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1 Working with decision-makers for resilient forests: a case study from the UK

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18 **Abstract**

19 Improving resilience in forests relies on an understanding of the values, knowledge and practices
20 associated with forests. In this paper, based on a case study from the UK, we present qualitative data
21 on how the concept of resilience is understood by decision-makers, the effectiveness of existing policy
22 tools to promote resilient forests and the current boundaries and social acceptability of different
23 management options. Our research reveals that the articulation of actual, possible and needed policy
24 responses reflects the challenge that resilience is a multifaceted concept with an array of potential
25 implications, connected with a diverse set of forest ecosystems. Our research suggests that the
26 collaborative development and promotion of an overarching vision for resilience, which recognises
27 the needs and contexts of different owners and managers in the sector, might begin to overcome the
28 current challenge of fragmented policy and lack of policy tools. This will necessarily involve discussion
29 and coordination across different areas of government and involve those agencies and organisations
30 responsible for the science behind resilience approaches and applications. In particular, there is a need
31 to contextualise and communicate resilience in line with stakeholder needs, and to articulate the
32 uncertainty associated with resilience measures in a range of situations so public agencies, forest
33 owners and managers can make informed choices.

34

35 **Introduction**

36 During the past few decades the paradigmatic underpinnings of forest policy around the globe has
37 been that of sustainability and how to manage the changing ecological, social and economic
38 dimensions of sustainable forest management - SFM (MacDicken et al., 2015). Over the same period
39 the concept of “resilience” has been developed in international science and policy associated with
40 many different sectors and systems, including: community development and poverty reduction
41 (Bahadur et al., 2013, Béné et al., 2014); economics (Briguglio et al., 2009); health, medicine and
42 environmental change (Almedom 2008); and the management of natural disasters and civil

43 contingency planning (Bahadur, 2010). Across these perspectives, resilience is described as a state,
44 and as a set of characteristics and processes which confer resistance or adaptability: change,
45 uncertainty and surprise are common elements too, with change often characterised by thresholds
46 (Brown, 2011). Forestry as a science and as praxis operates at the interface of social and natural
47 sciences, consequently, common agreement around the definition of resilience in a forestry context
48 has presented significant challenges. In response to the IPPC 2007, the most salient definition was
49 propagated by the Secretariat for the Convention on Biological Diversity, defining a resilient forest as
50 one, when viewed over an appropriate time span, where the forest ecosystem is able to maintain its
51 'identity' in terms of taxonomic composition, structure, ecological functions, and process rates
52 (Thompson et al., 2009). However, articulation of the concept in terms of the diverse spatial scale (e.g.
53 site, stand, landscape, region) and relevant temporal dimensions remains particularly challenging
54 (Ghazoul and Chazdon, 2017, Johnstone et al., 2016). The interaction between forest ecological
55 systems and social systems is also poorly theorised (Pramova et al., 2012). This is particularly
56 significant if, as Almedon and Tumwine (2008) point out, resilience is also about individuals and
57 institutions engaging with catastrophic events and experiences in a way that builds meaning around
58 the goal of maintaining their function without a fundamental loss of their identity. In other words, it
59 is the understanding and perspectives of individuals and organisations impacted by significant
60 changes, e.g. forest owners and managers, policy makers within policy bodies, that is needed to
61 facilitate the change in social institutions e.g. the strategic plans, policy measures and propagated
62 knowledge, norms and beliefs, that can accommodate changes experienced in the natural world.

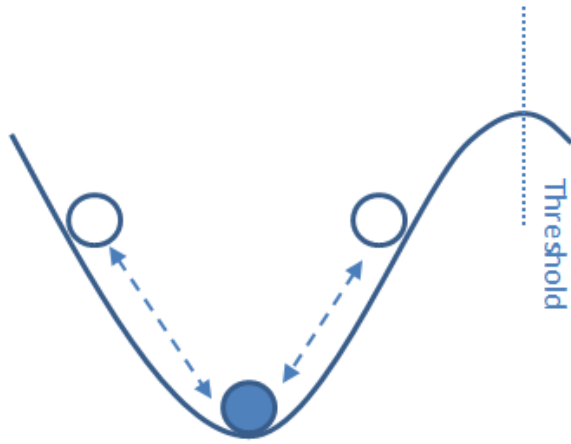
63 What is the policy making process and how it actually works is a topic of some academic debate (e.g.
64 Sarkkio et al., 2015; Michon et al., 2013; Konijnendijk, 2004). However, there is general agreement
65 that policy-making involves the goals, perceptions, problem prioritisation and solution finding of
66 stakeholders and policy actors. Underpinning decision-making around these aspects are their beliefs,
67 values and discourses, i.e. the scientific paradigms, evidence, knowledge and language to which they

68 subscribe, as well as assessment of the political costs of particular policy approaches (Coleman et al.,
69 1997, Keeley and Scoones, 2000, Keeley and Scoones, 2001).

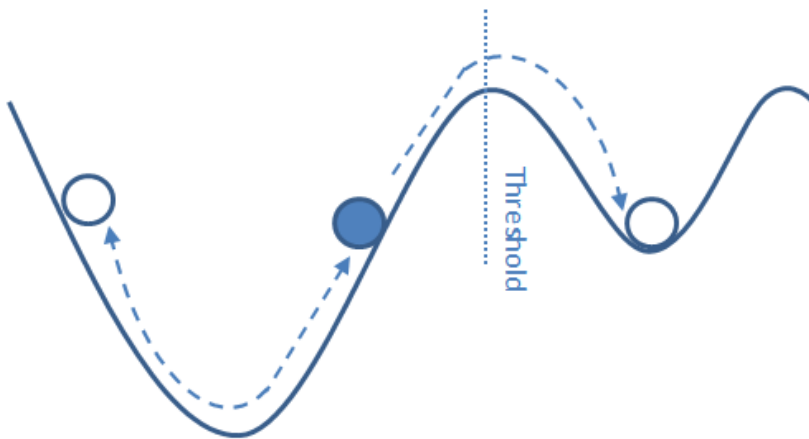
70 There are three distinguishable discourses in resilience science of forest systems that researchers and
71 academics have debated with different policy and decision-makers and forest sector stakeholders in
72 an attempt to evolve practice and action (see Figure 1, and DeRose and Long, 2014, Dymond et al.,
73 2015; Fuller and Quine, 2016). Models fit under the broad definition of forest resilience but have quite
74 different theoretical underpinnings. The first applies an engineering resilience perspective around
75 steady-states, stability and resistance to change, which seeks to minimise the effects of the
76 disturbance such that it continues along a particular pathway post-disturbance. The second model
77 applies an ecological resilience approach and assumes that more than one stable forest system is
78 possible, and that different states may recover to provide similar functions even though certain
79 characteristics (e.g. species composition) may have changed. The third model is propagated by socio-
80 ecological systems science: It suggests that forest systems are subjected to stochastic change and
81 dynamic processes that can adapt or transform forest ecosystems from one functional form, to
82 another, qualitatively different form. It also recognises that the interaction between the natural and
83 social system can shift thresholds in unexpected ways. However, studies in the United States (Bone
84 et al., 2016, DeRose and Long, 2014), New Zealand (Roche, 2017), and Germany (Sotirov et al., 2016)
85 illustrate that while policy makers may use these broad concepts to focus policy statements and
86 strategies around resilience, there is rarely an understanding and articulation of the concept that is
87 both clear and detailed enough to translate into mechanisms that support silvicultural operations and
88 forest management. Fuller and Quine (2016) discuss this in greater detail and show that the
89 complexity of multifunctional, multi-species, multi-scale and the long term nature of forestry makes
90 it difficult, and unrealistic, for a single or consistent definition of resilience in the forestry sector.

