The Effect of Climate Change on Irish Forests

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Summary

Any climatic changes that are projected for Ireland within the next forty years will influence not only the tree crops being planted today, but also many of the trees and forests already growing here.

Rising temperatures and carbon dioxide levels could alter the productivity of our forests, both directly and indirectly. Included here are changes in rates of photosynthesis, water-use efficiency, photosynthate allocation and damage from injurious agencies. Many of the projected responses of trees and forests are difficult to predict, however, as our current climate models are inexact and the forest-level response is unknown.

Irish forestry is currently going through a major transition and future effects of climate change may well be superimposed on even greater changes brought about more by socio-economic reasons than by climatic influences.

Nevertheless, Irish foresters and the Irish forest industry cannot afford to be complacent. Anticipation of potential threats and opportunities could result in significant benefits, a healthier forest estate and a long-term competitive advantage.

1. Introduction

The subject of forestry and climatic change was raised as far back as the 1930's and began to be addressed in forestry text books in the 1970's (Layser, 1980). It was not until the 1980's, however, that the specific effects of climate change on forestry were written on in any comprehensive way (Bolin *et al.*, 1986; Shands and Hoffman, 1987 and Eamus and Jarvis, 1989).

The longevity of trees and forest crops makes them of particular use in tracing past evidence of climatic change. It is also this longevity, however, that makes forests more vulnerable to future change. Although some 'forest' crops e.g. nursery stock, Christmas trees or coppice, may lend themselves to an agricultural-type manipulation, forests are essentially different to agricultural crops.

For the purposes of this paper, the focus will be on the effects of climatic change on plantation forests and forestry in Ireland. The effects on semi-natural woodland and trees have recently been dealt with elsewhere (Jeffrey *et al.*, 1991).

2. Assumptions

Over the last number of years, climate change has been a very controversial subject with its own share of sceptics and prophets of doom. More recently, however, there is growing scientific evidence that the observed rise in average global temperature is real and that sea levels are rising (Houghton *et al.*, 1990).

Although there is still uncertainty as to the magnitude of certain changes, a framework must be established within which certain assumptions are made for the purpose of this paper. The main assumptions relate to temperature and precipitation (Anon, 1990) while second order assumptions are taken from Rowntree (1990). The changes suggested here are mid-way between 'best' and 'worst' case scenarios.

2.1 First Order Assumptions

It is assumed that the following changes will take place in Ireland between now and the year 2030:

Average annual temperature: an increase of the order of 2°C
Precipitation : 5 to 10% increase in winter.
: 5 to 10% decrease in summer.

2.2 Second Order Assumptions

Seasonal fluctuation of temperature.
It is assumed that the influence of the temperature increase will be more strongly felt in winter and that the frequency of frost would, therefore, be reduced.

Precipitation
The models are in general agreement about the increase in winter precipitation; there is less consensus for summer.

Snowfall
Because the snow/rain threshold is associated with temperature, it is expected that warming would markedly reduce snowfall frequency.

Evaporation
Changes here are more difficult to predict. A general assumption might be that increased evaporation will lead to larger soil moisture deficits in mid to late summer.

Wind speed
In the long term (beyond the middle of the 21st century) it is expected that mean wind speeds and the frequency of storms will decrease. In the next few decades, however, storm intensity is expected to increase.

Cloudiness
Because of the increases in CO_2 and water vapour, it is expected that clear sky solar radiation will decrease. On the other hand, if soil moisture deficits limit evaporation, then some increases might be expected.

From the above, it can be seen that any projections made on climatic changes are very tentative. The effects on regional changes in climate are even more so. It is proposed, therefore, to deal with broad changes or trends only and to examine how these changes might affect the management of our future forests.

3. Assessing the Impact of Climatic Change on Irish Forests and the Forest Industry

3.1 The Problems

Because of the scale of the anticipated changes to our environment, models are required to project climatic trends into the future. Many such models are already in existence but improvements are required, particularly in fine-tuning the models for regional projections of local climate.

Even if we could be precise in predicting what climatic changes might occur, however, forest biologists are far from being in a position of confidence to predict the individual tree or forest response.

Eamus and Jarvis (1989) summarised the potential problems in this regard:

* Few experiments in this area have lasted more than two years and it would be highly speculative to extrapolate from these to longer time scales.

