Alternative management of Ireland’s western peatland forests to adapt to climate change and an expanding bioeconomy

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Introduction
The inherent factor of poor site productivity in western peatland forests combined with the reduction in management intensity from increased environmental considerations has brought some new challenges into forest management. Our study investigates new, alternative forest management models in the area chosen for this study, Clough forest, Co. Galway, to assess how these forests should be managed under future impacts of climate change and dynamic timber prices due to an expanding bioeconomy, and to quantify the impact this will have on forest ecosystem services (ES).

Modelling
Remsoft Woodstock was used to forecast the impact of forest management changes in the study area. The software uses linear programming optimisation, with an objective function to maximise Net Present Value (NPV) from mill-gate sales, using a 5% discount rate. The scenarios were run for 100 years. Besides NPV, the Woodstock model included multiple ES:

- Timber volumes
- Carbon storage
- Regulatory services – windthrow risk
- Water quality – phosphorous emission
- Cultural services – recreation and aesthetic beauty.

Forest management models (FMMs)
Current FMMs present in the landscape:

- Broadleaves – managed for continuous thinning or clearfell harvesting
- Buffer zones / setbacks – mainly around water courses
- Native Woodland Sites – protected due to their high biodiversity
- Sitka spruce mixtures – also contains mixtures of Douglas fir, Norway spruce, Scots pine etc.
- Sitka spruce monocultures
- Lodgepole pine monocultures.

Besides the currently used FMMs (cFMMs), alternative FMMs (aFMMs) were developed for blanket peat soils:

- Lodgepole pine 1,600 stems/ha – planted and then harvested for biomass around 50-55 years
- Lodgepole pine 1,100 stems/ha – planted and retained indefinitely
- Nepbin thin – heavy thinning of lodgepole pine monocultures to 500 stems/ha, followed by retention
- Modified Kronoberg – Sitka spruce and downy birch mixture, planted, thinned and harvested for sawlogs
- Bog restoration – restoration of bog to natural conditions.

Global climate and bioeconomy scenarios

- BAU – Business as usual. No climate change or dynamic prices implemented
- S1 – Temperature increase of 3.7°C by 2100. Early high demand for biomass
- S2 – Temperature increase of 2.5°C by 2100. Increased EU demand for biomass
- S3 – Temperature increase of 1.5-2.0 °C by 2100. Increased global demand for biomass

All scenarios were modelled twice in Woodstock: once using only current FMMs, and once using current and alternative FMMs.

Results
aFMMs improved the NPV of forest management, by allowing lower-cost reforestation options for marginal sites. Compared to only using cFMMs, the aFMMs led to the following increases and reductions in forest ESs:

- timber volumes, standing and harvested
- carbon storage per hectare
- area at high risk of windthrow
- volume of large trees, area of old forest, and area of broadleaves in the landscape
- reduced phosphorous emissions into watercourses
- recreation and aesthetic beauty of the forested landscape.

FMM proportions in select scenarios: top: S1 and S3 with cFMMs, bottom S1 and S3 with cFMMs and aFMMs

Scenario results for NPV, clearfell area (CF) and harvest volume: BAU cFMM was used as baseline for determining relative values

<table>
<thead>
<tr>
<th>Scenario</th>
<th>NPV ($)</th>
<th>Relative NPV</th>
<th>CF area (ha)</th>
<th>Relative CF area</th>
<th>Harvest volume (m3)</th>
<th>Relative volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>cFMM BAU</td>
<td>16,253,445</td>
<td>1.00</td>
<td>8,150</td>
<td>1.00</td>
<td>3,279,679</td>
<td>1.00</td>
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<tr>
<td>cFMM S1</td>
<td>23,153,650</td>
<td>1.42</td>
<td>13,114</td>
<td>1.61</td>
<td>4,522,287</td>
<td>1.38</td>
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<tr>
<td>cFMM S2</td>
<td>20,553,678</td>
<td>1.26</td>
<td>11,380</td>
<td>1.40</td>
<td>4,279,795</td>
<td>1.30</td>
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<tr>
<td>cFMM S3</td>
<td>25,708,948</td>
<td>1.58</td>
<td>16,488</td>
<td>2.02</td>
<td>5,277,293</td>
<td>1.61</td>
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<td>aFMM BAU</td>
<td>18,792,781</td>
<td>1.16</td>
<td>9,642</td>
<td>1.18</td>
<td>3,432,511</td>
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<td>aFMM S1</td>
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<td>12,506</td>
<td>1.53</td>
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<td>aFMM S2</td>
<td>24,435,369</td>
<td>1.50</td>
<td>11,640</td>
<td>1.43</td>
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<td>aFMM S3</td>
<td>28,834,054</td>
<td>1.77</td>
<td>13,053</td>
<td>1.60</td>
<td>4,136,468</td>
<td>1.26</td>
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</tbody>
</table>

Conclusions
Findings of this study have indicated that the study area would benefit from the aFMMs in future and that the landscape could provide a very different basket of ecosystem services. The aFMMs improved NPV by allowing the harvesting of sawlog quality timber that is currently present in the forest, followed by a low-cost reforestation option. Thus, it is likely that forest managers would be willing to utilise them. It might be necessary to reevaluate and redefine the management objectives for many western peatland forest stands, which management models that should be used, and the ecosystem services that these forests should provide.

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