Woodland monitoring in the UK

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Environmental Research Branch
Forest Research
The past - the impetus for forest health monitoring
Overview

• FR woodland monitoring schemes
  – National Inventory (NIWT)
  – condition survey of non-woodland amenity trees
  – Forest Condition Survey (FCS and Level I)
  – Environmental Change Network (ECN)
  – Intensive Forest Health monitoring Network (Level II)

• Results from the FCS
  – observed trends
  – derived observations
  – European comparison

• Intensive forest monitoring
  – a national data resource
  – model verification
  – individual plot trend analysis
  – ozone pollution
## National inventory of woodland and trees (NIWT)

**Ground truthing of 1% of forest area (1 ha plots): >40 000 plots; planned 5 year cycle**

<table>
<thead>
<tr>
<th>Stratum</th>
<th>Category</th>
<th>Options/comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meta-data</td>
<td>Owner status</td>
<td>Private, charity, FC</td>
</tr>
<tr>
<td></td>
<td>Woodland context</td>
<td>Forestry, farm, mixed</td>
</tr>
<tr>
<td></td>
<td>Management</td>
<td>Timber, game, conservation</td>
</tr>
<tr>
<td>Structure</td>
<td>% cover</td>
<td>Upper &amp; lower canopy, shrub</td>
</tr>
<tr>
<td></td>
<td>Standing deadwood</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Number of trees</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Abandoned timber</td>
<td></td>
</tr>
<tr>
<td>Fallen trees</td>
<td>7-20 cm, 20-50 cm, &gt;50 cm</td>
<td></td>
</tr>
<tr>
<td>Element</td>
<td>Woodland classification</td>
<td>Broadleaf, conifer, mixed</td>
</tr>
<tr>
<td></td>
<td>Thinning frequency</td>
<td>Once, twice</td>
</tr>
<tr>
<td></td>
<td>Access</td>
<td>(For extraction)</td>
</tr>
<tr>
<td></td>
<td>Dominant understorey (&gt;2m)</td>
<td>Species</td>
</tr>
<tr>
<td></td>
<td>Regeneration</td>
<td>Vegetative, seedling, both</td>
</tr>
<tr>
<td>Crop</td>
<td>Species</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Species make-up</td>
<td>Pure, mixed, intruded</td>
</tr>
<tr>
<td></td>
<td>Area</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Stocking</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Health</td>
<td>Crown dieback, windblow</td>
</tr>
<tr>
<td></td>
<td>Timber potential</td>
<td>Normal, remedial, unproductive</td>
</tr>
<tr>
<td></td>
<td>Planting year</td>
<td></td>
</tr>
<tr>
<td>Top height</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mammal damage</td>
<td></td>
<td>Bark stripping, browsing</td>
</tr>
</tbody>
</table>
Condition survey of non-woodland trees

- Established in 1993 (non-woodland amenity tree health monitoring scheme) and re-designed in 1999
- Funded by ODPM
- 106 plots (54 urban, 52 rural) each assessing a minimum of 30 trees and 6 genera; ~60% return rate for data
- primarily for reporting disease, climate and insect pest damage; some more detailed studies on crown density to provide a comparison with FCS
- unlikely to provide information on air pollution, but…..
Forest Condition Survey (FCS)

- Beech (59)
- Oak (86)
- Norway spruce (55)
- Sitka spruce (66+3)
- Scots pine (81)
- Mixed species (3)

- 24 trees - ‘external plots’
- Height measured on establishment
- Soil type identified on establishment
- DBH measured annually
- Crown condition measured annually
Forest condition: EU/ICP-Forests Level I

- ~90 plots
- >6000 plots across Europe, mostly 16 x 16 km grid
- 5 species (SS, NS, SP, Be, Ok)
- 24 ‘internal’ trees, 0.25 ha minimum area
- Measurements: as for FCS plus
  - Soil chemistry and description: (1994)
  - Foliar chemistry: (1995)
Forest condition survey (FCS): tree crown transparency
FCS crown condition

- SS - green spruce aphid
- Be - masting, climate
- Ok - winter moth, tortrix, climate, survey design
- SP - fungi, insects
European comparison
‘best local tree’ index

Reduction in crown density (%)

UK
Germany
Finland
Spain
Poland


Forest Research
Observed relationships between forest condition and nitrogen deposition (Level I)
Nitrogen deposition and ground flora

Changes in the nitrogen demand of beech woodland ground flora with proximity to the woodland edge; $R^2 = 0.35$, $p = 0.025$. 
Environmental Change Network (ECN)

Terrestrial site protocols

- land management and use
- soil survey
- soil solution chemistry
- meteorology
- rainfall chemistry
- atmospheric chemistry
- vertebrates
  - bats
  - birds
  - rabbits and deer
  - frog spawn
- invertebrate monitoring
  - moth
  - tipulids
  - butterflies
  - spittlebugs
  - ground predators
- vegetation assessment
Intensive forest health monitoring network (Level II)

