the concept meant many things to different managers. Furthermore, woodland owners/managers did not necessarily use the same definition as those applied by researchers or professional foresters. All of the segments provided examples of adaptation approaches they knew about, were willing to apply, or were already using. The most prominent of these actions were about diversification, particularly diversifying species choice in response to experienced and projected climate change, diversifying stand structure, age and composition in response to perceived pest and disease risk. These actions were mentioned most often by Multifunctional Managers, Timber Producers and Eco-centric Managers. The qualitative evidence suggested that Timber Producers and Enterprise Focused Managers were more likely to practice, or be supportive of, resistance actions, most prominent of which were actions in response to perceived risks of pest and diseases including the application of pest control measures and biosecurity, practicing modified thinning regimes, planting with different strains/provenances of the same species or choosing genetically tolerant trees.

**Table 4. UK land managers understanding of resilience and decision making factors differentiated using a modified segmentation model derived from Eves *et al.* (2015a)**

Land manager segment (% of sample)	Decision making factors			Exemplary quotes
	Understanding of resilience	Perspectives on risk	Barriers to action	
<p>Multifunctional Managers (41%) Average land holding c.51 ha</p>	<p>Definitions and potential actions 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). Believe “good land husbandry” best way to manage for resilience. 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. Long planning horizons mean risks of acting or not acting difficult to judge. 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 <u>multiple benefits</u> stops action. Not knowing what “the right” management measures are. Uncertainty over which tree species present functional alternatives to those under threat from climate change or from pests and diseases. Uncertainty how action now will support woodland in the future. Do not feel available advice suits their circumstances. Difficulty finding contractors with skills to enable changing practice</p>	<p><i>“We are trying to move away from all or nothing of one species or age range, continuous cover is part of trying to mitigate some of the risks with pests and diseases and climate change.”</i> <i>“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.”</i> <i>“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.”</i> <i>“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.”</i></p>
<p>Timber Producers (20%) Average land holding c.69 ha</p>	<p>Descriptions and potential actions combination of resistance (e.g. biosecurity) and adaptive (e.g. diversification species, age class, stand structure). Believe “Proper forest management” best way to manage for resilience. Likely 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 financial implications of that. Most willing to act on this issue. Timescales tied into shorter rotation cycles, so short term risk perspectives lead to inaction or resistance strategies for conifers. Willing to experiment to test future actions/responses as part of risk mitigation strategy.</p>	<p>Unpredictable and uncertain market demands and timber prices. Uncertainty about future demands of processing industry. Uncertainty about policy measures and tools particularly post-Brexit e.g. grant provision.</p>	<p><i>“... 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”.</i> <i>“It’s all very well to suggest this species and that species which we could grow, but at the end of the day, what are the timber mills going to say? Somehow or other, we have got to be productive on the other site and if this means planting a lot of Sitka spruce, if that’s the way to go, that’s the way we have to go”.</i> <i>“We know how Sitka performs on certain site conditions, its 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.”</i> <i>“we use the Forestry Commission’s ESC* for future climate change planning, it’s about looking at what species might be suitable for the future growing conditions that that particular site is forecast to have in a couple of decades’ time.”</i> <i>“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.”</i></p>

<p>Enterprise Focused Managers<sup>1</sup> (16%) Average land holding c.40 ha</p>	<p>Definitions and potential actions mostly resistance (e.g. preventive management including novel species, biosecurity, and improved thinning regimes). Focus on avoiding risk to the crop. Very likely have a formal woodland management plan which could help planning for resilience.</p>	<p>Risk is mainly associated with a loss of crop, and other economic and social value and financial implications of that. Most willing to act on this issue. View risk across business portfolio so woodland risks balanced against risk of loss in other parts of 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. Do not feel available advice suits their circumstances – costs not fully explained.</p>	<p><i>“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.”</i> <i>“the estate has concentrated on those things where we can generate a considerable income fairly rapidly. Woodland is not one of those things. I mean I value the environmental things as well, but the difficulty is if you put too high a priority to those objectives, you may not have the income to achieve those objectives. So I mean I’m very conscious of the fact that the estate as a whole has to be profitable to pay for environmental objectives.”</i> <i>“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.”</i> <i>“I mean growing Scot’s pine on a 80 or 90 year rotation is a hell of a lot longer time for it to be at risk of disease than Sitka growing on a 35 year rotation, isn’t it?”</i></p>
<p>Eco-centric Managers<sup>2</sup> (14%) Average land holding c.6 ha</p>	<p>Descriptions and potential actions 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.</p>	<p>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, risks of acting or not acting therefore difficult to judge.</p>	<p>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 efficacy of changing practice. Do not feel available advice addresses their approach to woodland management.</p>	<p><i>“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> <i>“I’m a great believer in letting nature take it’s course, so we’ll adapt to any changes taking place rather than trying to influence changes.”</i> <i>“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.”</i> <i>“they said something like “when the facts change, I change my opinion, what do you do?”. So I am responding in that way by being, certainly, broader-minded about the trees that I think will end up naturally coming through as a component in this place.”</i> <i>“I would certainly wait and see what happened, so I always resist, you know, I don’t always use advice like that, because [the advice] does seem to change.”</i></p>
<p>Individualists<sup>3</sup> (9%) Average land holding c.10 ha</p>	<p>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).</p>	<p>Views of risk differ. May not believe in climate/environmental change so may perceive little risk.</p>	<p>Focus on immediate threats, not longer term or diffuse threats Do not feel it is necessary/or they have no efficacy acting against e.g. climate change.</p>	<p><i>“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.”</i> <i>“I found it too dense for me to understand and again I was brushed off because I thought this wasn’t relevant to me, it was bigger forests, it wasn’t helpful to my two small fields .... and it would just be nice to have a beginners guide on what to do and how to do it.”</i></p>

