Climate change impacts and adaptive strategies: a focus on pests and diseases
Overview

• Historical trends of new pest and diseases
• Climate change risks
• Reducing impacts and PRA
• Geo-climatic models and DSS
  • 2 examples applied in Ireland
• Implications for forest operations and staff
• Adaptation strategies
• Conclusions
GLOBAL CHANGE

- Increasing international trade
  - Introduction of new exotics
- Land use/management effects
  - Biodiversity loss (natural control)
  - Desertification
  - Habitat fragmentation
  - Introduction of new or unsuitable forest species
  - Increase harvest or regeneration
- Climate change
- Ecology
  - Hybridisation/new races (Poplar rust)
  - Reinvasion (Dutch Elm)
- Stochastic effects
Climate change

Red band needle blight (Dothistroma septosporum)

Introduction

Colonisation (causal phase)

Establishment (naturalisation)

Spread (infection/invasion)

1955-2002

Increased introduction of CP (80% now infected)

Increased moisture for infection

Sexual reproduction

- Adaptation
- Increased wind dispersal of (sexual) ascospores


2006/7

Increased regeneration

Host stress

Persistence of founder population

Host stress and competition

Growth and survival

Adapted from Walther et al., 2009
Climate change-host maladaptation

- **Host Maladaptation**
  - Changes to environment occur at a rate too fast for species to adapt to change
  - Confounded by low genetic diversity

- **Pest/ pathogen adaptation**
  - Respond faster to climate change than their hosts
    - Higher mobility
    - Faster regeneration and growth
    - Higher frequency of genetic recombination

- **Introduction of exotic forest species to counteract maladaptation**
  - e.g. Replacement of Sitka spruce with CP in drought prone regions of UK and Ireland introduced red band needle blight
Reducing risks and impacts (PRA)

- **Pest/pathogen risk assessment (PRA)**
  - Structured procedure to mitigate and manage risk
    - International pest and pathogen convention guidelines (IPPC)
    - Must be justifiable under WTO SPS agreements
    - European plant protection organisation (EPPO) lists of potential pest and diseases
    - IPSM15 guidelines, excellent on wood processing/treatment

- **Failure of process**
  - Most introduced species not on EPPO list (Roques, et al 2008)
  - Insufficient enforcement (e.g. imported Ash- *Chalara* Ireland)
  - Need for geo-climatic DSS model to improve PRA
DSS-Species selection Ireland

Site analysis

Select site

Select CC scenario

Define site

Scenario 2050 A2

Suitability | Yield
---|---
SMR - Baseline: System Default | SNR - Baseline: System Default
SMRw = Very Moist, SMRs = Very Moist | SNRw = Very Poor, SNRs = Very Poor

<table>
<thead>
<tr>
<th>Species</th>
<th>Suitability</th>
<th>Pred. Yield</th>
<th>Limiting Factor</th>
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<tbody>
<tr>
<td>Alder</td>
<td>unsuitable</td>
<td>4</td>
<td>dams</td>
</tr>
<tr>
<td>Ash</td>
<td>unsuitable</td>
<td>3</td>
<td>snr</td>
</tr>
<tr>
<td>Aspen</td>
<td>suitable</td>
<td>8</td>
<td>snr</td>
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<tr>
<td>Beech</td>
<td>suitable</td>
<td>6</td>
<td>dams</td>
</tr>
<tr>
<td>Corsican pine</td>
<td>suitable</td>
<td>12</td>
<td>smr</td>
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<tr>
<td>Douglas fir</td>
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<td>11</td>
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</tr>
<tr>
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<td>suitable</td>
<td>7</td>
<td>dams</td>
</tr>
<tr>
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<td>7</td>
<td>dams</td>
</tr>
<tr>
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<td>suitable</td>
<td>10</td>
<td>dams</td>
</tr>
<tr>
<td>Lodgepole pine</td>
<td>very suitable</td>
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<tr>
<td>Scots pine</td>
<td>suitable</td>
<td>10</td>
<td>con</td>
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<tr>
<td>Sessile oak</td>
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<td>Sitka spruce</td>
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<td>snr</td>
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<tr>
<td>Sycamore</td>
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<td>5</td>
<td>snr</td>
</tr>
<tr>
<td>Western hemlock</td>
<td>unsuitable</td>
<td>10</td>
<td>dams</td>
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http://82.165.27.141/climadapt_client/index.jsp
Use ESC type approaches

- Must be fit for purpose, but subject to a large degree of uncertainty
- Aid in risk management
- Assess probability of introduction, spread and severity of outbreaks under current and future climates
- Must provide strategic and practical information

- Modelling Challenges
  - Spatial and temporal scale
  - Extreme events
  - Physiological plasticity, interactions, vectors etc.