<table>
<thead>
<tr>
<th>Measurement</th>
<th>No of plots</th>
<th>Frequency</th>
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<tbody>
<tr>
<td>Increment</td>
<td>20</td>
<td>5 yr</td>
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<tr>
<td>Crown condition</td>
<td>20</td>
<td>1 yr</td>
</tr>
<tr>
<td>Foliar chemistry</td>
<td>20</td>
<td>1 yr</td>
</tr>
<tr>
<td>Soil (chemistry &amp; description)</td>
<td>20</td>
<td>10 yr</td>
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<tr>
<td>Litterfall</td>
<td>13</td>
<td>2-8 wk</td>
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<tr>
<td>Deposition</td>
<td>10</td>
<td>2 wk</td>
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<tr>
<td>Air quality</td>
<td>17 (2)</td>
<td>4 wk (1 hr)</td>
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<tr>
<td>Soil solution</td>
<td>10</td>
<td>2 wk</td>
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<tr>
<td>Meteorology</td>
<td>6 (5)</td>
<td>1 day (1 hr)</td>
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<tr>
<td>Phenology</td>
<td>20</td>
<td>2-4 wk</td>
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<tr>
<td>Ground vegetation</td>
<td>20</td>
<td>3 yr</td>
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</table>
Intensive monitoring network
A national data resource

- Plot level data used as the basis for setting woodland critical loads
- Management accounted for
- Plot level data related to national forest estate

<table>
<thead>
<tr>
<th>Savernake 105</th>
<th>Coalburn 46</th>
<th>Loch Awe 26</th>
<th>Tummel 9</th>
<th>Rannoch 25</th>
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<tbody>
<tr>
<td>horizon depth</td>
<td>CEC</td>
<td>horizon depth</td>
<td>CEC</td>
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<tr>
<td>O</td>
<td>3</td>
<td>O</td>
<td>2</td>
<td>O</td>
</tr>
<tr>
<td>A</td>
<td>3</td>
<td>H</td>
<td>1.5</td>
<td>Ah1</td>
</tr>
<tr>
<td>E</td>
<td>19</td>
<td>Ah(g)</td>
<td>10</td>
<td>Ah2</td>
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<tr>
<td>2Btg</td>
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<tr>
<td>2BCtg</td>
<td>16</td>
<td>Bg</td>
<td>12.41</td>
<td>Bs</td>
</tr>
<tr>
<td>2Cgk</td>
<td>40</td>
<td>2BCg</td>
<td>9.61</td>
<td>BCg</td>
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</table>

<table>
<thead>
<tr>
<th>Thetford 15</th>
<th>Llynbrianne 38</th>
<th>Grizedale 21</th>
<th>Sherwood 21</th>
<th>Alice Holt 111</th>
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</thead>
<tbody>
<tr>
<td>horizon depth</td>
<td>CEC</td>
<td>horizon depth</td>
<td>CEC</td>
<td>horizon depth</td>
</tr>
<tr>
<td>O</td>
<td>2</td>
<td>O</td>
<td>4</td>
<td>O</td>
</tr>
<tr>
<td>Ah</td>
<td>13</td>
<td>H</td>
<td>13</td>
<td>H</td>
</tr>
<tr>
<td>Ah&amp;Bw</td>
<td>11</td>
<td>A</td>
<td>15</td>
<td>Ah</td>
</tr>
<tr>
<td>Bw</td>
<td>26</td>
<td>Bg</td>
<td>32</td>
<td>Bs</td>
</tr>
<tr>
<td>2BC</td>
<td>50</td>
<td>BC</td>
<td>53</td>
<td>BC</td>
</tr>
</tbody>
</table>

Cation Exchange Capacity - BaCl₂ extract (cmol+ kg⁻¹ oven dried soil)
Critical loads exceedance

acidity

keq ha\(^{-1}\) year\(^{-1}\)
- Not exceeded
- 0.0 – 0.2
- 0.2 – 0.5
- 0.5 – 1.0
- > 1.0

nutrient nitrogen
Deposition summary - trend analysis and model verification

- Nitrogen or sulphur in throughfall (kg ha$^{-1}$ yr$^{-1}$)
- Acidity in throughfall (kg ha$^{-1}$ yr$^{-1}$)

Locations:
- Alice Holt
- Severnake
- Grizedale
- Thelford
- Ladybower
- Ramnoch
- Coalburn
- Tummel
- Loch Awe
- Llyn Brianne
Comparison of modelled and measured deposition

**Wet deposition**

\[ y = 1.17x + 3.0 \]

\[ R^2 = 0.51 \]

**Dry deposition**

\[ y = 2.6x + 3.5 \]

\[ R^2 = 0.58 \]

**Total N deposition**

\[ y = 2.4x - 1.3 \]

\[ R^2 = 0.82 \]
Identification of long-term trends at individual plots

- foliar chemistry
Thetford plot ~200 m
Identification of long-term trends at individual plots

- soil solution
Ozone monitoring

![Graph showing mean O3 concentration (ppb) for different locations and seasons.](image_url)
Ozone induced visible injury
Summary (1)

- Large-scale monitoring schemes indicate no systematic change in the condition of UK forests over time
- Events and weather conditions in individual years have significant effects on crown density
- Intensive monitoring indicates some recovery from acid deposition at previously polluted sites
- Foliar concentrations of sulphur appear to be falling
- High nitrogen inputs associated with intensive animal husbandry appear to be leading to ecosystem damage at individual plots
Summary (2)

• Nitrogen deposition may be leading to a change in the groundflora associated with beech woodland; this phenomenon is particularly associated with forest edges and the proximity of intensive agriculture.

• Although the effects of ozone are largely unseen, visible injury is evident in some plots; reduced growth and needle retention in conifer species are also likely.

• There is no convincing evidence that there is widespread chronic damage to UK forests as a result of acid deposition or air pollution…”

• ……but, environmental/climate change is likely to present a greater threat to woodland ecosystems and ongoing monitoring is essential.