91 **Figure 1. “Cup and ball” schematic diagrams illustrating the common concepts of resilience currently**
92 **used in forest systems sciences and recognised in policy discourse**

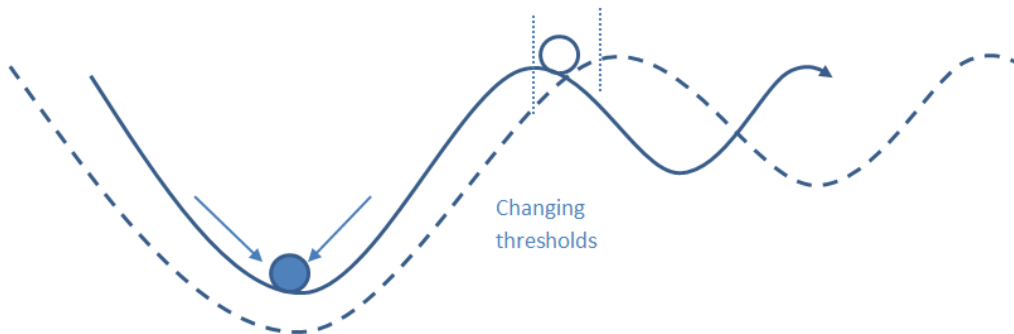
93 a. Engineering resilience after Gunderson (2000), assumption of only one stable forest system and
94 the ability of the system to return to that state



95
96 b. Ecological resilience after Gunderson (2000) assumes that more than one stable forest system is
97 possible, different states may provide similar functions even though species composition changes



98
99 c. Socio-ecological systems resilience after Artic Council (2013) assumes that changes in the social
100 system and environmental system may work together to shift thresholds



101
102

103 This complexity presents challenges for policy makers to complete the policy-practice process, to
104 understand and prioritise knowable threats facing forests, and to identify which approach to resilient
105 forest management should be endorsed. A pertinent case is the rise in attention to pests and diseases
106 and the associated political and economic risks which has led many forestry policy and decision-
107 makers to concentrate efforts in this area. The science is developing at pace, and for some key tree
108 pests and diseases, much work has been done to define the parameters, some of the silvicultural
109 responses, and the context for evaluation and manipulation of the organisms (Cavers, 2015, Cavers
110 and Cottrell, 2015, DeRose and Long, 2014, Klapwijk et al., 2016). The social dimensions of tree health
111 is a relatively new area for research, but work here is providing insights into the scope and scale of the
112 stakeholder landscape (e.g. Dandy et al 2017); knowledge and awareness of pests and diseases
113 amongst stakeholders and the public (e.g. Marzano et al 2015, 2016; Urquhart et al 2016); governance
114 issues (e.g. MacLeod et al 2010; Potter 2013; Pettersson et al. 2016); and stakeholder responses to
115 management options (e.g. Flint 2006; Chang et al 2009; Fuller et al 2016; Porth et al 2015; Sheremet
116 et al., 2017).

117 Sustainable forest management, forest resilience and protection of tree health are all stated policy
118 objectives for the devolved administrations in Britain. Recognising the cross-border co-operation
119 required to deal with tree and forest health, there is a GB wide strategy (DEFRA, 2014a,b,). In addition
120 England, Wales and Scotland have developed national level policy statements that make explicit and
121 implicit reference to forest resilience (Plant Health Service, 2015, DEFRA, 2014b, Welsh Government,
122 2013, DEFRA, 2014a). Alongside this, the Forestry Commission in England and Scotland, and Natural
123 Resources Wales have outward facing “forest resilience” webpages that make statements describing
124 policy positions and identify supporting resources for forest managers (Wales, 2016, Scotland, 2016,
125 England, 2016). However, on these pages the links between resilience and tree health are often not
126 explicit. Resilience is instead expressed in terms of forest stand structural diversity and tree species
127 diversity – the discourse is “adaptation”, for example to changing climates, and a focus on action with
128 little reference to the spatial scale and temporal dimensions. This highlights how far the complexity

129 of the stakeholder landscape also affects policy and decision makers. It is not only that each country's
130 decision-makers wish to frame resilience to fit their own context, they are also involved in a process
131 of identifying their priority audiences, i.e. those organisations and individuals along the length of the
132 forest management and value chain they wish to target, each with their own levels of understanding,
133 awareness and information and knowledge needs (Marzano et al., 2015, Marzano et al., 2016, Stenlid
134 et al., 2011).

135 There is scant research exploring these dynamics in the policy-practice process. Very little has been
136 uncovered about how policy and decision-makers come to understand resilience in a tree health
137 context, and how they go on to identify and prioritise particular threats and the potential changes to
138 practice that could meet specific risks and challenges. Even less is known about the barriers they
139 experience to realising their values, beliefs and aspirations around resilience and tree health. This
140 paper sets out to address some of these gaps by reporting research that aimed to better understand
141 the definitions of resilience and key concepts used by policy-makers in the UK, their views on key
142 policy tools and instruments that could or do promote tree health resilience (including their
143 effectiveness and challenges linked to them), as well as potential collaborative processes.

