

How is climate change affecting the pests, diseases and invasive species which threaten Scotland's forestry and woodland biodiversity?	Version
	24/03/16
<p>Pests, diseases and invasive non-native species (INNS) have the potential to disrupt key ecosystem functions and cause significant economic damage. Milder winters and warmer, wetter springs are likely to increase the risk from some over-wintering pests and diseases as a result of increased activity, reduced winter mortality and the potential to complete more generations in a season, resulting in larger populations. Other effects may be more indirect and result from a reduction in ecosystem resilience and therefore increased susceptibility to pathogens due to damage or stress as a result of drought, temperature extremes or storms. Changes in average temperature and rainfall will also alter the distribution of some native woodland species, facilitate the establishment of INNS and increase the invasive tendency of some.</p> <p>Whilst the climate response function of these organisms vary, and non-climatic drivers (e.g. deliberate or accidental introduction via human activities) are often more significant, there are a number of organisms where climate is seen to be a critical driver which are already causing considerable impact to Scotland's economy and wildlife. Two of the most significant risks come from:</p> <ul style="list-style-type: none"> • <i>Phytophthora ramorum</i>- a fungus-like pathogen whose distribution and prevalence is to a large extent determined by climatic factors. It poses a particular threat to larch, one of Scotland's most important timber species, causing significant damage and mortality to infected plants. • <i>Dothistroma</i> needle blight- which has become the most significant disease affecting coniferous trees in the UK and poses a particular threat not only to Scotland's commercial forestry but also to native Caledonian pinewoods. It is believed that an increase in intense rainfall episodes coupled with warmer springs may have optimised conditions for spore dispersal. 	

Adaptation options
<p>Scotland's forests are potentially at risk from a large number of different pathogens and INNS. The degree to which the risk from pathogens and INNS will alter with a changing climate is to a large extent still unknown and management objectives can vary both between and within sites. Therefore there is a strong emphasis on management supporting and improving habitat resilience to climate related threats.</p> <p>It is now considered that the eradication of <i>Phytophthora ramorum</i> on larch in Scotland is no longer achievable, therefore policies and actions focus on control to prevent or minimise any further spread of the disease and the damage it causes. Statutory Plant Health Notices (SPHNs) are issued by the Forestry Commission in affected areas, as part of a suite of biosecurity measures, and require the felling of infected trees and those in a surrounding buffer zone. New</p>

legislation introduced in 2014 brought in a change in restrictions to a smaller 'Management Zone' where *P. ramorum* is particularly prevalent. SPHNs are no longer issued for infected trees in this area as this has become an impracticable way to manage the disease. It is possible that at some point forest managers will assess that the risk of larch trees not reaching economic maturity has become too high to justify planting them. As a consequence there may be an overall shift in the proportional distribution of larch across Scotland.

The Forestry Commission Scotland's (FCS) *Dothistroma* Needle Blight Action Plan aims to limit the spread and potential impact of this pathogen. As well as increasing awareness, research and detection effort, the action plan also covers preventative measures (e.g. destruction of infected plants in nurseries, buffer zones around Caledonian pinewoods), and the prioritisation of felling infected stock. It is very difficult to develop a single management plan for all Caledonian pinewoods as risk may vary across and between sites and management objectives may differ (e.g. managing for nativeness, visual quality and/or to maintain critical habitats). Taking a whole Scotland view and implementing a variety of different management practices provides the best insurance for ensuring the continuance of Caledonian pinewoods. The approach that Scottish Natural Heritage are taking in tackling this disease is used as an exemplar of how their Adaptation Principles are being turned into action.

The Climate Change Risk Assessment for Scotland also highlighted the threat from green spruce aphid (*Elatobium abietinum*). This pest species is now widespread across Scotland and therefore the forestry and biodiversity sectors do not specifically target their control, but manage them as part of more general management strategies to control a large variety of pests and diseases.