* Few of these experiments have considered the potential effects from nutrient stress in a natural environment or of variations in soil type.

* There are suggestions from seedling trials that crown morphology and structure may be affected by CO_2 concentration. If this were to persist, it might have a major influence on the total amount of photosynthesis in stands of Sitka spruce (Russell *et al.*, 1988).

* Because of their size, trees do not lend themselves easily to direct measurements of the effects of CO_2. Unlike agricultural crops, therefore, prediction of the broader scale response to changes in climate are difficult.

As in the case of projecting changes in future climate, the only realistic way of assessing the potential effects on trees and forests is through the use of models. But can forest managers wait for such models? The forest

profession has always dealt with uncertainty of what the future might hold and foresters plant today with the belief that by the time their crop is harvested it will be what the forest industry of the 21st century requires.

3.2 Appropriate responses

Should foresters now respond to the climatic projections as they stand? If they do, then the response might involve some of the following:

1. Changes in the seed origins for our more commonly grown forest trees.
2. A broader choice of species for planting.
3. Silvicultural manipulation of existing crops.

These will now be dealt with in more detail.

3.2.1. Effects of climatic change on the choice of seed origins for our commonly grown forest trees.

Because of the lack of native productive coniferous species in Ireland, we have relied on imported seed for the majority of our forest plantations. Choosing the correct origin from which to import seed is crucial in the success of crop establishment and in the quality and quantity of timber yield.

From information collected and observations made on established field trials, Irish foresters now know the seed origins that suit their local climates best. These choices, however, may have to be reassessed in the light of suggested climatic changes. Foresters may have to move to more southerly areas when selecting the best origins for Douglas-fir and Sitka spruce.

The effect of climatic changes on the nature and scope of present tree improvement programmes is uncertain. Are todays plant breeders working on material that will be suitable for tomorrows forest or on material that will grow hopefully in a climate similar to that of today? Much of the seed for future forests in fact, will come from seed orchards selected for their performance over the *past* decades (Cannell *et al.*, 1989).

3.2.2. Choice of species

This response is often the one that first arises when climatic change is suggested. Species changes may require, however, that the yield of species currently in use is lowered as a result of climatic change. Our current average productivity of 14-16m^3 ha^{-1} yr^{-1} is significantly greater than other European countries. The sites where the maximum productivities for Sitka spruce are achieved are on wet mineral lowland soils of moderate fertility where climatic conditions such as high rainfall, high humidity, frequent fog and moderate annual ranges of temperature occur.

In western North America, Sitka spruce is confined in its natural distribution to the coastal fog belt. If the number of dry, warm days increases in Ireland, then Sitka spruce may become restricted in some eastern and south-eastern localities. Whether it increases its productivity in the wetter areas depends on other factors. For example, if chilling requirements are not fully met, then it may flush later and fail to exploit the longer growing season.

Other tree species adapted to milder areas, such as Monterey pine, Monterey cypress and some eucalypts, are able to grow almost continuously in milder parts of this country. Although such species have been damaged by frost in the past, the suggested warming may mean that their role in the future of Irish forestry may become more important. The average productivities for some of these alternate species are often higher than those for Sitka spruce.

The selection of any one species will not only depend on projected shifts in climate, however. In Ireland, socio-economic factors will also influence the choice of species that is planted. The level of European Community grant-aid for private planting already differentiates between broadleaf and conifer planting, and the European Community and the National Government may further influence the species that foresters plant in the future (Molloy, 1991).

3.2.3. Silvicultural inputs

The effects of climatic changes on the outplanting success of transplants on either afforestation or reforestation in Ireland is unknown. In the past, survival has generally been high, particularly on afforestation sites. Projected moisture stress in mid to late summer may require a move to containerized planting stock or changes in site cultivation techniques to lessen the impact on certain site types.

Similarly, because of the reduction in the chilling period as a result of milder winters, certain species such as Douglas-fir or noble fir may require additional investments in cold-storage facilities at the nursery stage or more careful site selection.

Silvicultural decisions may also have to be reassessed later in the life of the crop. Stands may have to have rotation length changed or may require more or less inputs in fertilization, pest management, etc.

4. The Forest Industry

Authors argue as to the absolute or relative importance of climatic change on forestry and the forest industry. Eamus and Jarvis (1989) state that the effects of CO_2 increases may be relatively small in relation to future changes in land-use and management practices. Hoffman (1984), on the other hand, argues that the effects of these climatic changes will have a

more pervasive influence on forestry than any other single environmental or technical change.