144

145 **Methods**

146 The main methods used in this research were three focus groups carried out in December 2015
147 involving 21 policy actors with an interest in tree health; and semi-structured interviews (n=12) with
148 key informants working in senior policy positions within UK Environmental bodies.

149 The focus group participants had been invited to a meeting to update relevant policy stakeholders on
150 progress of the PROTREE project¹. PROTREE aimed to measure the variability and adaptability of trees
151 to pests and diseases, and to find ways to get people involved in promoting healthier forests. A key

¹ PROTREE: <https://wiki.ceh.ac.uk/display/THI/The+Project>. Funded in the UK through the LWEC Tree Health and Plant Biosecurity Initiative (THAPBI).

152 part of the project was to ensure the research addressed the needs of stakeholders and produced
153 results that could be used on the ground. Following a detailed stakeholder mapping, analysis and
154 assessment, the project created a Science-Policy-Practitioner Interface for greater dialogue,
155 knowledge exchange and validation of project activities and outputs. The aim of the three focus groups
156 was to discuss the understanding of the term 'resilience'. Focus group discussions are a form of group
157 interview using a relatively open, non-directive qualitative technique to explore topics as perceived
158 by the participants (Fischer & Young, 2007). As well as understanding interactions between the
159 members of the group, an important aspect of the focus group is to examine the joint construction of
160 meaning. As such, this technique was well suited as an introductory methodology to explore the
161 meaning of resilience from the participants' viewpoint. Each focus group discussion lasted 15-20
162 minutes, included seven people and was facilitated by two of the authors (MM and JY). Following on
163 from the focus groups and building on the theoretical background on resilience highlighted in the
164 introduction, the authors developed a semi-structured interview guide aimed at national level policy
165 actors responsible for developing and/or implementing tree health resilience. A key informant
166 sampling approach was adopted and twelve high-level policy actors in government organisations in
167 England, Scotland and Wales (see Table 1) were identified and interviewed between March and August
168 2016. The interview guide (see Appendix 1) focussed on four key aspects regarding resilience:

- 169 • Definitions of resilience and key concepts used
- 170 • Key policy tools and instruments that could/do promote tree health resilience (including their
171 effectiveness and challenges linked to them)
- 172 • Opportunities and challenges in promoting resilience
- 173 • Collaborative processes and stakeholder engagement – including the identification of any
174 stakeholders currently missing from discussions and actions promoting resilience.

175 Key informants were selected based on the stakeholder mapping and the further identification of the
176 most experienced or senior policy actors in the main UK government bodies with responsibility for
177 forestry or who could provide insights on resilience in the environment sector.

INTERVIEWEE GEOGRAPHIC FOCUS	NUMBER OF INTERVIEWEES	INTERVIEWEE CODES
ENGLAND	5	PE1-PE5
SCOTLAND	5	PS1-PS5
WALES	1	PW1
CROSS-BORDER	1	PCB1
TOTAL	12	

178

179 **Table 1.** Distribution of interviewees according to background. Three focus groups were also carried
180 out (Codes: FG1, FG2, FG3) with cross-border participants.

181 Semi-structured interviews were carried out by two of the authors (JY and MM). All interviews,
182 excepting one, were carried out over the telephone. Research suggests that there is little difference
183 in the quality of data collected using telephone interviewing (Jäckle et al., 2006; Sturges and Hanrahan,
184 2004). Interviews took between 25-60 minutes and were transcribed verbatim in their entirety by a
185 professional organisation. Results from the focus groups and interviews were coded using NVivo. We
186 applied a grounded theory approach to organising the narratives following the general themes of the
187 interview guide. This resulted in six main coding nodes identified (Resilience concept; Communication;
188 Current or lack of knowledge about issues affecting trees; Policy tools related to resilience; Promoting
189 resilience and Stakeholders involved in tree health), and 29 sub-nodes. See Table 2 below for the
190 organisation of the coding, and results in terms of sources and number of references for each.

Node	Sub-node	Sources	References
Resilience concept	For what purpose(s)	12	53
	In what contexts the term is used	7	25
	Spatial scale	7	16
	Temporal scale	11	33
	Against what - pests, diseases etc	13	75
	Definition: engineering, ecological of socio-ecological	12	47
	Values	3	5
Communication	Communication - general	8	22
	Communication between government	7	25

	departments		
	Communication or consultation with contractors	2	3
	Communication or consultation with the public	10	46
	Communication with industry	11	52
Current or lack of knowledge, about issues affecting trees	Current knowledge, and lack of, about issues affecting trees - general	12	75
	Complexity of resilience issues	9	21
	Detecting pests and pathogens	5	22
	Sources of information and knowledge	13	49
	Uncertainty	6	26
	Understanding risk	4	10
Policy tools related to resilience	Balancing different policy needs	12	50
	EU level policies and knowledge exchange	5	21
	International level policies and knowledge exchange	3	5
	Scottish level policy tools and initiatives	5	24
	UK level policy tools and initiatives	13	83
Promoting resilience	Promoting resilience – general comments	4	9
	Financial costs	8	44
	Solutions that are or should be in place	13	163
	Role of organisations in promoting resilience	13	64
Stakeholders involved in tree health	Stakeholders involved	10	37
	Missing stakeholders	9	17

191

192 **Table 2.** Overview of the six nodes and 29 sub-nodes of the interview analysis including number of
193 sources and number of references for each.

194

195 **Results**

196 ***Definitions of resilience***

197 Given the complexities involved in identifying what resilience might mean in a forestry and tree health
198 context, we explored what policy actors from different organisations understood by the term.

199 A number of interviewees referenced resilience as the ability of forests and trees to “*carry on providing*
200 *benefits to society, despite threats such as climate change, pests and diseases*” (PE2) or “*to continue*
201 *to be able to provide the various ecosystem services and other services of forestry*” (PS3) and “*providing*
202 *the service that we provide sustainably and with contingency arrangements were things to change*”

203 (PCB1). Interviewees highlighted resilience as *“the ability of a forest to again cope with emergencies*
 204 *or cope with stresses that are put towards it and so on”* (PS2) comparing resilience to *“the health of a*
 205 *complete ecosystem and how robust it is to pressures”* (PE5) and that *“essentially, it’s protecting the*
 206 *things that are important to us under changing circumstances”* (PS1). Others provided definitions
 207 linked to components of resilience, namely *“recovery, resistance and adaptation”* (PE4) – in line with
 208 the frameworks and models of resilience described above (see Table 3).