<sup>1</sup> Renames “Profit-seeking guardians” in Eves *et al.* (2015) model

<sup>3</sup> Reclassifies “Aspiring manager” in Eves *et al.* (2015) model

<sup>2</sup> Renames “Disengaged Conservationists” in Eves *et al.* (2015) model.

\*Ecological Site Classification Decision Support System <http://www.forestdss.org.uk/geoforestdss/>



Multifunctional Managers and Eco-centric Managers were more likely than other types of land owners to practice or be supportive of recovery actions; these were mentioned less frequently, but were responses to perceived risks from climate change and pests and diseases and focused on replanting with different provenances or strains of the same species, or using natural regeneration from existing seed trees. Additional analysis of the BWS2015 data showed that those owners and managers who were motivated to protect/improve nature or protect/improve carbon stocks were most likely to consider age class ( $p < 0.001$  for both), species diversity ( $p < 0.001$ ;  $p < 0.05$ ) and genetic diversity ( $p < 0.05$  for both) as the most important factors they could change their practice around to improve forest resilience

The qualitative data revealed a strong differentiation in belief about forest management approaches between three of the land manager segments:

- The Multifunctional Managers often spoke of “good husbandry” being one of the most important routes to ensuring the resilience of individual trees and thus of their woodlands. The rationale that stood behind this idea was that providing the best conditions for trees to thrive, e.g. by reducing stress, was expected to confer some resilience.
- The Timber Producers were clear that “proper forestry”, i.e. following commercial silvicultural prescriptions to reach Yield Class potentials and to maintain stand health, would confer some resilience.
- The Eco-centric Managers held strong views about “nature taking its course” subscribing to the view that ecological processes rather than the actions of forest managers are the main drivers of adaptation likely to result in resilient forests and woodlands.

These general sets of beliefs, or “cognitive models”, were quite closely tied with the motivations and objectives which managers had for their woodlands, and consequently, the timescales they considered when thinking about resilience. For the Enterprise Focused Managers and Timber Producers, time scales were expressed in rotation lengths to harvest their main income generating species which they felt were relatively short term, i.e. over 35-55 years. The Multifunctional Managers and Eco-centric Managers viewed resilience and adaptation over much longer timescales of more than 100 years, which they related to slower growing broadleaved species, and older trees grown for multiple ecological, cultural and heritage benefits.

Whilst most land managers could say something about resilience in general terms, they could not clearly articulate which particular aspect of their woodland they wanted to be more resilient; if there were comments, it was about the forest or woodland composition, i.e. the species assemblages, and the general health and general economic value of their trees.

Woodland owners and managers were able to talk in greater detail about what their woodlands should be resilient against. Most of the pressures mentioned were environmental and ecological, and expressed as lists of climate change impacts, i.e. storms, and tree pests and diseases. There was very little mention of social or economic pressures acting on their woodlands other than concerns about changing market conditions or the potential impact of their neighbours land management actions on the health of their own woodlands.

Any comments by woodland owners and managers about “for whom” their woodlands should be resilient, tended to be limited to realising their own objectives. For Timber Producers, Enterprise Focused Managers and some Multifunctional Managers this was very much about income generation, and maintaining the supply of particular forest products to ensure the viability of their businesses. However, Eco-centric Managers and some Multifunctional Managers who managed for objectives connected with conservation of woodland biodiversity and natural heritage, also recognised the wider ecosystem service values their woodlands provided for “the environment” and society more widely.

