Forest Research

Enhancing the resilience of our trees, woodlands and forests

A framework for implementation

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The Research Agency of the Forestry Commission

Contents

Acknowledgements

Forest Research would like to thank Defra (through the Future Proofing Plant Health programme) for funding this publication and the research to develop the underlying framework, and those who helped to test an earlier version of the Framework, including participants from the England Woodland Biodiversity Group, Forestry England, Hertfordshire County Council and partners, the National Forest Company, Tilhill Forestry and the Woodland Trust.

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January 2022

Introduction

Interest in resilience and how to achieve it has increased in recent years as managers of trees, woodlands and forests have grappled with growing uncertainties related to climate change, pests and diseases, as well as other threats. However, a common understanding of what resilience means and how to go about resilience planning has been lacking. This framework introduces an approach to help facilitate a common understanding and support decision-makers who are interested in resilience. It aims to provide a structured way to think and plan at different levels, whether strategic, tactical or operational, and to help identify suitable management actions.

Resilience is how a system responds to a disturbance or threat. This can be broken down into four components, resistance, recovery, adaptation and transformation (Figure 1).

The framework is made up of five steps:

1. Define the system
2. Identify threats to the system
3. Identify the level of acceptable change
4. Identify the desired pathway and related management actions
5. Monitor and learn

The key points underpinning the framework are:

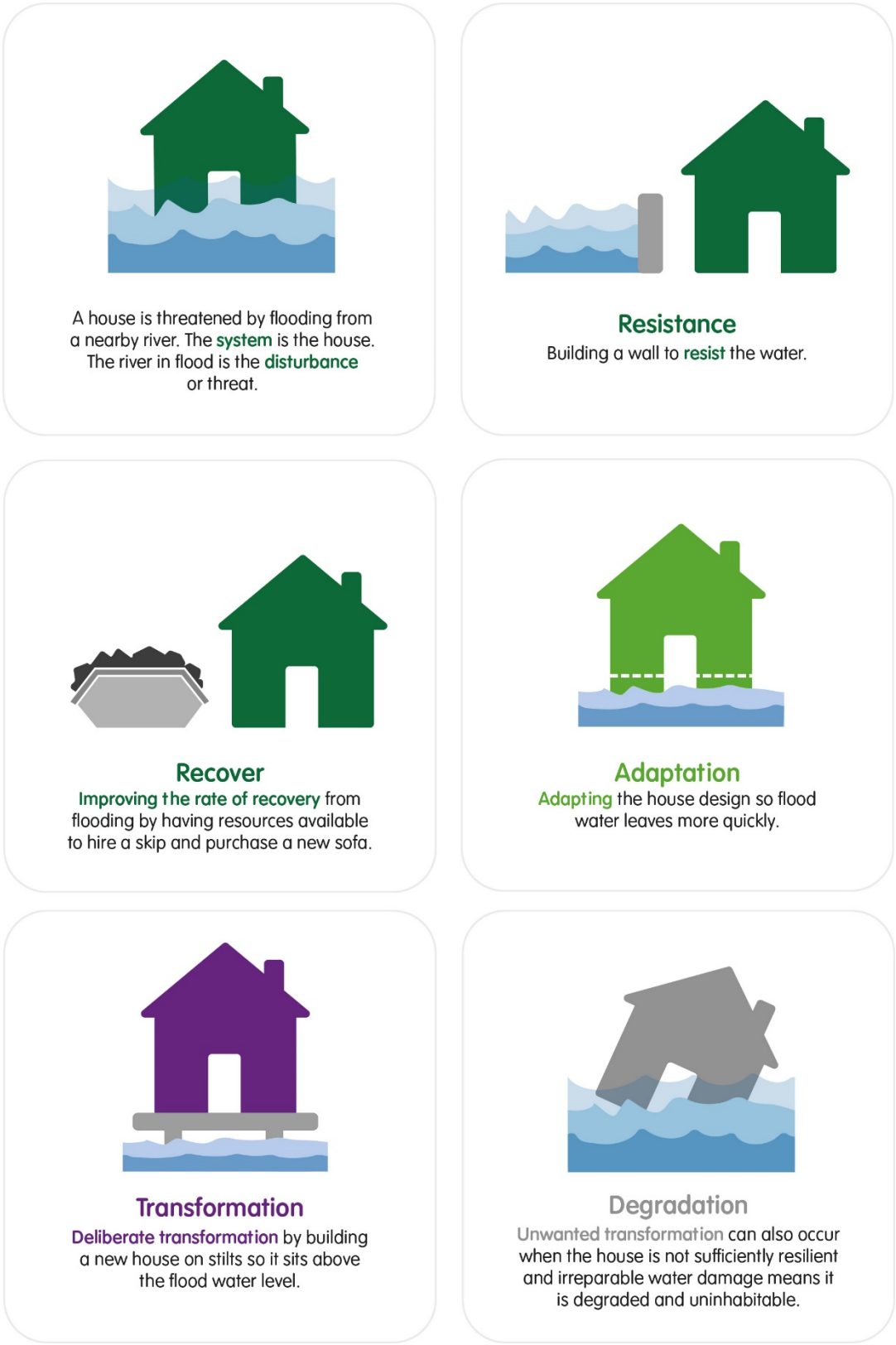
(i) The five steps in the framework ask questions and provide example responses as prompts to thinking and planning. The steps have been trialled using case studies with forest managers, conservation organisations and policymakers interested in resilience across a range of different settings. Examples of the responses from these users are shown throughout. The trials showed that the focus of the resilience planning and the possible actions vary for a range of reasons (e.g. depending on the size of the area being considered, management objectives and local context).

(ii) Those involved in resilience planning need to work together to develop a common understanding around resilience. This framework can facilitate those conversations.

(iii) Resilience does not usually require completely new thinking. It is more likely to involve bringing together existing ideas and priorities, and working through these in a joined-up, step-by-step way. A blank template with the key questions related to each framework step is available in Further resources. A larger version of the template is available online.

(iv) Resilience can be achieved through a set of actions that help with resisting, recovering or adapting to threats (Figure 1). A fourth situation (i.e. transformation) can also sometimes occur that can be positive or negative. How these responses are prioritised will depend on the woodland, trees or area of interest.

Figure 1 Basic illustration of a resilience framework considering responses to flooding for a house owner.