	Engineering resilience – towards resistance	Ecological resilience – towards recovery	Socio-ecological resilience – towards adaptation
Number of total mentions	6	10	14
Interviews where only one form of resilience were mentioned	0	3	2
Interviews where two forms of resilience were mentioned	2		
Interviews where two forms of resilience were mentioned		1	
Interviews where two forms of resilience were mentioned	2 (engineering and socio-ecological)		
Interviews where three forms of resilience mentioned	2		

209

210 **Table 3.** Types of definitions of resilience provided by interviewees.

211 Six interviewees referred to engineering resilience, seeing it as *“the ability of a system to rebound*
 212 *after pressure, after stress, after some sort of shock, for its ability to rebound into the state where it*
 213 *was before, at least into a stable state again”* (PE1). Definitions from eight sat within ecological
 214 resilience, whilst twelve interviewees and the two focus groups referred to socio-ecological resilience,
 215 described as *“essentially, it’s protecting the things that are important to us under changing*
 216 *circumstances”* (PS4). Seven interviewees used two or more of the definitions of resilience in their

217 interviews. Within a tree health focus, interviewees highlighted the need to take a pro-active stance,
218 *“resilience [is] what you can do to prevent the entry and establishment of an organism”* (PS2).

219 There were, however, some criticisms around the continuing debate on what resilience means, with
220 some embracing the complexity of resilience as a concept, and others the opposite. One interviewee
221 expressed that, *“scientists and academics do ... overthink these things and whether there’s actually a
222 much simpler sort of thing that we can do, a much simpler definition and a much simpler view of it
223 really”* (PE1). This chimed with another interviewee who warned that *“by the time we get down to the
224 bottom of some of these words, it just becomes pseudo intellectual buffoonery”* (PW1).

225 A number of interviewees highlighted the importance of context when talking about resilience. For
226 example, one interviewee suggested that resilience was *“a complex concept that can be quite context
227 specific that can mean different things for different perspectives”* (PE4). Others concurred commenting
228 that: *“resilience is a context dependent term, just like “strong” or “big” or any of those words, they
229 don’t make any sense unless you have component of context”* (PS1), or that the understanding of
230 resilience depends on *“the policy context and what the landscape is trying to do or be or achieve or
231 what the policy issues are”* (PS2). Another key issue for interviewees related to who interprets the
232 term and for what purposes. For example, one interviewee indicated that the term made them
233 *“uncomfortable because different people may interpret it in different ways... I’m not totally convinced
234 that having a new word is going to make us act more!”* (PE5) leading potentially to a situation in which
235 we might be *“confusing people by using the word “resilience”, as though it’s something new when
236 actually it’s just a series of different things”* (PW1). For another interviewee, this multiple dimension
237 was perceived as a positive: *“we need a myriad of different definitions that work for different scenarios
238 and also that they will be dealt with in different ways”* (PE1).

239 Ultimately, all three interpretations of resilience were referred to by interviewees, with most
240 participants reporting that they wanted to maintain a broad range of approaches that spanned
241 multiple definitions and could be adapted to fit their own current policy contexts.

242

243 ***Why do we need resilience?***

244 Interviewees highlighted how resilience was part of a broader ‘multi-objective’ context in which there
245 was a requirement to balance the needs of different goods and services. One interviewee commented:
246 *“we want carbon, we want recreation, we want conservation, we want timber and all the rest of it”*
247 (PS3). As such, the answer to why we need resilience depended on the perceived forest management
248 objectives and end users. For one interviewee this had led to *“thinking about how we can really use*
249 *resilience in terms of thinking about it from kind of quite a broad perspective to help us protect and*
250 *enhance the ecosystem services that are provided by trees”* (PE4). This included looking at the wider
251 resilience of the economy *“focusing in on the timber industry, how the timber industry will manage if*
252 *for example, we couldn’t provide them with certain species like ash, for example”* (PCB1), as well as
253 resilience related to other public services. One interviewee highlighted resilience as being essential in
254 a broader ecological sense: *“as air, water and land are interconnected, a resilient terrestrial*
255 *environment is required to protect the water and air environment”* (PS4).

256 However, embedding the concept of resilience in a wider environmental context also included a
257 dimension of change, as one interviewee describes: *“a huge wave of change is upon us. We’re going*
258 *to have to make some choices. So what is it we want to keep? What is it that we want to be resilient*
259 *and against what? That’s a huge question which absolutely has to be answered”* (FG1). A number of
260 interviewees pointed out that this above question required some initial thinking including
261 understanding *“what is enough resilience?”* (FG1), at what point in time (with levels of uncertainty
262 increasing over time), and what resources might be available for creating resilient woodlands.

263

264 ***Resilient against what?***

265 Interviewees commented that *“resilience is a set of characteristics that is going to protect a thing from*
266 *a threat. So the questions are, the resilience of what? Against what?”* (FG1). When asked what forests
267 could or should be resilient against, a large mix of external threats and inherent vulnerabilities were
268 outlined in the focus groups and interviews. The most cited threat was climate change, with one
269 interviewee highlighting in particular that *“we see evidence of more extreme weather events, storms,*
270 *floods, storms particularly that have a big impact on forestry”* (PE2). Another interviewee argued that
271 climate change concerns were influencing management in the long-term, *“in terms of what would*
272 *actually grow in the future climate”* (PS3). Only one interviewee stated that they were *“not sure to*
273 *what extent climate change is yet impacting on trees”* (PE5). Another stressed the increased concerns
274 around adverse weather conditions, such as waterlogging and water stress. There was limited
275 evidence, however, according to one interviewee regarding droughts: *“drought is affecting woodlands*
276 *I think, I don’t feel that we’ve got very much handle on how much and how widespread that is but I*
277 *think it’s a problem”* (PE5).