An interesting result to emerge from the qualitative data collected at the workshops and from some of the interviews, was the importance of woodland management plans as a planning tool that drove action. This was true whether those plans were ‘formal’, i.e. UKFS compliant and linked with grant applications, or ‘informal’, i.e. documents not prepared specifically for grant applications. Management plans were mentioned by some as the main reason they had been able to organise their knowledge and think through what resilience might look like on the ground over an immediate planning period and further into the future. Analysis of the BWS2015 data showed that owners of smaller woodlands ( $p < 0.001$  across size range) and those motivated by objectives related to amenity ( $p < 0.001$ ) and personal pleasure ( $p < 0.05$ ), were less likely to have management plans than others. When testing for differences associated with the land manager segmentation model there was a significant difference ( $p = 0.032$ ) in the proportion of respondents that have different kinds of management plans according to segment. Enterprise Focused Managers and Timber Producers most frequently held formal management plans, whereas Individualists and Eco-centric Managers most frequently had no form of management plan at all. The uptake of formal management plans by Enterprise Focused Managers and Timber Producers is obviously a function of their objectives related to productive woodland management. Amongst Multifunctional Managers there was mix of land managers with formal management plans, informal management plans, no plan at all, or a rough plan “held in their heads”.

### 3.6. Barriers to changing practice

The REA emphasised a fundamental aspect is the need for land managers to first believe that threats to their woodland exist, and secondly that their taking action can make a difference. The BWS2015 data revealed that more than half of private woodland owners were unsure that climate change would affect their forests, and showed that those owners

who cited personal pleasure and hunting/shooting as key motivations for woodland management were least likely of all ( $p < 0.001$ , both cases) to believe climate change would impact woodlands in the UK. Owners and managers of larger woodlands (i.e. closer to Enterprise Focused Managers, Timber Producers and some of the Multifunctional Managers) were more likely to be making some provision for the risks of wind, flood and pest and pathogen control ( $p < 0.001$ , all cases).

Table 4 provides a summary of the barriers to changing practice mentioned by different kinds of land managers. In addition, the BWS2015 data showed owners and managers of larger woodland (i.e. closer to Enterprise Focused Managers, Timber Producers and some of the Multifunctional Managers) were more likely to list: cost of adaptation work, loss of income that might be incurred by changing practice, and problems with negotiating conflicting information about the best measures to implement. Owners and managers of smaller woodlands (i.e. closer to Eco-centric Managers, Individualists and some of the Multifunctional Managers) were more likely to mention: lack of information ( $p < 0.05$ ), lack of time ( $p < 0.01$ ), and wanting to maintain the status quo ( $p < 0.05$ ), i.e. wanting to keep their woodland just as it is. The qualitative data to which the segmentation model was applied reflects some of the same trends found in the BWS2015 data. It was difficult to distinguish between specific barriers to adaptation practices, and barriers to other actions that might impact on resilience. However, the qualitative data suggests that there are two key dimensions acting to create or reinforce barriers to changing practice which are:

- how different kinds of land managers perceive risk and uncertainty in their decision making and their management response to those risks and uncertainties;
- the amount of information and knowledge land managers feel they have to be able mediate their uncertainty and implement measures.

### 3.7. Perceptions of risk and management responses

The qualitative data summarised in Table 3 shows discernible differences in attitudes to risk by land manager segment. These differences relate to their objectives and attitudes, but also how these link with, and contribute to, their forest management approaches, i.e. those cognitive models identified as “good husbandry”, “proper forestry” and “let nature take it’s course”.

Timber Producers and Enterprise Focused Managers perceive risk in terms of the financial implications of any loss of value from their crops, combined with the perceived risks of not producing what the market or value chain demands at a given time. The shorter time scales over which these segments viewed resilience, 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, e.g. pest control or modified thinning, only made economic sense where there was clearly added value to the likely end product. Two Timber Producers mentioned that reinstating “proper forestry” practices such as thinning that had fallen out of use over the 1980s and 1990s, represented a familiar and fairly low risk strategy for changing practice. Timber Producers in particular often expressed a “resistance” view of resilience: they felt that continuing to plant with species that have so far proved resilient, e.g. Sitka spruce, and using new improved strains of those species, was the least risky strategy to meet their objectives. The “resistance” and “adaptation” approaches preferred by these segments, meant that applying silvicultural techniques that improved biosecurity and resilience to pest and diseases through stand structure, e.g. modified thinning regimes, were also accepted by some. That acceptance was contingent on the financial impact of thinning being minimal, or the costs representing a reasonable outlay against the degree of perceived risk, or a return to spend in terms of the added value of the product likely to be produced. It was interesting to discover that many of the Timber Producers and Enterprise Focused Managers mentioned that they were experimenting with species informally at a small scale, as an approach to judging the suitability, performance and risks associated with planting different “novel” species. Across these two segments 35% mentioned conducting their own informal species trials.