Unfortunately, it is far too soon to be able to predict the biological or economic effects of global warming on forests or the forest products industry. The changes will not happen overnight. The industry, therefore, has time to plan a strategic response through the methods outlined above.

The Industry must also examine the anticipated response to climate change from other sectors which impinge on it. In Ireland, the pool of land available for afforestation is heavily dependent on the agricultural sector. It might, therefore, be important to assess the effect of changes in climate on the productivity of various agricultural crops with which forestry may compete for available land.

As discussed above under choice of species, however, it may be the European Community aid and other factors that will dictate what agricultural crops will be grown on what land rather than the potential effects of climatic warming.

Climatic change will also probably affect the energy industry. This again could influence the profitability of the Irish forest products industry in comparison to our competitors. It could also influence the species that we grow, as forest biomass crops might again become an economic land-use option.

5. Conclusions

The future climate is uncertain. Even the most conservative climatic models, however, project dramatic changes to our climate and these changes will have many effects on trees and forests. How well forest managers anticipate and respond to these changes will depend on the climatic, biological, social and economic factors that have been touched on in this review. The most important considerations may be:

Climatic models

Any form of planning requires forecasts of eventual outcomes. Our current climatic models need to be more precise, particularly in projecting regional climates, before responses can be planned.

Predicting growth responses

The responses of individual plants to increases in CO_2 concentration have generally been established and are quite well understood. The extrapolation of these results to the tree, forest or ecosystem level needs to be carried out through the use of biological models. Current forecasting models of future forest productivity may need to be updated or adjusted as more information is forthcoming. Further information is also required on the effect of climatic change on water-use efficiency, wood anatomy and chilling requirements of our most common tree species.

New genetic needs

It is generally felt that productivities will increase in temperate plantation forests. Can species and populations be bred to anticipate the climatic changes and grow even faster under the new conditions? If climatic conditions do change on specific sites, foresters may have to use alternative species rather than look to other seed origins of the existing species.

Planting and management

Do forest managers now sit back and allow the foresters of the future to deal with problems that might have been anticipated now? Foresters must become more aware of future climatic trends as models improve. Only then will they be in a position to manage the risks through manipulation of silvicultural practices, if changes are required. As forests move to better soils in the future, the choice of species will increase even in the absence of climate change.

Hazards

Changes in temperature, precipitation and wind patterns, and the trees response to them, will cause changes in the ecology of forests. Little precise information is available on how storm patterns will behave in our future climate. We can only anticipate the worst through proper cultivation and planting techniques, choice of species and thinning methods. Sitka spruce may suffer large losses of increment through aphid attacks, particularly on dry sites. We must also maintain vigilance against exotic pests – many of which would enjoy a warmer climate here.

The forest industry

Decisions here will not be taken in isolation. The availability of land for Ireland's major planting targets of the future is dependent on European Community and National Government decisions. How global warming affects agriculture will also affect the forest industry.

The global scene

The future trends in climate change are world-wide. In Ireland, anticipated changes in productivities, markets and income depend also on the response of world governments and world industry to our future climate.

Much of the discussion in this paper is of relevance not only to Ireland but to all the wood producing nations in the world. Climate change is a global issue and will therefore influence world supply and demand for wood and wood products and, therefore, prices and profitability (Pittock, 1987). A global forest sector model has been used to project the production, consumption, prices and trade of a number of forest products (Binkley, 1987). The model makes some interesting projections for national incomes to the year 2030. For example, Finland is set to increase its income by over

22 per cent while Australia and New Zealand are projected as losing almost 25 per cent of their income.

Because of the broad assumptions in Binkley's model, Pittock (1987) states that "the results should not be taken too seriously". Nevertheless, for a small trading nation such as Ireland, it acts as a reminder that whatever strategies are decided upon in relation to climatic change and the forest industry, they must take into account the global picture of wood supply and demand.

Many factors, therefore, will impinge on the future of our forests and forest industry. The changes brought about to our forests by climate change will be superimposed on these factors and, over time, may become inseperable from them. Today's forest managers, however, must not use this as an excuse to do nothing. Trees being planted today will still be growing when the climate will have already changed. A response is needed.

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