278 These stresses no doubt increase the vulnerability of individual trees, stands and forests to pest and
279 disease threats. Indeed, the second most cited threat was the range of pests and diseases affecting
280 forestry, including Dothistroma Needle Blight, ash dieback (*Hymenoscyphus fraxineus*), *Phytophthora*
281 *ramorum*, pine tree lappet moth (*Dendrolimus pini*), Emerald ash borer (*Agrilus planipennis*), *Xylella*
282 *fastidiosa* and Acute Oak Decline. Interviewees were particularly worried about *“those new and*
283 *emerging ones that always pose the biggest threat to our established woodlands”* (PE1). One
284 interviewee emphasised the potential and immediate impact of pests and diseases in the context of
285 resilience: *“you might have your plan to develop woodlands that are resilient to climate change with*
286 *a 50-100 year time frame but if you get a new disease in, that starts wiping out your existing*
287 *germplasm, then your whole plan’s gone to pot”* (PE1). Another noted their feelings of helplessness
288 against pests and diseases: *“because of the way these things are spreading now, airborne things etc.,*
289 *our inability to defend our borders if you like, to me that’s one of the biggest worries I’ve got, [...] the*
290 *Xylella type disease where it’s cutting right across a whole range of species and we don’t really have*

291 *anything, to prevent it's spread by insects*" (PW1). Many interviewees mentioned the role of
292 unregulated movement of plant material in the spread of pests and diseases and the lack of diversity
293 of trees planted leading to more damaging impacts of pests and diseases. Interviewees also
294 mentioned non-native tree species that were perceived to have invasive potential and act as vectors
295 for disease.

296 In addition to climate change and tree pests and diseases, other threats were identified. One
297 interviewee raised the problem of deer, stressing that pressures from deer browsing were *"getting*
298 *higher and higher, that's a real difficulty*" (PE5). Other interviewees mentioned the threats from air
299 pollution emissions including nitrogen oxides, and impacts of contaminants from diffuse pollution
300 from agriculture and contaminated sites on forests. Lack of active forest management was also
301 mentioned by interviewees. One interviewee highlighted that *"around 40% of England's woods are*
302 *currently not managed, they don't have a management plan, they're neglected, actually that's*
303 *probably where the biggest risks are*" (PE2).

304 Interviewees mentioned the complex mix of threats acting synergistically, with one interviewee
305 highlighting that *"if new pests and diseases do get introduced, if climate's changing, the climate could*
306 *become more suitable to these pests and diseases becoming established as well or conversely, it could*
307 *predispose some of our existing trees, whether they're native or plantation trees, to adapt*" (PCB1).
308 Another noted that *"it's always about interaction so I'm most worried about the interaction between*
309 *climate change, pests and diseases and industry which is still highly reliant on government intervention*
310 *and a resource which is still, [...] small, isolated and lots of it is neglected*" (PE2).

311

312 ***Resilience at what scale?***

313 Interviews revealed concerns about resilience across both spatial and temporal scales. Resilience was
314 seen by one interviewee as requiring an approach spanning multiple scales: *"so you can have*

315 *resilience at the gross level, the very large scale level, right down to resilience at a tree level*" (PS1),
316 emphasising that different issues relating to resilience would need to be adapted to the most
317 appropriate scale. For example, in terms of climate change, one interviewee advocated that *"more*
318 *integrated land-use management and diversification at all levels is required and also to make the*
319 *landscape more resilient to climate change"* (PS4). On the specific issue of wind throw (i.e. when trees
320 are toppled by strong winds), focus group interviewees highlighted action again at the landscape scale:
321 *"one of the things that FES is currently focusing on a lot is resilience to wind throw in the landscape*
322 *issue. So we've been designing a lot of our coupes to be more wind resilient"* (FG1).

323 Interviewees also discussed the issue of resilience with regards to the long temporal frames in forestry,
324 acknowledging the difficulties of dealing with threats in this context. Managing for the long-term was
325 seen as challenging: *"it's quite easy for them to think of it locally as being a five year thing but thinking*
326 *of it going forward for 50/100/200 years when the climate is going to not be as it is today, it's very*
327 *difficult for people to picture in terms of sustainable natural resource management"* (PW1). Again, the
328 issue of timescales was linked to overall policy context, priorities and objectives: *"the question of how*
329 *resilient we need to be depends on what point in time and what set of circumstances you have in mind.*
330 *So if you're saying we're going into a future where there are increasing levels of uncertainty, then what*
331 *we've got to be going for is the most resilient landscape we can possibly engineer"* (FG1).

332

333 ***Current policy tools promoting resilience***

334 To understand which formal and informal mechanisms may help facilitate actions for resilience, we
335 explored with interviewees what policy tools and guidance were currently available. One interviewee
336 argued that *"there isn't something that I'm aware of that I would obviously say "that's a policy", formal*
337 *or informal, that relates to resilience. I'm not sure I can obviously point to something and say, "That's*
338 *a policy that's directly linked to resilience"* (PE1). This may be expected for an emerging system
339 property, where it would be more likely to be integrated into other measures. As such, interviewees

340 highlighted existing policies and instruments that could facilitate resilience- focused actions, and
341 reflected on whether these existing policies and instruments were sufficient to express and
342 communicate their understanding of resilience to others.

343 At the national scale, statutory action was identified as *“the primary [tool] trying to reduce the*
344 *pressures”* (PS3). Added to that, interviewees mentioned grant aid mechanisms (e.g. specific grant aid
345 packages to support *Phytophthora* removal, for instance). A number of policy tools were also
346 mentioned by interviewees, including the Plant Biosecurity Strategy for Great Britain (Defra, 2014a)
347 and the Tree Health Management Plan (Defra, 2014b). The UK Forestry Standard (FC 2011) was,
348 however, identified as *“the UK Government’s, including the devolved administrations, [...] line on*
349 *sustainable forest management”* (PS3). This statement, and the focus for many interviewees on the
350 UK Forestry Standard (UKFS), reflected their understanding of resilience as closely linked to
351 sustainability, and the belief that if you implement sustainable forest management, resilience will
352 follow.