Multifunctional Managers generally dealt with longer planning horizons associated with the broadleaves that are an important component of their woodlands, and because of the multiple benefits they are looking to achieve. In terms of their perception of risks, the uncertainty associated with different time horizons tended to focus on two things: the shorter term immediate risks of known threats, particularly pests and diseases; and the longer term risks of not practicing “good husbandry” that would address environmental and financial risks. It was these longer term risks and pressures acting on their forest resource which were subject to the greatest degree of uncertainty and “unknowability”. These longer term risks were in their view very much associated with applying the right kind of “adaptation” and “recovery” actions. For most of them this meant increasing the diversity of species, diversity of function and diversity of stand structure which might also lead to increases in biodiversity and reduce stress on individual trees. Some Multifunctional Managers reported being concerned by 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 Multifunctional Managers had a landscape level view of their woodlands, and perceived other people’s woodland and land management practices as a risk to their woodlands. The main barriers to action amongst this segment was a general degree of uncertainty and confusion expressed about the best way to plan and act for resilience, particularly assessing the best adaptation measures to ensure that multiple benefits would continue to be provided over a long time horizon. For example, at the workshops one Multifunctional Manager explained they had an interest in moving to continuous cover forestry (CCF) to increase resilience to the impacts of climate change, but they were

unsure about how much this would cost in financial terms, and what the likely impacts would be on future income streams and levels of biodiversity. Many of the managers in this segment spoke of their fears of “not implementing the right management”, not having the right kind of information to facilitate changing practice, and for some, they were not totally convinced that action now would improve the resilience of their forests and woodlands in future. Lastly there was some mention of contractors not having the skills to support the willingness of owners and managers to change practice, e.g. move to CCF. Some of the Multifunctional Managers, around 18%, mentioned experimenting with informal small scale trials with new species and species mixes in their woodlands.

Eco-centric Managers did not frame risk as something to be managed as such, because, for the majority, their belief in natural processes being 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. In other words, Eco-centric Managers were not sure that they needed to take action to facilitate resilience, and if they did, they worried about the best action to take to support natural processes. Without a sense their management actions would have any efficacy, they did not seem to have a clear sense of why action might be necessary, and what difference they might make to the resilience of their woodland. There was little evidence that Eco-centric Managers were experimenting, although there was considerable evidence that this segment monitors the changes in their woodlands very closely.

Managing risks to woodland through insurance cover, was not used by the majority, i.e. 69% of those who provided data in the interviews (n=35). Of the 31% who did, insurance against wind damage was most prevalent. There were no significant differences in the frequency of insurance cover uptake observed by segment ( $p=0.432$ ).

### 3.8. Information, knowledge and communication needs

Most land managers felt that managing for resilience requires some specialist knowledge. This was less true for some of the Eco-centric Managers where they felt natural processes would drive forward adaptation regardless of human action.

Land managers amongst the Timber Producers were most confident about being able to access the kind of knowledge needed to be able to manage for resilience. It was the Eco-centric Managers and some of the Multifunctional Managers who expressed the least amount of confidence in the provision of information and knowledge suited to their smaller woodland contexts and their “good husbandry” or “let nature take it’s course” management approaches. Managers from all segments were able to describe the kind of information and knowledge which they would find helpful and facilitate their move towards more resilient forestry measures and actions. There were some similarities and differences in the information and knowledge needs between segments. Some of these insights are explored further in O’Brien and Ambrose-Oji *et al.* (2018), but the main issues to emerge were:

