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How can native woodlands adapt to climate change – a workshop to review the evidence base for adaptation options to inform policy and management
Thursday 23 August 2012, Edinburgh. Hosted by ClimateXChange and led by Scottish Natural Heritage, Forest Research and Forestry Commission.

This note begins with background to the event and its aims, then a summary of the key points and conclusions. Notes on the presentations and discussions follow. The agenda, participants and a list of references are included in an Annex below.

Backgound

SNH has identified a priority in its new 3 year Climate Change Action Plan, to work with FCS to develop guidelines for building adaptive capacity in woodlands. Given the emerging potential impacts from climate change on woodlands, not least increased pests and diseases, it is an issue that is beginning to demand attention. There are a range of potential management responses which themselves have risks, and decisions on which options to take in different circumstances need to be based on scientific evidence. Conserving native woodland ecosystems raises particular challenges but many of the issues are also relevant to commercial woodlands using non-native species.

Aims of the workshop

1) to explore what we know about the risks to native woodlands from climate change, their capacity to respond, and appropriate management responses
2) to agree what needs to be done to take this forward including how CXC might help SNH/FCS bring together the evidence base
3) to consider the scope for developing guidelines or other support for woodland managers in relation to climate change

SUMMARY OF KEY POINTS

Questions:

- Is there a consensus on what climate change scenarios we're adapting to (models, timescales)?
- What is the best approach to native woodland management: 'go with the flow' (promote natural adaptation), 'keep the status quo' or 'extreme intervention'?.
    - What does this mean at site/landscape/national scale?
    - How does the best approach vary with objectives?
- Do we know enough now to make management interventions?
- How do we deal with cultural barriers to adaptation?
- How fixed are the 'communities' we value?
- What are our objectives? Based on ecosystem structure, function, services or species?
- What is adaptive capacity? Define measures of success.
- How do other issues interact with climate change: deer, pests and pathogens?
- 'Old tree' issue – 'evolvability' – is it enough for timescales suggested by climate change predictions?

Things to do:

- Assemble these issues to increase awareness and promote debate
- Examine provenance trials through a climate change lens
- Identify risks by species/woodland type - build on Berry (and other) Report(s):
- How would tree species composition change in different parts of Scotland for different woodland types, and why, under different scenarios?
- Consider implications of climate change for obligate woodland species
- Adaptive management trial of higher intervention
    - Test some management interventions
    - Target incentives to promote alternative approaches
    - Capture different approaches in the sector – what are different people doing? - engage
- Look at what woods provide – services and their vulnerability to climate change
- Explore economic values of benefits and losses, and costs of different approaches
- Expand scope of experiments for future, especially genetic data

Conclusions:

It was agreed that we need to capture the issues identified during the workshop, and the current evidence relating to these.

We agreed to circulate the following summary of key points – questions and ideas for action – as a table against which people could indicate the priority that should be attached to this, policy objectives current work that is relevant, indicators of success, and ideas for future work.

We should then explore, possibly through ClimateXChange preparing a paper that builds on the table and sets out the key evidence gaps relating to these issues - the range of options, current evidence and ideas for future work.

DETAILED NOTES

Opening presentations

Mary Christie, Scottish Natural Heritage

SNH's *Climate Change and Nature in Scotland* highlights action needed to maintain healthy ecosystems, with their functions and benefits for people, in a changing climate and to help nature adapt to climate change.

This means addressing three challenges.

- To deal with uncertainty means taking a flexible and adaptive approach, responding to new information and adjusting plans and policies, supported by monitoring and research
- To promote resilience means making space for nature and natural processes, promoting diversity and the importance of protected sites as part of wider networks
- To accommodate change means to accept hat ecosystems tend to be dynamic and will change in response to climate change, e.g. in species composition and the patters of habitats so we need to plan to accommodate these changes.

Climate Change and Nature in Scotland also highlights eight Adaptation Principles which range from low risk options such as reducing other pressures to higher risk options that need more evidence and analysis. These higher risk options include:

- taking an adaptive approach to land and conservation management, e.g. by changing objectives and management measures in response to new information
- planning for habitat change where assessments indicate looses of habitats or species are inevitable
- considering translocation of species where assessments indicate a likely loss of species despite new management measures and where there are suitable areas for nature to adapt.

So, what does this mean for native woodlands, for the evidence we need and the action we need to take?