Who should use this framework?

This framework is aimed at managers of trees, woodlands and forests, as well as other stakeholders with an interest in these habitats (e.g. policymakers, community groups). It applies across a range of management objectives and a diversity of settings, from urban amenity trees to ancient woodlands to commercial plantations. It can be tailored to a range of spatial scales from local to national, and to a range of timescales. The framework steps can also be applied by related businesses and organisations such as sawmills and nurseries.

When and where is it useful?

This framework may be useful in various contexts:

- Facilitating planning within an organisation, or discussions between organisations (including those that may have differing priorities);
- Considering ways of enhancing the resilience of trees, woodlands and forests;
- Reacting to concerns about increasing threats (e.g. tree pests and diseases);
- Responding to an organisational drive to focus on resilience;
- Demonstrating planning for resilience to internal or external stakeholders;
- Exploring the resilience concept, challenging current thinking and reassessing perspectives.

The framework is designed to be valuable for people interested in resilience across a range of different settings and in relation to different types of threats. The text below shows how it can link with wider policy, using tree health in England as an example:

The key recent tree health document is Defra's Tree Health Resilience Strategy (THRS). This describes policy objectives to protect England's tree population from pest and disease threats. It sets out the reasoning and the strategy for building resilience, including actions to resist, respond to, recover from and adapt to these threats. The identification of actions in the THRS relates closely to Step 4 of this framework.

The framework can be used to support implementing the THRS. It helps to encourage a joined-up process for thinking about resilience (Behavioural goal 5) and identifying the most appropriate actions to take (Chapter 6 of the THRS). Those with a focus on tree health should also consult the THRS for potential actions and the rationale for focusing on resilience in relation to pests and diseases.

Other strategies will provide equivalent context for those focussing on other threats or trees, woodlands and forests in other countries.

How to use the framework

It is expected that most people will initially read the framework individually to assess if it is right for them or their team. If you decide to work through the steps of the framework, then doing so as a group is recommended, ideally involving a diversity of perspectives to challenge thinking and stimulate fresh ideas. At each step we have provided hints and tips and a table providing examples from case studies, and throughout the framework you will find dark purple boxes containing guidance for those facilitating group work (Box 1). The framework begins by introducing the concept of resilience. A five-step process is then described, followed by detailed information on each step.

Box 1 Facilitator's Guide

You might find bringing together a team of people with a facilitator an effective way to work through this framework. The benefits of a facilitated workshop are that it supports more complete and different ways of thinking. A facilitator can help to challenge the team's assumptions and promote discussion on the opportunities and threats.

Aim of the workshop: To bring together different teams or organisations to develop a strategy or management plan focused on creating a resilient system.

Role of the facilitator: The ideal facilitator is someone who can prompt conversation, engage the group with different ideas and promote consideration of factors outside the status quo. To support open discussion this responsibility is often best placed with someone who does not hold a position of authority. As the facilitator you may want to learn more about resilience ahead of the workshop; there is recommended resilience reading at the end of this document. In larger groups, the facilitator may need support from one or two others.

Requirements:

Time: Workshops last 2–6 hours. Previous participants have found that an initial 3-hour workshop, with an additional follow-up session lasting 1 hour a few weeks later to reconvene and review agreed actions, can be effective.

Participants: It is best to get a wide range of participants involved. This could be across a team or organisation (e.g. budget holders, managers and ground staff) or could be across several organisations who are stakeholders. Participants should have the opportunity to read through the framework beforehand and be encouraged to bring relevant information with them.

Materials: A whiteboard or flipchart paper, notepaper and any previous information on your area of interest (e.g. previous strategy or forecasted threats).

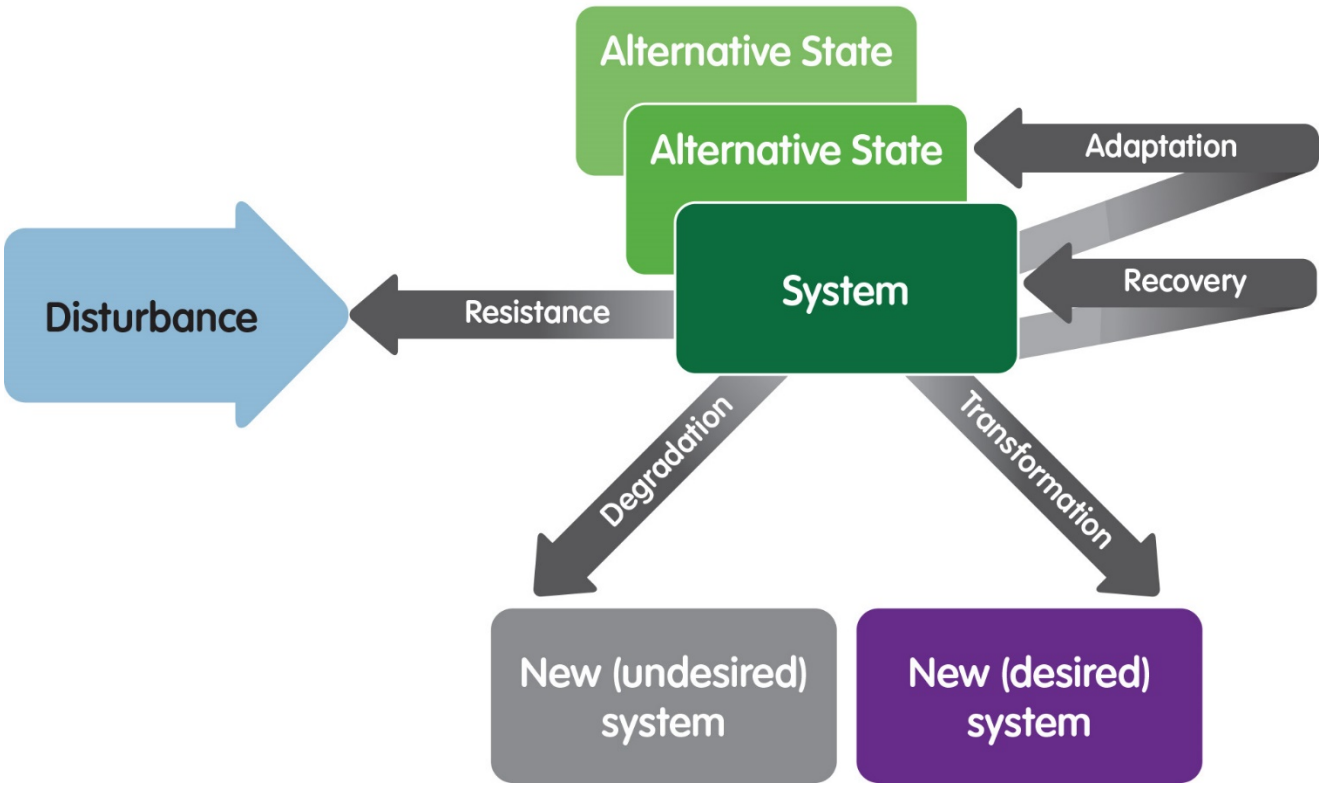
Recommended agenda:

10 minutes	Introduction
15 minutes	Define and discuss the group's understanding of resilience
2 hours	Steps 1–4 (~20–25 minutes for each step)
30 minutes	Consolidate discussion
	Reflect on the discussion and any points that require further consideration
10 minutes	Step 5: Monitor and learn
10 minutes	Review required actions to meet the identified opportunities and threats
	Organise a follow-up meeting

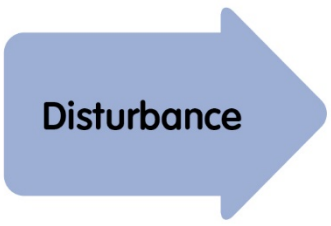
The resilience concept

Resilience can be broken down into four components: **resistance**, **recovery**, **adaptation** and **transformation** (Figure 2). These reflect how a system (e.g. a group of trees, woodland, forest) changes in response to **disturbance**. Each of the four components might occur without intervention, but they can also be supported or hindered by management actions. Note that the distinction between some of these components depends on how the system is defined and can sometimes be blurred, particularly between adaptation and transformation.

Figure 2 Illustration of the resilience concept.

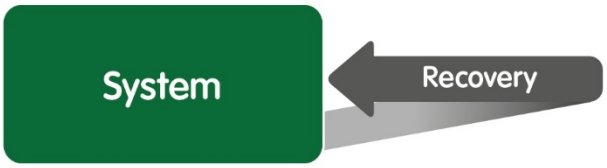


Disturbance is the threat, shock, stress or disruption to the system against which resilience is sought. There may be multiple disturbances, particularly when long planning timescales are considered, which may include climatic, biotic (e.g. pests and diseases) or economic (e.g. threats to markets). Many disturbances may not be preventable or predictable (e.g. drought, storm, novel pests), hence the focus on the resilience of the affected system.

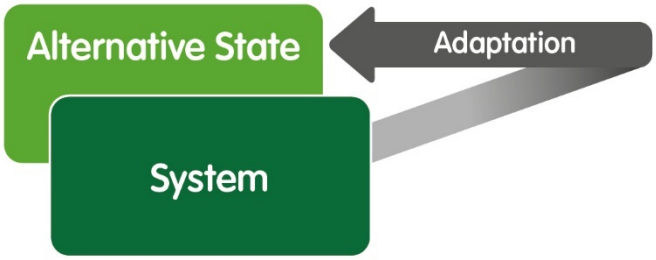


Resistance is the ability of a system to prevent or absorb impacts from a disturbance and continue to function in the same state. Resistance may be enhanced through preventative actions (e.g. deer fencing to reduce the impact of browsing).

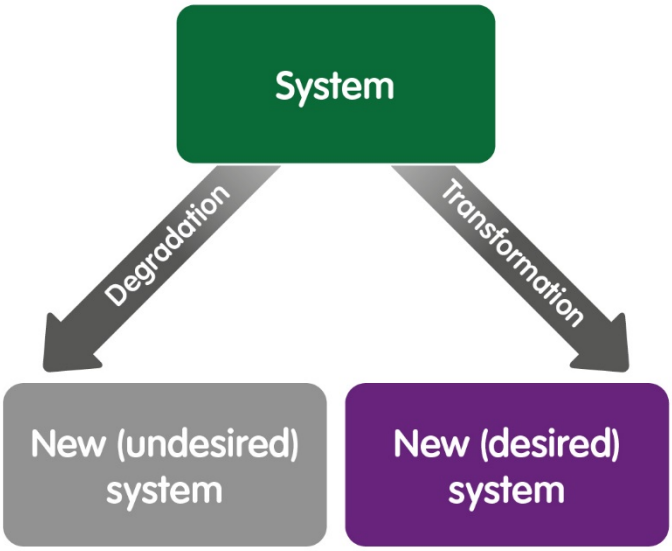
Recovery is the ability of a system to bounce back to its original state (e.g. with fundamentally the same structure and function). Recovery is therefore a process/activity that largely occurs after the impact of disturbance, but preparatory steps can be taken (e.g. protecting natural regeneration in a semi-natural woodland to promote recovery after a windthrow event).



Adaptation can describe the often longer process through which the system is modified to accommodate impacts without losing its essential character/identity (e.g. the mix of tree species may change over time in response to disease, but the overall functions/values of the woodland remains).



Transformation is when the response to the disturbance is so dramatic it results in the creation of a new system. This may be acceptable or even planned when the existing system is undesirable (e.g. poorly growing trees on deep peat being removed to allow peatland restoration) or when adaptation will be insufficient to counter a threat. Alternatively, transformation may involve **degradation**, when recovery fails after a disturbance and a new unwanted system develops by default (e.g. the failure of felled areas to recover due to overgrazing).



Framework overview

Below is an overview of the five steps upon which this framework is based. In the following pages, each step will be introduced in more detail, with suggestions on how to apply the step to your context, including hints and tips that have emerged from case studies.

1 Define the system.

What are you considering making more resilient?

2 Identify threats to the system.

What main threats or disturbances might impact the system in the future?

3 Identify the level of acceptable change.

How far can the system be modified before it ceases to be recognisable or desirable?

4 Identify the desired pathway and related management actions.

What actions might bring about positive responses to present or future disturbances?

5 Monitor and learn.

What can you do to learn about the resilience of your system, identify possible degradation and inform future management as you go along?

Step 1: Define the system

What are you considering making more resilient?