The management strategies important for maintaining and improving the adaptive capacity of both forestry and native woodlands include:

- Increasing the diversity of forest tree species grown in Scotland - this is a key adaptation strategy identified in FCS' Climate Change Programme for building resilience to climate change related threats (including pests and pathogen outbreaks) and an uncertain future climate.
- Improving habitat connectivity - providing the means for species to track changing climate space.
- Natural regeneration - allowing genetic adaptation through natural selection in response to climate change and other environmental pressures.
- Preventing excessive deer browsing - the Scottish Forest Strategy promotes a landscape scale approach to deer management and identifies strategic priority areas; the Forest Enterprise Scotland Deer Management Strategy (2017-2020) will identify management options and measures for sustainable deer management.
- Clearing woodland INNS (e.g. *Rhododendron*) - clearance programmes have received targeted funding through the EU, Scottish Forestry Grants Scheme, Scottish Rural Development Programme and SNH discretionary funds.

There is good policy commitment to directly tackle pests, diseases and INNS in the forestry and biodiversity sectors as well as to increase general resilience and thereby maintain the economic viability of commercial forestry and the defining characteristics of native pinewoods. Relative to

many climate risks, there is a large and growing amount of existing data and associated effort committed to continue monitoring of these critical pathogens. However there is still relatively little known about the actual economic and/or biodiversity loss being sustained as a consequence of their presence. Whilst there is guidance regarding best forestry practice to minimise the risk of their spread and to increase general woodland resilience, there is currently little data available to enable monitoring of many (if not most) management strategies (e.g. thinning of forest stands). Furthermore the majority of data available is restricted to the National Forest Estate (NFE) which holds less than 40% of Scotland's woodland.

What do the indicators tell us?

CXC's indicators focus on a number of key pests and diseases which have a known link to climate change and with known high impacts, as well as the distribution of INNS. It will be increasingly important to understand and monitor their prevalence and understand how legislation and action on the ground is managing these risks and reducing the economic impact. The suite of indicators on pests, diseases and invasive non-native species cover:

The RISK of exposure to key pathogens whose abundance and distribution is known to be influenced by climatic factors:

- *Proportion and area of pine woodland exposed to Dothistroma needle blight (DNB)* uses the annual surveys of the National Forest Estate (NFE) by Forestry Commission Scotland (FCS) to calculate the pine forestry at risk of infection due to proximity to known outbreaks. There has been a dramatic increase in identified infection since first detected in 2002, with the result that between 2007 and 2013 the proportion of pinewood within the NFE at risk rose from approximately 9 to 60%.
- *Proportion and area of Caledonian pine woodland exposed to Dothistroma needle blight (DNB)* uses the Caledonian Pinewood Inventory and annual DNB surveys of the NFE to identify the core native pine woodland areas at risk of infection due to proximity to known outbreaks. Between 2007 and 2013 the exposed area increased from less than 100ha to over 1600ha (approximately 9% of core Caledonian pinewood), with Glen Affric being the most exposed.
- *Proportion and area of larch within Phytophthora ramorum Risk Zone 1* uses the climatic risk zones defined by FCS and monitors the proportion of this important timber species within the highest risk area. The latest data shows that 41% of NFE larch is at high risk. In order to provide further detail to assess any change to the proportion of Scotland's larch within Risk Zone 1, this indicator will also be informed by analysis of the proportion of new planting (including restocking) of larch species that occurs within each Risk Zone.

The potential IMPACT on forestry and woodland biodiversity, by monitoring the prevalence of key pathogens and invasive non-native species:

- *Forest area and proportion of stands infected by Dothistroma needle blight* is based on surveys which have taken place annually since 2006 to monitor the distribution and spread of the disease. Approximately 15% of the total high pine forest area of the NFE has now been found to contain signs of infection. The majority of infected forestry is in the

north and north east of Scotland, reflecting the general distribution of pine across Scotland.