Jo Ellis, Forestry Commission Scotland

Climate change adaptation actions are set out in

- The Implementation Plan for Climate Change under the Scottish Forestry Strategy
- The Forestry Commission's Climate Change Action Plan
- The UK Forestry Standard Forests & Climate Change Guidelines
- Achieving diversity in Scotland's forest landscapes
- The Action Plan for Forests for the Scottish Adaptation Programme (in development)

Whilst these provide advice on general adaptation actions, FCS would like to produce guidance to help forest managers adapt to climate change. However this is site specific, depending on both the manager's objectives and the site location. Also the changing impact of pests and diseases could change things hugely. So FCS plan to develop guidance which helps people use available tools such as:

- Ecological Site Classification including climate change projections
- Wind throw – forest gales
- Using alternative conifer species for productive forestry in Scotland
- Achieving diversity in forest landscapes
- Outputs from research forests

Gordon Patterson, FCS

We are at an early stage of understanding the impacts of climate change. Rsearch so far has focussed on timber species and effects on timber productivity, rather than on aspects important to semi-natural woodland management. Climate space models don't account for species interactions nor the effects of extremes. The focus has been on trees, rather than other species, as these drive the system.

Models indicate that there won't be dramatic changes in tree composition at least initially. Some species may move north, such as small-leaved lime, field maple and hornbeam. So there may be a change in the balance of species. Pest and disease drivers may change. Otherwise tree death and natural regeneration will drive changes over a long time. So we will have time to react because of the long lifetime of trees.

The adaptive ability of trees depends on physiological and genetic factors. Why should we respond, why take action to change these? Why not see what happens? There is no need to rush into general solutions if we're not so concerned about allowing change to occur. If we intervene, we need to recognise what we're losing.

Other factors are significant. Deer are a constraint on natural colonisation and will influence species composition. Pests and disease impacts are affected by global trade.

There is general advice for foresters to help adaptation with new genotypes. But for semi-natural woodlands this raises difficult questions. Can present populations adapt? Are other issues more significant? Most species may be able to adapt if we give space to adapt, e.g. through networks of native woods, allowing genetic processes to work. There is already guidance on ensuring a wide genetic base, e.g. by sourcing seeds from enough parent trees.

So we need woods that are more robust with a range of species, and we should expect and accommodate change at the margins, such as more birch in pinewoods and a higher proportion of minor trees and shrubs. Native trees populations are generally large enough and well enough linked in the uplands. In lowland areas we need to enhance networks, to improve links.

Duncan Ray, Forest Research

Ecosystems, with their capacity to adapt, and climate change adaptation are linked, so we need an ecosystem approach to adaptation.

The Ecological Site Classification incorporates climate change projections. Work has been done on drought and waterlogging sensitivity of tree species. This is reflected in the ESC maps of Scot's pine suitability for timber production. These maps could be re-done to show where native pinewoods will be compromised by climate change. Ash is another example.

Modelling so far has indicated:

- The northerly expansion in range of oak, beech, ash
- The northerly expansion of hornbeam and lime except in the oceanic west

A review of forest managers' concerns indicated that they are finding the uncertainty around climate change difficult to deal with but they have confidence that they can cope, e.g. with drought, pests etc.

Forest Research are working on:

- Vulnerability and site sensitivity
- Tools to control a range of risks
- Addressing forest managers' concerns through forest policy
- Probabilistic climate projections to understand the likelihood of hazards

The aim is to safeguard woodland ? to delay impacts to ecosystem services in the future.

Discussion – key points, questions and suggestions (unattributed)

<u>Climate projections – dealing with uncertainty around impacts</u>

What are we adapting to? What timescale/year in the future and what emissions scenario, e.g. 2050 low/2050 high?

Uncertainty is integral to dealing with climate change – the resilience approach acknowledges this.

We can manage existing woodlands to maintain resilience but woodland regeneration and new planting is more vulnerable.

Resilience is not just about climate change. We need resilience to other factors and change such as pests and diseases. So we are not adapting to a scenario we can predict.

But we don't have enough understanding of the possible impacts. Perhaps we should choose two scenarios and look at whether or not pine would still regenerate, and whether this was affected by competition or by drought tolerance. What are the tipping points to change, and where does it matter?

So we need to look at a range of possibilities and whether there is enough plasticity within woodlands/trees.

Some things provide a buffer to climate change, e.g. soils won't change so much. So there are factors we can rely on, and those we can't.

Alternative approaches to adaptation – going with the flow or a less precautionary approach to increase diversity

How much do we need to know if we are simply to go with the flow? Does climate change challenge our existing woodland classifications?

But even if we choose to go with the flow, we still need objectives. We still need to define the problem, e.g. which species would be affected by the high scenario.

But what are we trying to do? The adaptation principles are good but is anyone doing them or do we need a change of mindset. Perhaps there is an overuse of the precautionary principle. Is a precautionary approach into the future? The principles of resilience suggest we need diversification of genetic material, but we are not embracing this. What about trying out diversification in an area of native woodland and comparing this approach to an area where we wait for change and carry out reactive adaptation?

Resilience is compromised by fragmentation. If we get wider extremes such as drier or wetter summers, we need a diverse range of species with space to adapt. So we need to provide more space.