It is essential to be clear about the focus of your thinking. For example, you might focus on the ecological integrity of woodland, in which case the system might be defined by the tree species or woodland type (e.g. an oak woodland). Alternatively, you might want to focus on the resilience of your organisation, which includes objectives beyond forest management. Different spatial scales (e.g. the size of woodland or number of sites) and time frames (influenced by budgets or management plans) will impact the assessment of threats and appropriate actions. It is also necessary to define the main functions or services that you want the system to maintain over these scales. Table 1 contains guiding questions that will help to pin down the system identity and some examples from our case studies.

Table 1 Guiding questions and examples for Step 1.

Guiding questions applicable to all settings	Forest management company	County council
(a) What is the system? For example, woodland, ecosystem, organisation, business.	A large privately owned upland conifer plantation dominated by Sitka spruce	The entire county's treescape, including both publicly and privately owned trees, from street trees to ancient woodlands
(b) What is the time frame being considered? For example, years, decades, centuries.	35–40 years to match the average rotation length	Working to a 25-year vision with 5-year management plans while keeping longer timescales in mind
(c) What is the spatial scale being considered? For example, local, catchment, regional, national.	The entire 600-hectare forest site	County scale
(d) What are the main functions/services to be maintained?	To generate financial returns for investors	Multiple objectives (e.g. amenity, biodiversity, carbon sequestration) reflecting the diverse ownership

Hints and tips for Step 1

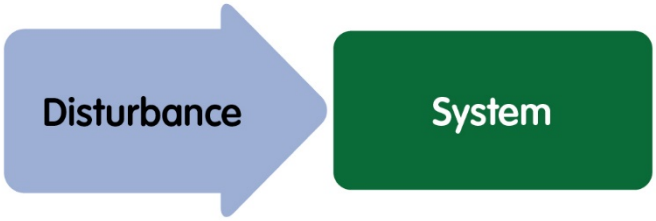
- Clear system identification is important and will ease progression through later steps. Testing ideas among colleagues can be helpful and reaching a common understanding will be important if the group work is to continue (Box 2).
- You may want to repeat the steps to focus on more than one system (e.g. a single woodland and a group of sites at a landscape level). This can be performed in parallel or one after the other.
- Defining timescales in the context of trees and ecosystems can be challenging. It may be dictated by management plans, budgets and rotation length that provide intervention points.
- Sometimes the system of interest becomes clearer after working through subsequent steps. You can return to Step 1 to refine the identification later in the process.
- It may be useful to start broadly then narrow in on the system later to avoid missing some threats.
- If the aim is to manage a transformation to a new system, use the same guiding questions to help identify both the current system and the future desired system.

Box 2 Facilitating different opinions

Definitions and areas of priority can differ between and within teams. As a facilitator, it is important to allow each person the opportunity to contribute, and to challenge the group to question the current way of thinking. It might be useful to mind-map all the definitions of resilience and possible systems. This can help the group to reflect on the similarities and differences. It might also be useful to refer to this later to see if there have been any changes of opinion after the workshop.

When defining the system, it might be worth considering all versions of the system (e.g. wildlife, economic, business or species) before deciding on a single definition that suits your context. It is possible to adjust your focus as you discuss each step. It is also possible to return to Step 1 and change how the system is defined later in the workshop.

Step 2: Identify threats to the system



What threats may challenge the system's ability to persist in its current or desired state?

These may be biotic (e.g. pests), abiotic (e.g. drought) or social/economic/political (e.g. built development pressure) threats, shocks and stresses (Table 2). Some threats may be commonplace and manageable, while others may represent an unacceptable challenge to your system. Some may be negatively impacting your system already, whereas others may not yet be present. Threats can also interact (e.g. climate change and disease), leading to further disturbance.

Table 2 Example systems and threats for Step 2.

Main category of threats	Publicly managed multifunctional forest	Restoration site (plantation on ancient woodland site) managed by conservation organisation
Biotic (biological)	• Mammals (e.g. squirrel and deer) • Insect pests (e.g. pine weevils) • Plant disease impacting species choice (e.g. *Dothistroma* needle blight affecting Corsican pine)	• Mammals (e.g. squirrel and deer) • Current and new insect pests and diseases • Loss of natural processes (e.g. woody debris)
Abiotic (physical/chemical)	• Pollution (excessive atmospheric nitrogen deposition) • Climate change (wetter/warmer winters and hotter/drier summers) impacting fire risk and water availability	• Climate change (in particular high rainfall events becoming more frequent, coupled with the steep terrain causing erosion and flooding)
Social/economic/political	• Reduction in value of timber markets • Future food security may involve land-use change from forest to agriculture • Recreational disturbance to ground nesting birds	• Opposition to thinning and felling (limits the options for building irregularity into the even-aged stands) • Increased competition for funding internally and from other charities