353 Interviewees did, however, mention that the UKFS was difficult for forest managers to follow in its
354 entirety, which may lead to foresters choosing certain aspects of the UKFS that ‘fitted’ with their
355 needs. In addition, the UKFS was seen as only part of the solution: *“UK Forestry Standard gives you*
356 *the basic building blocks, you have to be cleverer than the UK Forestry Standard I suspect, in order to*
357 *get resilient woodlands”* (PW1). The suitability of the UKFS as an instrument for promoting SFM
358 amongst the majority of the UK woodland owners was raised, in particular for those with small
359 landholdings. Perceived largely as a regulatory guide and a practice standard for the grant application
360 process, the relevance of UKFS as a source of advice was questioned if not accompanied by further
361 translation and contextualisation to different types of woodland owners. As one interviewee
362 observed for smaller landowners, *“it’s very hard for them to engage, there’s so much regulation on*
363 *woodlands and I know that landowners complain a lot about that”* (PE5). This could lead to a situation
364 in which *“people could walk into owning a woodland pretty blind and not be aware of any of the*

365 *regulations that they're supposed to be undertaking*" (PE5) – and in turn the negative impact of 'over-
366 regulation' on building resilience. There was little explicit recognition of either the UKFS or related
367 regulations as tools to manage and communicate resilient forest practice. However, it was interesting
368 to note that a chain of custody certification i linked to the UKFS such as Grown in Britain was seen as
369 having the potential to impact on resilience by improving awareness of provenance (where
370 plants/timber come from). This again reflects the loose definition of resilience by interviewees, which
371 allowed a large number of initiatives to be linked to resilience. Other advice sources mentioned by
372 interviewees included guidance notes and practice guides produced by the Forest Research and the
373 UK Plant Health Risk Register². A number of advisory boards were also mentioned including the UK
374 Plant Health Advisory Forum which includes industry, non-government organisations and government
375 that *"try to get together, to look at issues and look at new plant health legislation that's coming on*
376 *board and try to get messages over as well"* (PS2).

377 At the European level, the main policy tool mentioned by one interviewee was the European Plant
378 Health Directive (Directive 2000/29/EC). A comment on this Directive from the interviewee was that
379 *"you're not really supposed to intervene with national measures, national legislation against pest or*
380 *disease until you know that there is a real threat of that pest or disease coming in"* (PCB1) . This
381 resulted in a situation where responsiveness was key, however *"by the time [...] we found that there*
382 *was ash dieback within the plant trade, the disease had probably been here for a decade before then*
383 *and that is the problem with that regime"* (PCB1). The European level was mainly mentioned by policy
384 interviewees in relation to sources of information on forest pests and diseases and their management,
385 either from EU sources such as the European & Mediterranean Plant Protection Organisation (EPPO),
386 or learning *"what's happened in other member states, either through the approaches that they've used*

² <https://secure.fera.defra.gov.uk/phiw/riskRegister/>

387 *to control an organism or where they've had problems"* (PS2) and the EU level monthly meetings of
388 the Chief Plant Health Officers³ to discuss emerging issues.

389 At the International level, interviewees highlighted the International Plant Protection Convention
390 (IPPC), described as a forum *"where countries get together once a year to discuss the development of*
391 *international standards, to try to prevent the entry of pests and diseases but also to facilitate trade"*
392 (PS2), and the World Trade Organisation (WTO) that sets the standard for free trade between
393 countries. In terms of advice, one interviewee pointed to the USDA website which has up to date maps
394 showing the locations of pest and disease occurrence and outbreaks as worth monitoring in the United
395 States.

396

397 ***Suggestions and challenges to promoting resilience***

398 The emphasis was very much to have a number of options at hand to facilitate resilience and adapt
399 strategies based on woodland owner and manager needs and priorities: *"one of the issues here is*
400 *getting this basic tenet of don't put all your eggs in one basket"* (CB1). Again, the broad definition of
401 resilience adopted by interviewees allowed for a wide range of ecological, policy and social options to
402 be suggested.

403 Although one interviewee noted they were *"not sure that anybody has necessarily any solutions at the*
404 *moment"* (PS2), others highlighted a range of mechanisms to support or advise forest managers on
405 promoting resilience. These included practical actions (e.g. thinning, sanitation felling, chemical
406 spraying applications); grant systems (to support tree removal in response to Statutory Plant Health
407 Notices or remove potential vectors such as *Rhododendron ponticum*); advice and guidance promoting
408 diversity in terms of tree species and genetic variability; and greater coordination amongst and

³ <http://www.consilium.europa.eu/en/council-eu/preparatory-bodies/working-party-chief-plant-health-officers/>

409 between relevant stakeholder groups. Each is explored in turn, including suggestions and challenges
410 highlighted by interviewees and participants of the focus groups.

411 Interviewees looked to other sectors and internationally for practical management actions to deal
412 with pests and diseases *“thinking about other forms of resilience-building, so using technology, some
413 of the evolving technologies in terms of crop protection may be required, like aerial spraying [for
414 Dothistroma Needle Blight]”* (PS3). Interviewees also thought about landscape resilience generally,
415 suggesting actions such as expansion of native woodland core areas and corridors, expansion of
416 riparian and wet woodlands in appropriate locations and with appropriate design, strategically placed
417 trees, shelterbelts, and woodlands for mitigation of diffuse pollution (air and land). For farmers, there
418 were calls for integration of trees within the agricultural setting and collaboration on catchment-wide
419 initiatives for multi-benefits as well as economic gain including incentives to utilise grant schemes.

420 There was a focus on the benefits of grants: *“grants do help and certainly, I think landowners like
421 pretending that they don’t use grants, they’re just a pain but I think they definitely do help oil the
422 workings”* (PE5). Another interviewee felt that *“if someone is in for a financial return and you want
423 them to change behaviour, compensating them for that change of behaviour is an obvious mechanism”*
424 (PE1). However, other responses to the grants approach was that it might make woodlands less
425 resilient *“what that results in is lots of woods which have a form of management which will only carry
426 on if they carry on getting a grant and that is a very unresilient system”* (PE2).

427 Promoting diversity in terms of tree species and genetic variability was a key theme amongst policy
428 respondents: *“one of the key things that I always seem to come back to is just variation, [...] part of
429 the fact that we have a lack of resilience is probably because we are growing monocultures and I think
430 you could argue the same in forestry or anything, if you have a lack of variation, certainly from a pests
431 and pathogens point of view, it’s an instant, easy target”* (PE1). According to some interviewees,
432 increasing diversity (e.g. in the face of climate change and to protect forests against pest and disease)
433 might require non-native provenances better suited to future site conditions and climate in the UK;

434 but introducing non-traditional species was also seen as requiring shifts in the timber market and
435 changes to saw mills and other industry components and with potential risks of introducing new pests
436 and diseases. Another suggestion was enriching genetic diversity as “... especially in light of very
437 cataclysmic diseases that might be knocking out 80% or more of the trees, if we have resilient
438 genotypes that we know of then I don't think it would be remiss to help spread them” (PE5).

439 A very strong theme through all the evidence sources was the need for more advice and guidance at
440 a practical level about how to respond to the threats posed by climate change as well as pests and
441 disease. As one person expressed it, “it's very difficult to find advice, there's not one single place where
442 I can go and say, “this is what I need to do”, I'm coming up with my own definition of what resilience
443 might be but I'm not getting it from any formal advice from anyone” (PE1).