- **Explaining and justifying why planning for resilience is necessary:** The data suggest that many owners particularly those amongst Multifunctional Managers and Eco-centric Managers were not necessarily convinced that they should be acting to address resilience in their woodlands, or that their actions will have any impact. Owners in these segments were often very unclear as to what the models and predictions were around risks to their woodlands, what their management options were in response, and how sound the advice about action might be, i.e. whether they should trust it and act on it.
- **Tailoring resilience advice and information to types of owner:** It is unsurprising that the need to tailor advice to different kinds of land managers and owners was raised as a significant issue. Although Timber Producers and some Enterprise Focused Managers felt relatively well informed in general terms, many other respondents felt that this need had not been adequately addressed by the sector, and the importance of small woodland owners and non-professional woodland owners and managers had been largely overlooked. However, many respondents recognised that much research was now being done to address the risks challenging forestry, but argued that this research and advice was not translated into a form they could usefully apply. As one person put it *“I just need something easy clear and practical, it has to be based on science, yes lots of science, but I need language I can understand with advice I can actually act on”*. As well as producing advice about particular types of woodland, or specific challenges, there continues to be a need to build information and advice around the approaches to risk and management held by different kinds of owners and managers. For example, advice to Eco-centric Managers needs to build on their belief in the primacy of ecological process. Key issues to come through from the data were gaps in advice, or poor knowledge about where to find advice and information, concerning:
  - Woodland management planning and integrating resilience approaches
  - Resilience for multiple benefits
  - Resilience in relation to biodiversity and broadleaved woodland
  - Resilience for those wanting to work with ecological processes.
- **Financial aspects of resilience approaches:** Timber Producers, Enterprise Focused Managers and Multifunctional Managers stated that one of the barriers to changing practice is their lack of knowledge about the financial costs of adaptation approaches to resilience. Evidence from workshop participants showed that as well as wanting to know more about the actual costs of implementing adaptive practice, Enterprise Focused Managers and Multifunctional Managers also wanted to understand more about how to assess the impact that changing tree species and diversification would have on the value of the land and the potential revenue from timber/firewood in the future. The Timber Producers wanted to understand better the business costs and benefits of either taking action or not taking any action at all.

- **Training for resilient practice:** was mentioned as a need by a number of respondents, and whilst there were no clear patterns of difference between land manager segments there were comments about:
  - **use of current tools:** by Timber Producers, Enterprise Focused Managers and Multifunctional Managers who felt there could be more training to increase uptake, improve efficiency of use and avoid inappropriate use around the current suite of decision support tools focused on future resilience such as the Forestry Commission's Ecological Site Classification tool (ESC), Forest Gales and the interpretation of some of the bulletins and literature coming from Forest Research
  - **aspects of resilience not clear to non-professional foresters:**, this group expressed the biggest gap in either the time available to attend training, their ability to meet the costs of training, and their ability to identify what training was needed and where it could be sourced. As one of them put it *"we can't do it right, we can't do it different if we don't have help"*.
- **Dissemination channels and platforms for information and advice about resilience issues.** There were many comments about the lack of signposting and easy to find or easy to navigate information sources. Land managers made a range of comments about preferred platforms and forms of information and advice. A consistent issue mentioned by all kinds of land managers during the interviews and workshops was their perception that there were too many sites and locations for the guidance and information. As one person amongst the Multifunctional Manager segment explained *"we've had to do quite a lot of work to pull together just the provenance information and the species information that's out there. There's some great stuff done by the FC but it's not always that easy to get hold of. You have to do quite a bit of digging and it shouldn't be difficult. We should make it mainstream and make it very easy to get hold of"*. There were comments across segments that some of the available information is conflicting, e.g. the advice about provenance and tree species diversity, depending on the point of view of the organisation (or the part of the organisation) publishing the advice. In addition, in some instances details about the source of information and advice was not clear, so land managers were not able to make a judgement about the perspective being promoted and the legitimacy of the information being provided.

## 4. Conclusions

This Research Report has presented primary data and secondary evidence exploring some of the factors important in land manager decision making. It has provided a synthesis of the beliefs and understandings of different kinds of land managers about woodland resilience, their broad perceptions of risk and how those perceptions shape their management approaches or create barriers to action in support of resilience. The application of a segmentation model has successfully revealed differences and similarities

in these factors between land managers. Land managers amongst the Multifunctional Manager and Eco-centric Manager segments are those who hold the smaller sized woodlands, and represent the woodland owners and managers least likely to feel most confident about changing their practice or finding the right kind of support to do so. This has important implications for policy which aims to encourage resilient woodland management amongst the owners of small woods.

## 4.1. Understanding resilience

Whilst the majority of land managers recognise the word “resilience” it is generally understood to be about the sustainability of forests and woodlands. The only component of resilience that is commonly discussed in explicit terms is adaptation and this is very closely allied with diversification. Whilst all land managers were able to present lists of ecological and environmental threats being assessed as part of their understanding of the pressures acting on their woodlands resilience, there is little conscious recognition of the socio-economic dimensions of resilience. Only Timber Producers, Enterprise Focused Managers and some Multifunctional Managers made reference to this in relation to markets and financial values of timber crops. The recommendation that land managers themselves should be defining which parts of their woodland should be resilient to what threats, and for whom, continues to be a problematic proposition.