This implies that genetic adaptation is a problem. But in semi-natural woodlands, the general approach could be to allow change, to build on existing diversity which we have already done by planting new woods.

A research question might be to ask whether new woods or existing woods are adapting better.

The question is about 'evolvability'. Where the climate is changing we need to give the genetic resource a chance to evolve, by increasing turnover through regeneration, and by scattering new material and allowing natural selection to act. To get new cohorts of seedlings regularly, we need to remove herbivore pressure.

So does 'Going with the flow' involve a challenge to the status quo, to current practice?

Other pressures

At present as are not solving the herbivore problem. The condition of native woodland is getting worse despite SNH, FCS and NGOs knowing what is necessary. Deer are the main problem, and we need to direct effort towards this.

We also need to recognise that deer will respond to climate change, and that landscape changes, such as more mixed (wooded and open) landscapes, could increase deer numbers.

So we need to reduce other pressures as the Adaptation Principles say.

Contributions

Duncan Stone, SNH

The benefits and services we get from native woodlands come largely from big old trees, e.g. in Scot's pinewoods. Most climate impact modelling looks to 70 years ahead, such as the Ecological Site Classification. But 70 years doesn't give you a big old tree – you need 200-400 years.

So, to deliver services into the future, we need to look 200-400 years ahead. When regenerating pinewoods, we are taking a bet about whether the pine tree will be good 200-400 years later. We can't be certain about this, but we still have to do something today. So we shouldn't try to predict what's going to happen but rather take a risk-based approach.

The question to explore is whether the range of genetic diversity we have is a sensible risk. We do have lots of diversity in native tree populations in Britain but elsewhere diverse populations are succumbing to pests and diseases.

Joan Cottrell, Forest Research (with Stephen Cavers, CEH)

We are having a robust discussion about the role of genetic diversity for adaptation to climate change. Joan seems to agree with the main thrust of what Gordon said..

Genetic variation provides the raw material. Adaptation is the product of 4 processes:

- mutation,
- genetic drift,
- gene flow and
- natural selection.

Gene flow and natural selection are most important for climate change.

What is the current genetic diversity of UK tree populations? It comes from:

- the founding material – where did the first trees to colonise the UK 10,000 years ago come from; and from
- the effects of natural selection and gene flow after colonisation

Natural selection tends to reduce diversity and gene flow increases diversity.

Genetic variation may be measured using common garden trials, to see how individuals from different sources perform under the same conditions or molecular tools.

For Scots pine, the founding material possible came from two sources (the north-west population represents a separate one from the rest).

For gene flow, low genetic differentiation between sub-populations would indicate high gene flow due to seed and/or pollen dispersal. Scots pine is wind pollinated and in Spain, a study demonstrated 5% of pollinations arose from long distance pollen flow, i.e. more than 100 km. Studies have shown that infrequent long distance dispersal events are important for gene flow.

Natural selection has acted to promote differences between local populations, e.g. in cold tolerance and drought tolerance.

So for Scots pine there is high within population diversity and effective gene dispersal, so a high potential to adapt, and Scots pine can be expected to survive and grow in a broad range of environments beyond the home range.

Actions we can take to improve this potential are:

- To encourage gene flow across the landscape (particularly for non-tree species with lower dispersal ability)
- To increase turnover of the generations to ensure that natural selection has the raw material to work on so that adaptation can occur as quickly as possible. Selection pressure is greatest during the seedling growth stage

What we don't know:

- Rate of local adaptation – given a particular rate of generational turnover how quickly will natural selection act to produce an adapted population.
- Importance of long distance gene flow for adaptive capacity
- Scale of local adaptation
- Environmental factors driving adaptation, e.g. soil moisture
- Costs of non-local gene flow for adaptation
- How to incorporate evolvability into projects

A published prediction for Scots pine (at the European level) is for expansion and stabilisation for northern European populations. However, the time scale remains undefined.

Chris Quine, Forest Research

Reflecting on the 'Read Report' (2009), there are several challenges to adaptation:

- Cultural barriers to adaptation
- Questions around what we are trying to conserve – how valid are existing species or ones over the border?
- A lack of woodland management amongst lowland broadleaved woodland has meant declines in species adapted to open/early seral stages with shrubs
- People's perception is that non intervention is good for wildlife, so we need a story to explain why intervention is actually good for biodiversity

Further discussion – issues around uncertainty and intervention

We could look at provenance trials for other (non-timber) species – ash, rowan, and birch that were established in the 1990s and see how they are doing.
It is valid that trees are seen as providing the structure in woodlands, but for community interactions as need to understand the rivets that hold things together, and what happens to these. What are the functional roles of these? What about new natives? What are the tipping points in terms of ecosystem services and biodiversity, in terms of the impacts of climate change and pests/diseases?