- However, need a proactive approach to develop adaptation strategy
  - Scientific understanding always needs improvement
• Fomes butt rot (*Heterobasidion annosum*)
  – Infection by airborne basiospores during thinning and clearfell
  – More prevalent of mineral soils, certain species (McAree 1975, 1981, Keane 1987) and warm wet sites (Pyatt, 2001)
  – Urea stump treatment cost (400 to 500k €/a)
  • Safety concerns for forest workers
  • EU water quality framework consideration
DSS- Fomes

• DSS based on GIS system using **climate, soil and management**
• **Aim:**
  • to identify high risk sites
  • risk assessment under different climate change and management scenarios

Peat soils, low thinning, cool wet

Warmer, well drained mineral soils
Fomes- future risk

- Future risk:
  - Climate change (temp. SMD)
  - Introduction of new plantation species
  - Increase harvest 3Mm$^3$ to 7 Mm$^3$ by 2030

<table>
<thead>
<tr>
<th>Risk category</th>
<th>BAU</th>
<th>Climate change 2050 A2</th>
<th>2050 optimal spp selection from CLIMADAPT</th>
<th>Increase thinnings</th>
</tr>
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<tbody>
<tr>
<td>Low</td>
<td>45.9</td>
<td>42.6</td>
<td>28.1</td>
<td>26.6</td>
</tr>
<tr>
<td>Medium</td>
<td>22.3</td>
<td>23.5</td>
<td>42.3</td>
<td>26.9</td>
</tr>
<tr>
<td>High</td>
<td>31.8</td>
<td>33.9</td>
<td>29.6</td>
<td>46.5</td>
</tr>
</tbody>
</table>

Management and spp. selection largest risk influence in future
To improve the standard of treatment:

1) **Training**: Ensure that machine operators and harvesting Managers are familiar with the reasons why stump treatment is important and how to use **DSS**.

2) Apply treatment only where it is needed using **DSS**.
   - Reduced safety risk (chemicals)
   - Reduced environmental risk and cost

3) Improve the equipment and the materials available for treatment.
Large Pine weevil (*Hylobius abietis*)

- Most important pest in Ireland
- Increase occurrence due to increase in clearfell and replant- due to double by 2030
- Exacerbated by predicted climate change impacts
- Forest contractor carry risk (establishment contract are on a 5 year free to grow basis)
- IPM approach with DSS
  - leaving an appropriate fallow period to allow weevil emergence and dispersal
  - using resistant plants
  - releasing natural enemies such as nematodes for the biological control of weevil.
- Contractors must understand life cycle for effective control

Wainhouse et al., 2007
Large Pine weevil-current control

- Dipped plant cypermethrin or spray (FSC limits use by 2015)
- Use DSS (BFC), stump inspection

However, problems experienced with ‘fly-ins’ - from nearby forest stands
In addition climate change will influence life cycle
Limited literature on potential climate change impacts
  - Difficult to develop DSS without understanding impacts
Some evidence of increase mortality as moisture deficit increases
• Also an increased likelihood of increased occurrence of moisture deficits > 200mm in east and south of the country
  – Reduce suitability of Sitka spruce on free draining soils (Tene et al, 2011)
  – Increase seedling mortality due to weevil damage

- Increased temperature increases development and size of adults (Inward et al., 2012)
- Climate change and increased clear fell/ re-plant likely (double by 2028 Phillips, 2011) likely to increase severity and incidence of weevil damage in the future
Large Pine weevil - Climate change

Vulnerability to Hylobius increases everywhere, especially westwards into Wales and northwards into lowland Scotland.