444 More integrated land-use management and diversification at all levels was highlighted as needed to
445 encourage resilience at the landscape scale, particularly in response to climate change and associated
446 threats of more flooding, diffuse pollution, pests and diseases. Respondents felt there was a lack of
447 integration between forestry and other government policies, especially relating to land use due to “a
448 legacy of being seen as of only marginal relevance to other land uses and woodland expansion is
449 sometimes seen as a threat to farming. A process of addressing the flaws in the relationships between
450 different land use sectors needs to be developed” (PS4).

451 A more general aspiration amongst interviewees was to work “collaboratively with a range of
452 stakeholder organisations, environmental NGOs” (PE4) towards collective solutions to shared
453 problems. In terms of key partners to include in this collaborative approach, interviewees mentioned
454 the nursery sector, saw mills, private forest owners, government and statutory organisations, advisers
455 and professional bodies. Interviewees highlighted a range of stakeholders who were currently missing
456 from discussions and should be more effectively engaged, including nurseries (referred to by one
457 person as “the forgotten child at the bus-stop”(PS3)), other policy linkages such as those working on
458 the Chemicals Regulations Directive, woodland owners who do not engage with public agencies

459 through grants and regulations (estimated to be two thirds of all woodland owners according to one
460 interviewee), small woodland managers and owners, agents, community woodland groups, local
461 authorities who own woodlands, major institutional investors, and individuals and groups that design
462 and make financial predictions for forestry products. According to one interviewee, identification of
463 stakeholders should be followed as a first step as *“early engagement with them in understanding what
464 their challenges are and how they operate is essential if you're going to... to redesign your woodlands
465 to make them more resilient”* (PE1).

466

467 **Discussion**

468 Understanding what resilience in forests means in practice has been the focus of several recent studies
469 (Rist and Moen 2013; DeRose and Long 2014; Bone et al 2016; Fuller and Quine 2016). Bone et al
470 (2016) documented the extent to which resilience had been incorporated into US Forest Service
471 communication while in the UK, Fuller and Quine (2016) suggest that policy makers need a greater
472 understanding of what resilience encompasses and how it relates to the principles of sustainable
473 forest management in order to develop appropriate policies. Resilience is becoming an increasingly
474 popular concept to use when discussing how natural, social and economic environments can
475 withstand or respond to current and future threats (Adger et al 2011; Cavers and Cottrell 2014). In
476 forestry, growing pressures and uncertainties surrounding the potential implications of climate
477 change and increasing threats from introduced pests and diseases appear to make resilience an
478 attractive concept (Cavers and Cottrell 2014; Fuller and Quine 2016). Nevertheless, there is general
479 agreement that the complexities inherent in forestry and other environmental contexts presents
480 challenges to policy makers in the context of providing a clear definition and associated recommended
481 actions (Fuller and Quine 2016).

482 There is little to suggest that resilience is an entirely new idea with Bone et al. (2016) describing it as
483 the *“latest in a string of similar terms”* (p437) while others highlight ambiguities around current use

484 of the term (Brand and Jax 2007; DeRose and Long 2014; Hodgson et al 2015). Our interviews with
485 policy-makers from different UK agencies with environmental responsibilities, highlighted that most
486 knew about the range of definitions of resilience in the scientific domain, but were choosing to adopt
487 broader concepts around resilience, depending on their diverse policy interests, objectives and
488 perceived threats . However, there was some concern over the breadth and complexity of what
489 resilience might encompass in terms of scale, time, forest management objectives and the other
490 elements. Bearing in mind the strong message about the need for advice that can be understood and
491 implemented by a range of forest owners, increasingly complex definitions are unlikely to promote
492 practical actions and are more likely to add to confusion. Consequently the usefulness of the term and
493 whether it actually meant anything new, or different to “sustainability” was questioned by many
494 participants. In contrast, others were more comfortable with resilience as a concept that was more
495 flexible and fluid, with the possibility of many potential definitions tailored to the different audiences
496 and their objectives.

497 A number of authors have already acknowledged the difficulties of providing a single definition and
498 that resilience in forests is likely to be complex and context specific (Rist and Moen 2013; Fuller and
499 Quine 2016). The continuing debate around the definition of resilience is not simply a theoretical and
500 paradigmatic one though; the implications and impacts are practical, influencing individuals’ belief in
501 versions of resilience, the potential advice given and acted upon, and the policy direction and
502 instruments to flow from that definition. However, the variety of opinions generated by scientists of
503 different traditions, different forestry sector interest groups, public agencies and government policy
504 makers is not likely to readily result in a settled agreement at a strategic, issue-based or site-based
505 level. Without intervention, any certainty, consistency or clarity, in the messages about types of
506 resilient management actions to be applied in different contexts will remain elusive. Unsurprisingly,
507 policy respondents tended to take a broader viewpoint looking at protection of the ecosystem services
508 provided by forests. However, there was a strong agreement that context is important and that there
509 was a need, as Carpenter (2001) suggests, to identify resilience in terms ‘of what, to what’ (see also

510 Fuller and Quine 2016), coupled with additional concerns over resources needed to build resilience
511 and what was sufficient. It was very clear from interviews and focus groups in this study that policy
512 makers did not put forward a clear resilience-specific agenda or set of actions but rather a wide range
513 of measures of control and/or management of threats and diseases.

514 The two key pressures on forests of most concern to our respondents were climate change (Allen et
515 al 2010; Nelson et al. 2016; Keskitalo et al., 2016), including extreme weather events, drought,
516 waterlogging and species choice; and tree pests and diseases (Boyd et al 2013; Freer-Smith and
517 Webber 2015). These two issues can be interlinked, as climate change can lead to greater physiological
518 stresses for trees, create opportunities for new pest and diseases, and change population dynamics
519 of predators and prey. Several tree species which have been widely used over the years in UK forestry
520 are becoming temporarily less favoured due to susceptibility to pests and diseases or changing climatic
521 conditions (Marzano et al 2016). Under-management of forests was considered negatively by some
522 respondents but some research suggests that 'neglect' could contribute to resilience (Dandy 2016).
523 There is a need to better understand at which stage neglect becomes a hindrance to resilience, and
524 what proportion of 'neglected' woodland is helpful.