## 4.2. Resilient Practice

In terms of resilient practices there was an overwhelming focus on adaptation, specifically diversifying species choice. There was some mention of diversifying stand structure and stand composition in response to experienced and projected climate change, and in terms of resilience to the increase and incidents of pest and diseases. However, there are a far wider range of measures that could be considered in response to the risks associated with climate change, and many of these require less technical expertise and are less drastic or costly compared to changing species. For owners and managers of smaller woodlands and broadleaved trees a particular barrier to action was their long term time horizons and their scepticism that action in the short term would confer resilience in the future.

There were differences between managers in their management planning approach. Using management plans to work through future scenarios and possible management responses was mentioned by some land managers, most often the Enterprise Focused Managers and Multipurpose Managers. Although the presence of a plan can help plan for resilience, managers still need to assess risks and have a good understanding of the options and measures available to them to decide on appropriate and effective actions. Having a plan can create a false sense of security. A snapshot study of the formal woodland management plans of private owners in 2015 assessed the extent to which managers plan for climate change adaptation and resilience (Atkinson *pers comm*). Typically those plans recognised adaptation and the need to build resilience but did not necessarily include appropriate actions.



There are some clear differences in the approaches to management for resilience amongst the different land manager types. Our research showed that there were three strong management approaches that were shaping land manager decision making about which measures and practices they might adopt. These were Multifunctional Managers ideas of 'good husbandry', Timber Producers conceptions of 'proper forestry', and Eco-centric Managers' belief in supporting ecological processes to 'let nature take it's course'. This reflects findings in other research showing different land manager perceptions of forest management. It illustrates the importance of understanding these cognitive models if policy formulations and communications strategies are to properly engage with private woodland owners and managers through targeted language and the provision of what will be considered legitimate advice (see for example Feliciano *et al.*, 2017).

None of these three approaches to management are likely to be sufficient to increase resilience unless they include an assessment of the projected risks, including short and longer term risks from climate change and other threats and pressures, alongside the planning of a response. None of the land managers expressed any particular sense of urgency regarding the need for such assessments or changes to their practice regardless of their cognitive model or segment membership. The need to stress the justification for change, and the urgency for change is still needed across the forestry and woodland sector.

### 4.3. Barriers to action: Belief, knowledge, risk perception and confidence to act

The findings of our research concur with those from other studies showing that motivation and attitude alone do not explain how the behaviour of woodland owners and managers changes. One element driving behaviour change is an owner or manager's belief that there is a point to acting, and that the action will have an impact on the issue being addressed (Norgaard, 2011, Oakes *et al.*, 2016, Sousa-Silva *et al.*, 2016). Part of the belief and confidence to act may be linked with strategies for collective action being apparent or possible. Building this belief in efficacy relies in part on building individual knowledge and awareness of specific resilience issues and what are the practice options. However, awareness, knowledge and action are three quite different things (Khanal *et al.*, 2017). Building belief and the confidence to act rests on more than the provision of information. Learning that facilitates change is a continual process and one that builds through practice, social learning and discussions with peers and networks. As Andre *et al.*, (2017) put it "*it is seldom a lack of knowledge and information that limits adaptation processes, but rather the question of what knowledge is available, how is it produced and communicated, and to whom*".

As our research demonstrates, different kinds of owners and managers need to have confidence in, and recognise, the legitimacy of the information sources to which they have access. This means different kinds of owners may well be looking for advice from different organisations which they feel most represent their interests and management

perspectives; e.g. Ecocentric Managers will be looking for information and advice that shows how to work with ecological processes in a way that fits in with their “let nature take its course” beliefs as well as focusing on the ecological and natural heritage benefits of their management. Various organisations serving both the larger commercial and the smaller non-commercial managers in the forestry and woodland sector have started to post information about resilience. However, a central, easily navigable “hub” of collated information does not yet exist. This perpetuates a situation for the smaller woodland owners and managers in particular, where negotiating access to, and uptake of information remains a complex and confusing task, and a barrier to changing practice. The efforts of the Forestry and Climate Change Working Group in bringing together over 30 organisations in support of the Climate Change Accord demonstrates that there it is possible to build consensus that action to adapt is required. However more needs to be done to create these ‘hubs’ of information for landowners.