By mid century degree days > 8°C have increased by 30-50%. Weevil activity will be 4-6 weeks longer in general.

Sweeney and Teck (ICARUS), 2013
• **Higher damage and increased activity**
  - Revise current DSS
  - New controls, new training
  - Increased economic risk for contractors

• **Reduced planting window**
  - Establishment window will be reduced due to climate change, impacts on contractor earning
  - Need for business diversification and staff retention issues

• **Seedling specification**
  - Increase water recharge capacity, decrease evapotranspiration loss
  - Transplant seedling RCD min 5cm (Dillon, Coillte)

• **Breeding/selection**
  - Early selection of low shoot to root ratio seedlings or high RCD
  - Selection of drought tolerant genotypes
  - GM trees?

• **Nursery production and supply**
  - Dipped plants to reduce environmental and safety risks on site
  - Use of containerised seedlings to replace bare root stock
  - Use of alternative control measures e.g. Conniflex

**Large Pine weevil-Forest operations**
Forest managers and contractors

- **Need for bottom-up communication:** (monitoring programs not efficient) move towards community and ground based information transfer-
  - e.g. monitoring websites, blogs etc, structured bottom up monitoring plans
- **Training and access to DSS and IPM**
- **Knowledge of PRA and bio-security plans for infected stands**
  - Guideline for forestry on international phytosanitary standards
    - Plain language, assessable (FAO, IPPC)
- **Increase financial risk for contractors**
  - Many large forest companies now use contractors
  - Establishment survival, pest control and *force majeure*
  - *Contract exposure to risk must be well defined*
- **Reduced establishment windows-seasonality of available work**
  - Staff retention issues, cash flow
- **Increased regulation may limit management options**
• Health risks
  – Oak precessionary moth larvae (rash)
  – Mycotoxins e.g. dothistromin (red band needle blight) - not proven
  – Exposure to control chemicals – highest health risk

• Safety
  – Increased emphasis on non chemical control
  – Biological control, but requires training and understanding of biology
  – GM trees???
  – IPM options such as management
    • Thinning to reduce red band needle blight
    • Establishment windows for large pine weevil, use of physical barriers e.g. Conniflex
    • Reduced chemical control using DSS to identify high risk sites (Fomes)
Adaptive strategies

• Principals
  – Based on sound science, but acknowledge uncertainty
  – Proactive versus reactive approach
  – No regret options, e.g. CP and red band needle blight
  – **Assessment required at site level**, avoid regional generalisations
  – Backed by action plans to ensure implementation

• Remove implementation barriers
  – Ensure best practice shared across institutions
  – Training and easy access to DSS, implement bottom up
  – Encouraging changes in society’s expectations about future forest risks, values and benefits
  – Reduce reliance on use of historical approaches and trends (e.g. empirical growth models or old IMP control measures)
Adaptive strategies - examples

• Enhance forest genetic resource
  – Habitat connectivity and gene flow
  – Diversification in plantations

• Selection and breeding
  – Tolerant genotypes and provenances
  – Use available DSS, get species selection right, but acknowledge P&D risks

• Develop DSS for PRA and IPM control measures including future climate

• Revise existing IPM practice (e.g. weevil life cycle change)

• Better enforcement of phytosanitary regulation (e.g. import of ash)

• ID of silvicultural control measures
  – Thinning to reduce spread or fallow period to reduce infestation
  – Reduce risk of natural disturbances

• Optional destruction and bio-securing SOP in infected stands
Living plant material and phytosanitary control is a massive issue. Insects and pathogens will exhibit an higher adaptation to climate change, compared to maladaptation by forest tree spp. Many future risks are a function of global change and management. Potential to improve on current PRA using geo-climatic DSS, but must acknowledge caveats. Largest uncertainty regarding new introductions. Must understand impacts before adaptation plans can be developed. Need to develop new IPM plans and DSS, where pests and diseases have established. Barriers need to be overcome to ensure adaptation plans can be met. Need for training and improved information flow between foresters, policy makers and scientists. Increased operation risks associated with climate change, but there are feasible practical solutions.
BE AWARE AND ACT NOW!