- *Forest area infected by Phytophthora ramorum (Pr)* monitors the extent of infection and provides a gauge for the likely impacts of the disease on the forestry sector and a context for understanding the scale and effectiveness of actions to reduce the spread of the disease. Currently the disease is concentrated in south west Scotland with an estimated 5000-6000ha of larch infected in Dumfries and Galloway (7.7-9.2% of Scotland's larch woodland)
- *Proportion of native woodland affected by invasive non-native plant species* draws on data gathered in the Native Woodland Survey Scotland, providing a partial measure of the impact of invasive species in native woodlands and a proxy of their impact on biodiversity. The latest data shows that 19% of surveyed units recorded the presence of INNS (1.8% of native woodland area) with *Rhododendron* representing two thirds of these records.

Monitoring key management ACTIONS and strategies which either target specific control measures or increase the general resilience of the natural environment:

- *Number of forest sites served with a Statutory Plant Health Notice (SPHN) for Phytophthora ramorum (Pr)/Area of forest felled under Special Plant Health Notices (SPHNs) for Phytophthora ramorum (Pr)* monitors this important biosecurity measure to limit the spread of the disease. Between 2010 & 2015, 236 SPHNs were issued, with approximately half these being issued during 2012/13 alone. The introduction of a 'Management Zone' in the most affected area means it is currently difficult to ascertain how affective this measure is in restricting the spread of infection.
- *Diversity of tree species ordered for planting in Scotland* uses data from a survey of the conifer stock ordered from nurseries by both the public and private sectors, capturing information about species choices and diversification. Increasing diversity is a critical strategy to increase overall forest resilience to a wide number of potential risks as well as delaying or reducing the build-up of pests and diseases within a woodland area. Whilst there has been a small increase in the number of novel species, the amount and species composition of ordered conifer has remained quite constant.
- *Planted forest tree species diversity index* considers the composition of standing forest in Scotland and measures the diversity using the Shannon Index (an ecological indicator of diversity which accounts for both the number of species and their proportionate distribution). There is some evidence to suggest that there has been a slight increase in the diversity of planted forest species over the last 20 years in Scotland as a whole, though broadleaf woodland continues to be generally more diverse than coniferous. There is variation across Scotland however, dependent upon a number of factors including proportion of commercial forestry, species suitability (soil type and climate), as well as local, site-by-site, commercial and biodiversity management strategies.
- *Area of woodland with active, approved deer management plans* provides a measure of the extent of management to reduce deer impacts which pose a significant threat to the resilience of woodlands. Deer browsing, bark stripping and trampling can prevent woodland regeneration, damage standing stock and increase vulnerability to pests,

diseases and INNS. Currently approximately 55% of Scotland's woodland are under active deer management.

- *Amount of natural regeneration in native woodlands* draws on the Native Woodland Survey Scotland to help build an understanding of the extent to which management actions are limiting the impact of e.g. INNS and deer browsing, and enabling native woodlands to be resilient to stressors, including climate change. Many Caledonian pinewood areas have until recently had a poor regeneration record, and there is concern that impacts of DNB on young trees could further threaten the age class structure, and hence continuity of these woodlands. Approximately 21% of native woodland is in the regeneration stage, but only 17% is classed as 'established regeneration' which is likely to be insufficient to sustain native woodlands.

It is hoped that future availability of suitable data will enable the development of a number of additional indicators:

- Area of Caledonian pinewood containing *Dothistroma* needle blight
- Pine stand management activity to limit spread of pests and diseases

Other relevant indicators

Scotland's agriculture is also at risk from pests and diseases whose prevalence and distribution is in part determined by climatic factors. CXC indicators focus on two (one crop disease and one livestock parasite) where climatic factors are utilised to provide early warning systems for management purposes.

- *Risk of liver fluke (*Fasciola hepatica*) in cattle and sheep*
- *Prevalence of liver fluke (*Fasciola hepatica*) in cattle and sheep*
- *Range and prevalence of climate marker pests and diseases in crops: Number of potato blight outbreaks*
- *Area of cultivation under glass or plastic structures*

In addition to native woodlands, Scotland's freshwater environment is identified as at particular risk from invasive non-native species.

- *Freshwater habitats with reported presence of key invasive non-native species (INNS)*

CXC's indicators also examine how the changing climate is affecting the productivity and sustainability of Scotland's forestry and this is addressed by a separate narrative along with its associated indicators:

- *Suitability and productivity (forestry)*