Note: see more examples on the template in Further resources

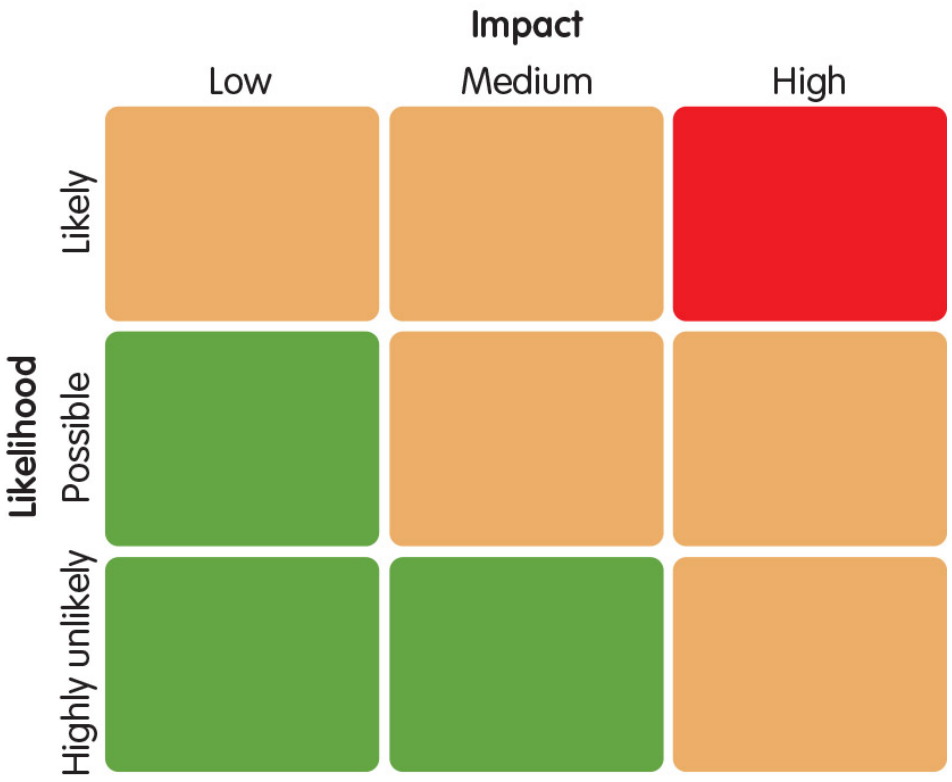
Hints and tips for Step 2

- On the first attempt, treat this step as a brainstorming exercise. Evaluation of actions, prioritisation and synergies can take place later.
- You may want to add further columns to Table 2 to include:

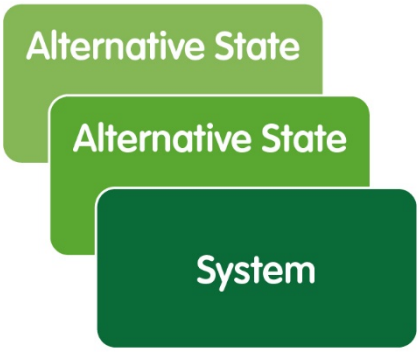
  (i) What is the likely frequency of the threat within the timescale of interest, and does the severity increase and decrease in 'pulses' or is it more prolonged and ongoing?

  (ii) Are there synergistic effects in which one threat acts to increase the impact of another (e.g. the potentially increased susceptibility of stressed trees to secondary pests/diseases)?
- After threat identification, you may want to use a matrix to order by impact and likelihood (Figure 3). The focus should be on high/medium risk threats in the red and amber sections. The categories can be expanded to fit your circumstances.
- Look back at the system identified in Step 1. Do the threats match the defined system?

Figure 3 Threat identification matrix.



Step 3: Identify the level of acceptable change



How much can the system (or planned future system) change before it reaches an undesirable state?

At what point do the key structural or functional aspects identified in Step 1 become threatened and require action, either to avoid the threshold being reached or to bring the system back to a desirable state? These are often challenging questions and the answers are highly dependent on the system of interest and the local context (Table 3). There may be several acceptable alternative states (e.g. woodland of varying age or species structure), but maintenance of the system (i.e. always a form of woodland) may be the goal. Natural systems may not rapidly return to the pre-disturbance state, requiring judgements regarding whether recovery is taking place or if the path is one of degradation, in which case interventions may be required. An acceptable length of time for recovery to the pre-disturbance state should be selected.

Table 3 Guiding questions and an example for Step 3.

Guiding questions applicable to all settings	Conservation organisation woodland
Is the level of acceptable change defined by structure? For example, the mortality of certain species or habitat loss.	Positive: • Increase in native broadleaved species • Increase in ground flora Negative: • Increase in invasive species • Loss of target indicator species

Is the level of acceptable change defined by function? For example, reduced carbon sequestration or income.	Positive: • Increase in natural regeneration • Increase in structural diversity and mosaics Negative: • Decline in visitor numbers or public support
Are the boundaries fuzzy or precise?	Species change and visitor numbers can be measured for a precise boundary Desired level of natural regeneration is a fuzzy boundary
Are thresholds involved?	Multiple thresholds including the required complement of indicator species to achieve the desired habitat
Are there potential trade-offs or different stakeholder priorities?	Increase in visitors (desirable for public engagement) could result in site damage and wildlife disturbance

Hints and tips for Step 3

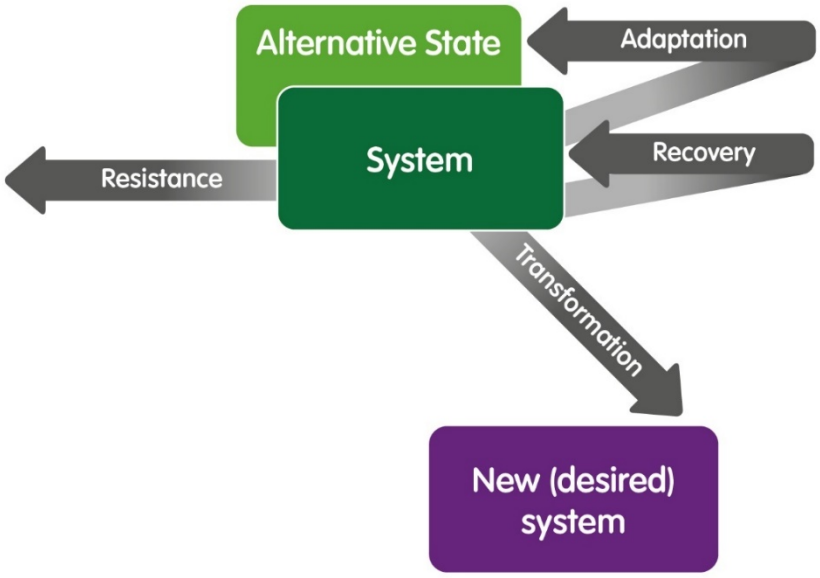
- This step will reinforce/test the clarity of the initial system definition (Step 1), which may need to be adjusted to make progress.
- It is often challenging or undesirable to define precise boundaries to acceptable change (Box 3). In these cases the boundaries are deemed 'fuzzy'.
- It can be helpful to think about both positive and negative changes, and thereafter the thresholds or boundaries between them. This process may also be useful when planning a managed transformation to a new system.
- It may also be helpful to describe signs of degradation, that is, unwanted change towards an undesired system (e.g. reduced regeneration of a desired tree species, greater unpredictability in yields, soil erosion at specific sites).

Box 3 Scale and position of acceptability

Change in a system may be more or less acceptable at different levels and scales in different organisations. The group might want to break into smaller groups to consider how a change could affect different stakeholders. For example, if a native tree species is affected by disease, what other species might this have an impact on? People and organisations will be invested with different interests, so take a moment to identify the groups you might not usually consider. Here are some possible questions to think about:

- Is the change more acceptable at a county or neighbourhood scale?
- Is the change positive or negative?
- Where are the conflicts and agreements between the interested groups?