Our research has also emphasised that a general desire to “do the right thing”, is tempered with real uncertainty and a fear of “doing the wrong thing”. This means that many owners and managers, regardless of woodland size, remain reticent to act on what they perceive might be poor advice: they would rather not act to change their practice. So it is therefore important for advice and information to present “no regret options” that can accommodate perceived uncertainties, or the need to change approach if new information or new threats emerge.

#### 4.4. Signposting information

Taking all these factors into account, we can conclude that there are specific resilience issues about which land managers need more information:

- **Information to explain and justify the need to manage for resilience**, i.e. an overview of resilience issues, climate change projections and material explaining why there is a need for change, how urgent this is, and what effect individuals can have. Important to all land managers but particularly Multifunctional Managers and Ecocentric Managers not necessarily convinced that they should be acting to address resilience in their woodlands.
- 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 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 for a particular type of woodland.
- **Information about financial aspects of resilience approaches**: Timber Producers, Enterprise Focused Managers and Multifunctional Managers stated that one of the barriers to changing practice is the lack of knowledge 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 the potential revenue from timber/firewood in the future. Timber Producers wanted to better understand the business costs and benefits of either taking action or not.

- Information to understand **time scales and required lead time** to make appropriate changes to forest management.
- Need for guidance to know how to **integrate resilience approaches** into woodland management planning.

This information will need to take into account the different approaches of importance to land managers in the way the information is framed and presented, heeding the main concerns and perspectives of land managers, particularly:

- Lessening risks to the value of commercial stands through resistance and adaptation approaches – of interest mostly to Timber Producers and Enterprise Focused Managers, but also some Multifunctional Managers
- Maintaining streams of multiple benefits from woodlands using resistance, adaptation and recovery approaches – mostly of interest to Enterprise Focused Managers and Multifunctional Managers
- Supporting the ecological processes driving adaptation – of interest mostly Eco-centric Managers but some Multifunctional Managers.

Finally, Table 5 marshals links to existing information and resources according to these issues and approaches, signposting the resources likely to be of interest to different kinds of land managers.

**Table 5. Signposting information about resilience issues of concern to different kinds of land manager**

Resilience issue	Land manager approach	Links to information
Why land managers should act now to build woodland resilience	Better understanding of resilience issues. Overview of climate change predictions.	<a href="#">LWEC Report Card on the Climate Change Impacts on UK Agriculture and Forestry (2017).</a> <a href="#">Forestry Commission. Information Note 69. Climate change and British Woodland</a> <a href="#">Forestry Commission. Research Note 301. Impacts of climate change on forests in Wales</a> <a href="#">Forestry Commission. Research Note 301. Effeithiau newid yn yr hinsawdd ar goedwigaeth yng Nghymru</a> <a href="#">Forest Research. Report. Impacts of climate change on forests in Scotland</a> <a href="#">Climate change: impacts and adaptation in England's woodlands</a> <a href="#">Royal Forestry Society. Resilient Woodlands – what should we be doing and why?</a> <a href="#">Sylva Foundation. Trees and Climate Change a Practical Guide for Woodland Owners</a> <a href="#">Sylva Foundation. Forest management and silvicultural responses to predicted climate change</a> <a href="#">Forestry Commission. Research Information Note21 The Impact of Climate Change on Forest insect pests in Britain.</a>
Woodland management planning for resilience	Why woodland planning is important and how to do it	<a href="#">Forestry Commission. Managing native broadleaved woodland</a> <a href="#">Forestry Commission. Practice Guide 22. Building wildfire resilience into forest management planning</a> <a href="#">Forestry Commission. Practice Guide 12. Design techniques for forest management planning</a> <a href="#">Royal Forestry Society. Wise About Woods training courses</a> <a href="#">Royal Forestry Society. Wise About Woods - Woodland management resources</a> <a href="#">Small Woods Association training courses</a> <a href="#">Sylva Foundation. My Forest planning tools</a>
Silvicultural practice	Building resilience into commercial stands	<a href="#">Forestry Commission. Bulletin 125. Climate change: Impacts on UK forests</a> <a href="#">Forestry Commission. Practice Note 18. Choosing Sitka spruce planting stock</a> <a href="#">Forestry Commission. Practice Note 16. Respacing naturally regenerating Sitka spruce and other conifers</a> <a href="#">Forest Research. Report. The evidence supporting the use of continuous cover forestry in adapting Scotland's forests to the risks of climate change</a> <a href="#">Forestry Commission. Silvicultural Guide. Successful Underplanting</a> <a href="#">Royal Forestry Society. Best practice silviculture for commercial woodlands case studies</a>