525 We found that policy-makers were unaware of a single policy tool either regulatory, incentive, or
526 communications or campaign based, that was specifically focussed on resilience. Whilst this may not
527 necessarily be a barrier to increasing resilience, it does suggest that interested stakeholders may need
528 to make additional efforts to learn about issues and potential solutions, and face the challenge of
529 navigating a complex array of multiple and often contradictory information sources. What
530 interviewees did highlight was the array of available policy tools with the potential to act on some
531 aspect of improved resilience. However, none were considered to be fully effective, because they
532 focussed on specific threats rather than synergistic effects i.e. emergent resilient properties of forest
533 ecosystems, or they were not rapid and responsive enough to address the immediate and often
534 sudden impacts from threats such as pests and diseases. In addition there were comments about

535 barriers related to awareness and understanding, such as regulatory tools being too complex for
536 certain audiences (highlighting the challenge of trying to communicate the vastly more complex issues
537 surrounding resilience), or many owners and stakeholders simply being unaware of their very
538 existence. This highlights a very real concern about knowledge exchange breakdown between policy
539 and societal actors (Young et al., 2014). It may be that the understanding of resilience as a flexible
540 concept, with many potential definitions tailored to specific target audiences, requires a nuanced and
541 dynamic policy approach. In other words, policy needs to develop and support a range of tools with
542 some relevance to resilience from which audiences can select depending on their management needs
543 and forestry context (DeRose and Long 2014; Fuller and Quine 2016). The challenge for policy makers
544 then is to contextualise resilience in line with stakeholder needs (Fuller and Quine, 2016), and,
545 importantly, propagate awareness of this through communications channels and platforms trusted by
546 those stakeholders.

547 Moving away from policy tools, it was apparent that certain general approaches were seen as
548 beneficial to improving resilience. Promoting resilience was seen as a joint challenge requiring
549 collaborative action between all stakeholders: from government departments to forest managers,
550 owners and other relevant actors. Whilst interviewees outlined a number of existing collaborative fora
551 and processes, it was acknowledged there were stakeholders currently missing from existing
552 processes. In the UK forestry sector, public agencies regard the uptake of grants by private forest
553 owners as a key route to engagement with policy, either by directly changing the behaviour and
554 practice of forest and woodland owners and managers, or by using engagement as a route for
555 communication. However, research suggests that many owners, particularly small woodland owners,
556 do not engage with the grant system (Lawrence and Dandy 2014), and engagement may have limited
557 influence on other parts of the sector. Communicating with such stakeholders and identifying factors
558 that will motivate them to act appears to be an important priority for the future (Marzano et al 2015).

559 Currently, the lack of specific resilience tools means it is difficult to clearly identify what is being
560 adopted, and to what extent these approaches are proving effective in terms of achieving 'enough
561 resilience', whatever that may mean to different actors. Whilst improving resilience may be a policy
562 goal, we are still some way from knowing whether and how this is being achieved. For example, a
563 focus on resistance involves actions that try to prevent the impacts of change whereas adaptation
564 accepts that disturbance will likely happen and develops strategies to cope with or respond to that
565 disturbance. There are potentially differences in approach that could result if one pursues resistance
566 (e.g. development of resistant/tolerant trees) as opposed to adaptation (e.g. changing tree species
567 composition) at different spatial scales and landscape types. Temporal actions also make a difference
568 when identifying implications of resilience thinking on forest planning with pre-emptive actions
569 signalling a desire to avoid or defer significant impacts while post-disturbance actions embrace or
570 adapt to change (Fuller and Quine 2016:15).

571 Our research revealed that different types of owners, managers and businesses in the forestry sector
572 not only have different needs and work in different contexts, but also their understanding, acceptance
573 and application of resilience concepts may vary from stated policy positions. Actions promoted for
574 example to adapt to climate change, may not be suitable or convincing to them. Our evidence
575 suggested the need for greater articulation of responses more closely aligned with transformation
576 (e.g. grants for phytosanitary felling, "redesigning British woodlands", accepting alternative land uses
577 to forestry), resistance (e.g. tree breeding, dealing with pest outbreaks using chemicals) and recovery.
578 This presents part of the challenge for decision makers and those involved in policy responses, as
579 resilience is a multifaceted concept with an array of potential responses, connected with an equally
580 diverse set of forest ecosystems. The collaborative development and promotion of an overarching
581 vision that recognises the needs and contexts of different owners and managers in the sector might
582 begin to overcome the challenge of fragmented and uncoordinated policy and policy tools for
583 resilience. This will need to involve many - including different areas of government, agencies and
584 organisations responsible for the science behind resilience approaches and practical responses, and

585 sector representatives; it will need to address ways to articulate the uncertainty associated with
586 measures, and the contexts in which they might be applied so public agencies, forest owners and
587 managers can make informed choices.

588

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598

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700 Annex 1

701 PROTREE – Policy questions:

702 • Informant details

703 ➤ Background e.g. country, discipline, training

704 ➤ Organisation

705 ➤ Role

706 ➤ Length of time in role

707 ➤ Location

708 • Definitions of resilience and key concepts used:

709 ➤ What/when do you use the term resilience and what do you mean?

710 ➤ In a forestry context what do we want to be resilient against and why?

711 • Key policy tools and instruments that promote tree health resilience:

712 ➤ What do you think of role of formal or informal mechanisms (grants, regulation, social
713 peer networks, membership of bodies, campaigns such as Grown in Britain, toolkits,
714 PES, guidelines UKFS or other etc) might be in promoting or encouraging resilience
715 whether as policy tools/instruments or something else?

716 ➤ Will policy documents such as the UKFS help deliver resilience?

717 ➤ What are the other key tools/instruments that impact on resilience at country, UK and
718 EU scales?

719 ➤ Do they help/hinder tree health resilience?

720 ➤ Are there trade-offs/conflicts between these policy tools/instruments?

721 ➤ Any examples of benefits/successes of policies?

722 ➤ What are the barriers/challenges to implementation of policies at the country/UK/EU
723 scale?

724 • Promoting resilience

725 ➤ What do you think managers should be doing to promote resilience?

726 ➤ Is the forest sector following policy guidelines (UKFS) for adaptive management (and
727 therefore) resilience? How do they know this?

728 ➤ What changes/additions to policies are needed to promote resilience?

729 ➤ Who should be involved in resilience planning and decision-making (or who/which
730 stakeholders missing)?

731 • Communication

732 ➤ To what extent do you draw on different types of information and advice? Where
733 from?

734