Step 4: Identify the desired pathway and related management actions



Which pathways and management actions produce the desired system outcome?

Resistance, recovery, adaptation and transformation represent pathways to increase resilience or change to a more resilient system. Focus can be given to one component (e.g. prioritising management techniques to increase **resistance** to an anticipated disturbance such as a pest). However, resilience may also be achieved by identifying appropriate actions for each component and then selecting from them.

It is important to identify, evaluate and prioritise a range of actions. Some actions already being taken may well apply, but there may also be a need to develop new methods, adapt old ones and consider the collective effect of all the actions being implemented. It is necessary to consider how management plans might be affected by future disturbance events or by changing objectives. A narrow set of actions, or locking the system into one rigid pathway, could be detrimental in the future, even if it appears suitable at present (Table 4).

The management objectives will influence responses to disturbance and the methods chosen for building resilience. For example, if it is vital to maintain the system in a particular state, then methods that emphasise resistance or very rapid recovery might be prioritised. The strengths and weaknesses of different management options and their potential for both desirable and undesirable consequences should also be considered.

Table 4 Management action examples for Step 4.

Resilience component	Actions identified in response to the threat of insect pests and diseases by a private forest management company for an upland plantation	Actions identified in response to the threat of drought by the County Council managing trees in a diversity of settings
Potential resistance actions?	• Clean machines regularly (i.e. biosecurity of harvesting machinery, lorries and excavators) • Buy-British-first policy when sourcing plants (although some imports needed to meet demand) • Rhododendron removal (host for *Phytophthora ramorum*)	• Plans and capabilities for watering to combat drought (especially of newly planted trees) • Vegetation management (e.g. weed control for young trees) • Site choice for new planting (e.g. use of sustainable drainage systems in urban areas)
Potential recovery actions?	• Licensing of mills (e.g. to accept infected timber) • Alternate restocking systems (e.g. use of natural regeneration) • New rides to improve inspection and harvesting access	• Further use of the resistance measures outlined above (e.g. watering and vegetation management), if mortality has yet to occur • Pruning of street trees • Coppice management in woodlands
Potential adaptation actions?	• Alter restocking choices (e.g. no larch planting after *P. ramorum*) • Adjust forest design (e.g. thinning to increase airflow and reduce foliar pathogens) • Continuous cover forestry (site-specific, as a form of diversification)	• Planting drought-resistant species • Installation of grey water systems • Amend local plans to directly reference best practice guidance • Encourage public engagement in watering schemes
Potential transformation actions?	• Species change (e.g. trialling the use of Lutz spruce in the east)	• Infrastructure planning (e.g. changes to verge width) • Choose not to replace certain trees • Shift woodland creation to other less drought-prone areas

Note: see more examples on the template in Further resources

Hints and tips for Step 4

- Similar to Step 2, treat this step as a brainstorming exercise on the first attempt. Evaluation of actions, prioritisation and consideration of trade-offs and synergies can take place later.
- Depending on your focus, you might find it useful to look at toolkits and guidance available elsewhere, such as the UKFS or the Woodland Star Rating self-assessment scheme. Further resources are also available at the end of this framework.
- Categorising actions as part of resistance, recovery or adaptation pathways is useful for understanding timescales and for identifying complementary actions that ensure resilience is fully considered. However, actions do not always clearly belong to one pathway or another. If one is causing difficulty, consider making a holding decision and a note to come back to it later. You may eventually decide that the same action belongs in more than one pathway.
- The pathway under which certain actions are listed may change depending on how you identify the system in Step 1.
- Once completed, you may want to prioritise actions (Box 4), search for recurring actions and synergies and develop an implementation plan. This could also take into consideration potential trade-offs and conflicts/unintended consequences of potential actions.

Box 4 How to prioritise actions.

Step 4 may result in a long list of possible actions. The best way to deal with this is to evaluate, prioritise and assign each task to the relevant person or team. There are several ways of approaching this and different teams may find that one method works better than another. Once you have created a list of possible actions, here are two possible methods to prioritise them:

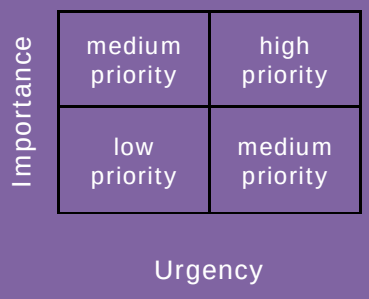
The Breakdown

Identify the short- and long-term goals.
Breakdown the tasks required to achieve the goals into actions.
Categorise each action into a time frame (e.g. this year, next month, this week).
Assign the actions to the relevant person or team.

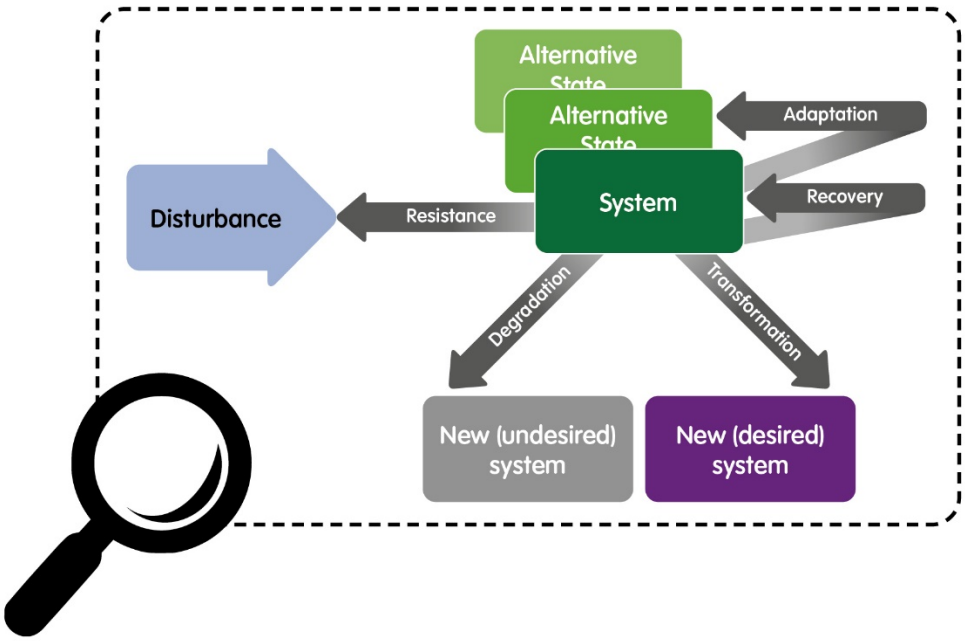
The Matrix

Create a 2 x 2 table, with Importance on the y-axis and Urgency on the x-axis. Assign each action to an area on the table based on how urgent and important each is. Thus, highly important and urgent actions would appear in the top-right corner. Assign a deadline based on the priority level.