	Resilience for multiple benefits	<a href="#">Forestry Commission. Research Note 201. Climate change: impacts and adaptation in England's woodlands</a> <a href="#">Forestry Commission. Research Note 24. Converting planted non-native conifer to native woodlands: a review of the benefits, drawbacks and experience in Britain</a> <a href="#">Forest Research. Report. The evidence supporting the use of continuous cover forestry in adapting Scotland's forests to the risks of climate change</a> <a href="#">Royal Forestry Society. Resilient woodlands case studies</a> <a href="#">Royal Forestry Society. Best practice silviculture for commercial woodlands case studies</a>
	Supporting ecological processes for resilient woodlands	<a href="#">Forestry Commission. Practice Guide 201. Managing ancient and native woodland in England</a> <a href="#">Forestry Commission. Practice Guide 14. Restoration of native woodland on ancient woodland sites</a> <a href="#">Forest Research. Report. The evidence supporting the use of continuous cover forestry in adapting Scotland's forests to the risks of climate change</a>
	Tree species information – novel trees, tree diversity, provenance and genetics	<a href="#">Forestry Commission. Information Note 86. The Role of Forest Genetic Resources in Helping British Forests Respond to Climate Change</a> <a href="#">Forestry Commission. Information Note 82. Choosing provenance in broadleaved trees</a> <a href="#">Forestry Commission. Ecological Site Classification Decision Support System (ESC)</a> <a href="#">Royal Forestry Society. Species Profiles Project</a> <a href="#">The SilviFuture project</a>
Pests and diseases	Building resilience into commercial stands	<a href="#">Forestry Commission. Practice Note 17. Minimising the impact of the great spruce bark beetle</a> <a href="#">Forestry Commission. Practice Note 14. Managing the Pine Weevil on Lowland Pine</a> <a href="#">Forestry Commission. Information Note 61. Managing the threat to restocking posed by the large pine weevil, Hylobius abietis: the importance of time of felling of spruce stands</a> <a href="#">Forestry Commission. Research Note 30. Choice of silver birch planting stock for productive woodlands</a>
	Resilience for multiple benefits	<a href="#">Forestry Commission. Information Note 35. Natural regeneration in broadleaved woodlands: Deer browsing and the establishment of advanced regeneration</a> <a href="#">Forestry Commission. Research Note 29. Ecological impacts of ash dieback and mitigation methods</a>
	Supporting ecological processes for resilient woodlands	<a href="#">Forestry Commission. Information Note 35. Natural regeneration in broadleaved woodlands: Deer browsing and the establishment of advanced regeneration</a> <a href="#">Forestry Commission. Research Note 29. Ecological impacts of ash dieback and</a>

		<a href="#">mitigation methods</a> <a href="#">Woodland Trust. Case study. Addressing tree diseases within plantations on ancient woodland sites</a> <a href="#">Woodland Trust. Case study. Woodland restoration and the fight against tree disease</a>
	Tree pests and disease information	<a href="#">Forestry Commission. Information Note 72. Birch Dieback in Scotland</a> <a href="#">Forestry Commission. Practice Note 15. Managing acute oak decline</a> <a href="#">Forestry Commission. Research Note 21. The influence of climate change on forest insect pests in Britain</a> <a href="#">Forestry Commission. Research Note 04. Potential impacts of drought and disease on forestry in Scotland</a> <a href="#">Forestry Commission. Research Note 02. Red band needle blight of conifers in Britain</a> <a href="#">Royal Forestry Society. Tree Pests and Diseases information</a> <a href="#">Royal Forestry Society. Wise About Woods training courses</a> <a href="#">Small Woods Association training courses</a> <a href="#">Woodland Trust. Wood Wise - tree pests and disease</a>
Economic aspects, financial costs and benefits	Building resilience into commercial stands	<a href="#">Forestry Commission. Research Note 26. Timber properties of noble fir, Norway spruce, western red cedar and western hemlock grown in Great Britain</a> <a href="#">Forestry Commission. Research Note 03. Benefits of improved Sitka spruce: volume and quality of timber</a> <a href="#">Forest Research. Report. Costs and revenues of transformation to continuous cover forestry. Modelling silvicultural options with Sitka spruce</a>
	Resilience for multiple benefits	<a href="#">Defra. Tree Health Resilience Strategy</a>
	Information about gaining income from woodland	<a href="#">Sylva Foundation: Guide to marketing timber from woodland</a>
Time scales	Understanding about time horizons and future options planning for resilient woodland	<a href="#">New approach for evaluating options for climate change adaptations in forestry - Future Forest Management Pathways</a> <a href="#">Royal Forestry Society: Evaluating options for robust forest adaptation to climate change, article</a>

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