What are our objectives? For semi-natural woodlands, there's a risk that we throw away what we are trying to protect. So is it not better to expand and try out diversification within the expanded areas whilst conserving existing woodlands?

Why do we 'have to do something today?' Why do we no longer need a precautionary approach? Why can't we wait if we don't yet know?

But we'll never know in time to act. There is no certainty. If we wait 50 years there will still be uncertainty. There is no safe place.

But surely to have old trees in the future we simply need not to cut them down, to have long term retention?

A *laissez faire* approach in the early C20th gave us 5% woodland cover. We shouldn't be doing the same thing everywhere but are we happy with the current trend in condition of native woodland? Age class of tree populations is not normally distributed; there is not a good range of species. This reflects past management.

This is an unnecessarily false polarisation, i.e. responding when climate change happens or understanding what might happen. We should manage native woodlands to retain current diversity by addressing deer, fragmentation and increasing the diversity of species that should be there. And we should build resilience at the wider scale. We shouldn't be trying to predict or force the outcome to be something, as we can't predict what changes there are going to be. There is an urgency to reverse impoverishment and degradation.

We need to remember that the wider landscape will also change in response to climate change (e.g. as a result of food security objectives and changes in land capability), and this will affect gene flow.

A study of beech, suggested that 6 generations of beech required 200-300 years. This kind of adaptive process may not keep up with the rate of change.

Natural evolutionary processes will continue but management options can accelerate opportunities and increase turnover. We need bigger areas, and more natural tree-lines to allow natural processes. We need frequent cohorts because in any one year there may not be the right climate impacts to act (unlike what happens we use fencing for regeneration).

Is the question to ask whether climate change will be so severe that it will impact on survival of big trees, not just young trees?

ANNEX

Agenda

1300 Welcome, objectives & round table introductions - Chair, Simon Pepper

1315 Summary of policy/management needs/challenges/commitments in current climate change action plans, - SNH (Mary Christie) & FCS (Jo Ellis)

1325 Update on resources available or in development for forestry managers - Jo Ellis, FCS

1330 What are the key questions we need to ask about adaptive capacity and management responses - Gordon Patterson, FCS

1340 Summary of evidence for potential effects of climate change on native woodlands, FR - Duncan Ray, FR

Questions/discussion

1400 What we know/don't know about the capacity of woodlands to adapt to climate change risks and possible management responses - contributions (5-10 mins each)

Duncan Stone, SNH, Sarah Green, FR , Joan Cottrell FR, Chris Quine FR

1445 Questions/discussion

1500 Tea break

1515 Discussion of next steps/way forward

1545 Sum up

1600 Finish

Papers circulated to participants or referred to:

Report of measures/actions/ strategies/ policies (including research) prepared by Defra for: Implementation by Parties of Recommendations No. 135 (2008) and 143 (2009) of the Bern Convention Standing Committee on guidance and further guidance on biodiversity and climate change. (circulated)

Informing climate change adaptation in forestry management. Science for Environment Policy. DG Environment News Alert Service. 26 July 2012. (circulated) ec.europa.eu/**environment**/integration/research/**newsalert**/pdf/294na6.pdf
Source: Littell, J.S, Peterson, D.L., Millar, C.I., & Kathy A. O'Halloran, K.A. (2012) U.S. National Forests adapt to climate change through Science–Management partnerships. *Climatic Change* 110:269–296. DOI 10.1007/s10584-011-0066-0

Understanding the implications of climate change for woodland biodiversity and community functioning. Synthesis of the key findings. (circulated.)
http://www.forestry.gov.uk/forestry/infd-7wzjbt
This synthesis report summarises the work done in an earlier report commissioned by the Forestry Commission *Understanding the implications of Climate Change for woodland biodiversity and community functioning*, which reviewed the known effects of climate change on woodland biodiversity and functioning.
Pam Berry and Yuko Onishi, environmental Change Institute, University of Oxford, and James Patterson, centre for Environmental Management, University of Nottingham. Report commissioned by the Forestry Commission (UK) January 2012. (circulated)

Achieving diversity in Scotland's forest landscapes. Forestry Commission Scotland Practice Guide. 2012.

Using alternative forest species for productive forestry in Scotland. Scott McG Wilson for Forestry Commission Scotland.

UK Forestry Standard Guidelines: Forests and Climate Change. Forestry Commission (UK)

Climate change and nature in Scotland. Scottish Natural Heritage. June 2012.
http://www.snh.gov.uk/publications-data-and-research/publications/search-the-catalogue/publication-detail/?id=1421

Climate change and nature in Scotland. Background and context. Scottish Natural Heritage June 2012.
http://www.snh.gov.uk/docs/A730136.pdf

Woodland networks in a changing climate: Threats from land use change
Alessandro Gimona, Laura Poggio, Iain Brown, and Marie Castellazzi, James Hutton Institute. Biological Conservation 149 (2012) 93–102.

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