The time frame will differ between actions and goals as your system may work on a 5- or 25-year cycle.



Step 5: Monitor and learn



How might the system change and when will the desired outcome be achieved?

The outcomes of the management and the implementation of the actions identified in Step 4 should be monitored and assessed to learn more about the resilience of your system.

In this way, management can adapt to the sequence of events that occur, to early signs of degradation and the changing environmental/economic/socio-political conditions. Monitoring also helps to understand how effective different actions are, and how they might be changed in the future (Table 5). Such learning may be a continual process, but a formal review may need to be scheduled to ensure that lessons are captured. It is important to ensure that information is collected and stored in ways that allow review and learning.

A useful exercise can be to examine a selection of priority threats and associated potential management actions from the previous step and compile a list of monitoring activities (some of which you may already conduct; others may be desirable).

Table 5 Monitoring examples for Step 5.

Threat	Current monitoring	Desirable monitoring
Insect pests and diseases	• Allow access to Observatree volunteers • Regular surveys (e.g. for ash dieback) • Forestry Commission aerial survey	• Further collaboration and knowledge exchange with neighbouring land managers • Further training in pest/disease identification
Habitat degradation	• Site-level species and habitat surveys • Monitoring locations of invasive species	• Woodland Wildlife Toolkit could help identify management actions to increase habitat quality and availability • Coordination with national monitoring (e.g. bird surveys)

Hints and tips for Step 5

- Consider the routine information collected by your organisation and collaborators, and whether this can be used to focus on resilience.
- Build in staged reviews and link this to resource planning that supports further action. Start with a manageable set of actions and monitoring sources and subject these to scrutiny. This will build knowledge regarding what works for your context. Take the opportunity to reflect and build such opportunities into your future actions (Box 5).
- Some organisations create ‘resilience champions’ to support teams and managers in applying and monitoring resilience more broadly across the organisation.

Box 5 End of the workshop

The end of the workshop is a good opportunity to reflect upon what has been discussed. Sometimes the discussions themselves are the most valuable activity. You could ask different members of the team to give their reflections to the group. After the meeting it may be useful to provide a summary of the key discussion points for future reference. Other users of this framework have found it productive to arrange a follow-up meeting to review the assigned actions in Step 4. This meeting could also be an opportunity to discuss how to monitor and record, as prompted in Step 5.

Conclusion

Resilience is a term often used when considering desirable futures for trees, woodlands and forests but less often is there a clear description of what is sought or the consequences for current decision-making and actions. This framework introduces resilience and shows how ideas can be developed and implemented in practice. The aim is to help identify the benefits of the concept for managing trees, woodlands and forests, and how potential pitfalls can be avoided. The approach should be adaptable to many situations – for example, considering the resilience of individual woodlands, whole forests, businesses and organisations. The framework can be used for individual study or to facilitate group discussion which may help to build links and understanding among people with different priorities and ideas (Boxes 1 - 5) and then underpin future work. Developing an approach to resilience is unlikely to be a one-time activity. Capturing the thinking together with the initial plans and then revisiting them is likely to be worthwhile.

Frequently asked questions

Further information can be found on the Forest Research website at www.forestresearch.gov.uk.

1. How does this relate to the UKFS?

This document can provide a means of taking forward aspects of the guidance in the UK Forestry Standard (UKFS). It can support planning and management depending on the element of interest. The UKFS covers many elements including soil, biodiversity and climate change and these could be considered as part of your system of focus or a disturbance.

2. What if I do not understand one of the steps?

That is not uncommon, it can be difficult to understand completely after one reading. Try rereading the document then applying the steps to a simpler system. It is always possible to go back over the steps with a different system once you have developed a better understanding of how they work. Additionally, there are resources at the end of this document to support you.

3. How can this framework help if I want change in my system?

It is possible to change a system through the transformation pathway. Consider what the desired boundaries of change are during Step 3 and focus on management actions that prompt creating a new (desired) system.

4. What is the difference between a system and a state?

The system is the focus of interconnecting items, for example, a house (Figure 1) or a woodland. Both consist of individual components to form a whole. The state is the condition the system is in, for example, a flooded house or one with intact flood defences; or an ancient woodland (with/without regeneration or other key characteristics).

5. Why are some of the terms and definitions different from other resilience literature I have seen?

Resilience is a topical concept and appears an attractive goal at a time of great uncertainty in the midst of both environmental and societal changes. However, it is also a complex concept with competing definitions, interpretations and understandings. These definitions vary between disciplines and there is not necessarily one ‘correct’ interpretation. As such, it may be worth considering other approaches. However, it is important to be clear on how you are using the term, to avoid misinterpretation. Also refer to the list of further reading that includes other approaches.

6. Why is there so much literature about resilience?

Resilience is a concept focused upon by many different disciplines from psychology to engineering, and it has a long history, particularly in academic literature. The last five years have also witnessed a noticeable increase in the general interest in resilience and how to apply it in different situations. Whilst definitions vary, this framework aims to direct the user to understanding how implementing resilience could work within their area of interest. The framework can be used beyond woodlands, trees and forests. Also refer to the additional resources on resilience available at the end of this framework that may develop your understanding of and provide insight into different ways of thinking about resilience.

7. What exactly does resilience mean?

The definition varies among different disciplines. Within the context of this framework, resilience is defined as to how a system responds to a disturbance or threat. This can be broken down into four components, namely, resistance, recovery, adaption and transformation.

8. Why does this framework not give me a list of actions to implement?

Simple, formulaic responses are unlikely to be helpful and may make things less resilient if misapplied or widely applied at the expense of diversity of actions. A fixed ‘menu’ of resilience actions is not appropriate because this cannot properly reflect the wide range of different objectives and local settings in which resilience planning can be applied. As each system is individual there is no one-size-fits-all solution. However, the toolkits listed in Further resources may provide more specialised actions to consider.

Glossary

Term	Definition
Adaptation	A modification that creates a new or different system that retains the original function
Alternative state	A different condition of the same system (e.g. a degraded ancient oak woodland)
Recovery	The ability to return to a normal or healthy condition
Resilience component	Resilience can be broken down into four components, namely, resistance, recovery, adaptation and transformation
Resistance	The ability to prevent or absorb impact, thus reducing the effect on the system
State	The current condition or specifics of a system (e.g. a young oak forest or ancient oak woodland)
System	An interconnecting network or collection of entities (e.g. a forest, a city park or a tree-related business)
Threshold	An edge or point at which a small change in conditions results in a large change in the system (e.g. if most of the trees in a forest have a similar strength, then winds that slightly exceed a certain speed could result in widespread windthrow)
Transformation	A marked change or alteration that creates a new system

Further resources

Toolkits

- Natural Resources Wales: information on increasing resilience through **diversity in woodlands**.
- NatureScot **ecosystem approach** toolkit containing a **Caledonian forest** resilience example.

Information

- **UK Forestry Standard** and related content.

Reading on resilience

- *Tree Health Resilience Strategy*, Defra (2018).
- *Resilience and tree health: a basis for implementation in sustainable forest management*, Lauren Fuller and Chris Quine (2016).
- The **Resilience Alliance** is a research organisation that focuses on resilience in social-ecological systems as a basis for sustainability.
- Explanation of important resilience concepts and implementation, including a podcast series on **resilience and global change**.
- Royal Forestry Society: **Forest resilience knowledge hub**.

Resilience implementation framework template

(Available to download from www.forestresearch.gov.uk)

Step	Action	Clarifying questions	Answers		
1	Define the focal system	What is the system? (e.g. ecosystem, organisation, business)			
		What is the time scale being considered? (e.g. years, decades, centuries)			
		What is the spatial scale being considered? (e.g. local, catchment, regional, national)			
		What are the main functions / services to be maintained? (e.g. habitat provision, carbon sequestration, financial return)			
2	Identify threats to the system	What are the possible threats/disturbances?	Biotic (biological)	Abiotic (physical / chemical)	Social / economic / political
		What is the likely frequency within the timescale of interest?			
		Are there synergistic effects?			

3	Identify boundaries of acceptable change	Is it described by structural changes? (e.g. mortality of components of ecosystem; loss of habitat?)		
		Is it described by functional changes? (e.g. change of growth rate leading to loss of carbon sequestration?)		
		Are the boundaries precise or fuzzy?		
		Are thresholds thought to be involved?		
4	Identify resilience component to target and related management actions		Example threat A	Example threat B
		Potential resistance actions?		
		Potential recovery actions?		
		Potential adaptation actions?		
		Potential transformation actions?		
5	Monitor and learn	Can adaptive management be practised? (e.g. monitoring put in place to learn as implement)	Current monitoring	Desirable monitoring

Example threats (Step 2)

This list serves to prompt thinking in relation to Step 2. It is not an exhaustive list of considerations and should be used in reflection of your own specific circumstance.

Biotic	Abiotic	Socio-economic
Mammals (e.g. grey squirrel and deer) leading to a loss of regeneration, loss of value, increased mortality.	Climate change (e.g. changing temperatures and rainfall) leading to changes to site/species suitability, or to phenology (e.g. flowering/seed setting).	Change to grant scheme supporting land use or business development – changing owner/management objectives.
Tree Disease (e.g. Ash dieback, *Phytophthora ramorum*) leading to increased mortality or reduced growth.	Pollution (excessive atmospheric nitrogen deposition) impacting tree health or soil characteristics.	Reduction in value of markets (e.g. domestic timber) affecting viability of operations.
Loss of specific species (e.g. pollinating insects) leading to a lack of seed supply; of tree species (e.g. ash) leading to changing composition.	Extreme weather events – (e.g. winter storms causing large scale windthrow of trees; extended droughts leading to reduced growth, increased mortality, increased risk of wildfire; high rainfall events causing erosion, damage to infrastructure, flooding; unseasonal frosts).	Visitor impacts (e.g. recreational disturbance to ground nesting birds; footpath erosion) affecting site qualities.
Loss of natural processes (e.g. woody debris) leading to a loss of habitat quality.	Soil degradation through erosion or compaction.	Increased competition for funding internally and from other organisations impacting upon investment.
Insect pests (e.g. pine weevil; oak processionary moth) leading to increased mortality or reduced growth.		Decline in visitor numbers impacting support for or direct investment in 'system'.
		Building and infrastructure development leading to a loss of trees/woods.
		Arson and other vandalism (e.g. fly-tipping).

Example management actions (Step 4)

Appropriate actions may relate to one or more of the components (e.g. resistance, recovery, adaptation and transformation). This list serves to prompt thinking on management actions but is not intended to be exhaustive and should be considered in relation to your own specific circumstance for Step 4. The toolkits recommended in the RIF document may provide additional support.

PLANNING ACTIONS

- Contingency planning
- Diversification through forest design (age, species choice, silvicultural systems, new acquisitions)
- Procurement policies (e.g. biosecure plant sourcing policy)
- Infrastructure planning (e.g. road systems for access)

SITE-BASED OPERATIONS

- Choice of restocking/replanting methods
- Vegetation management (e.g. removal of competing vegetation around planted trees)
- Watering regime (e.g. for street trees)
- Pruning, thinning, and other management operations
- Biosecurity (e.g. cleaning machinery regularly)
- Improved monitoring to increase chance of detecting pests/pathogens at an early stage

INVESTMENT

- New methods/equipment to improve inspection and refine monitoring (e.g. remote sensing)
- Specialist equipment and training to manage specific tree disease (e.g. canopy sprayers)
- Diversifying income stream (e.g. beyond timber sales)
- Public engagement activity (e.g. to improve public support for changes to plans)
- Citizen science partnership (e.g. Observatree to broaden surveillance)

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