AN ECOLOGICAL OVERVIEW OF PLANTATION FORESTRY

DAVID WHITEHEAD*

ABSTRACT

The terms used in the description of ecological processes are discussed, and their use with respect to plantation forestry is clarified. Disturbance in natural ecosystems is very common and the idea of a climax community is seldom realised in fact; disturbance may even help to maintain forest structure. High diversity is not always associated with stability and examples of forest ecosystems which are dominated by single species, often in uniform age classes, are provided. Climate is an important variable in the structure and composition of an ecosystem although it is considered that this is not so important within the time scale of most plantation forestry. It is emphasised that diversity is not necessarily directly related to productivity. The role of management in maintaining ecological balance is discussed and it is concluded that there is little ecological harm in plantation forestry provided precautions are taken in management options.

INTRODUCTION

With increasing interest in environmental and recreational activities there is considerable concern about the conservation of natural forests and the introduction of widespread planting of exotic species. This concern is accentuated by the fact that much of the plantation forestry is dominated by large areas of single species, often in uniform age classes. Perhaps there is no better example than the pre-eminence of *Pinus radiata* in New Zealand.

Ecology is a relatively new science, and during the last 50 years has progressed from being purely descriptive to being based on firm mathematical principles. Like any science it demands rigorous collection of data which are used to test hypotheses. It has become popular to criticise plantation forestry on ecological grounds but much of the criticism is itself ecologically unsound and this has led to many articles where misconceptions have been used in concluding that plantation forestry is ecologically dangerous. This paper sets out to clarify some of these misconceptions and to present a balanced view of plantation forestry in ecological terms. Although this review is short, the conclusions drawn are based on a wider range of examples from the literature.

*Forest Research Institute, Rotorua.

SUCCESSION AND CLIMAX

Ecology is the study of the interrelationships of organisms with each other and their environment, and the unit of study is the *ecosystem* (Odum, 1972). Energy is required to maintain the structure of an ecosystem and this must originate from the sun. Energy flows through an ecosystem and is lost, whereas nutrients cycle and are removed only by, for example, removal of biomass, weathering of soils, and leaching.

The changes in structure and composition of an ecosystem with time are termed *succession* and the term *climax* has frequently been used to describe a final state, at and subsequent to which the structure is stable. It is overwhelmingly apparent from the literature that although climax is a useful concept it is seldom realised in ecosystems. Changes in structure are very common owing to natural calamities which may vary in size from a single storm to a catastrophe on a larger scale.

Fire, especially important in the *Eucalyptus* forests of southwestern Australia, the savanna areas of Africa, the boreal forests of north America, and the coniferous forests of the Pacific coast of America, is a major cause of disturbance in forest ecosystems, often being started by lightning strikes (Jones, 1945). There are many examples of natural disturbance in communities and they have been categorised and reviewed by White (1979). Species composition after a disturbance may continue the same or be quite different and because of dynamic changes taking place the present structure of an ecosystem gives no indication of its previous or future structure. In many ecosystems cyclical succession is exhibited where different species become dominant after a disturbance. Forcier (1975) illustrates this point with the birch-maple-beech succession at Hubbard Brook. After a disturbance yellow birch is the first species to colonise and grow rapidly to produce a canopy while sugar maple forms an understorey. As the maple grows more quickly than the birch, it later becomes dominant and this environment encourages the development of beech seedlings. Beech eventually dominates until there is another disturbance and the cycle is broken to be renewed again at any point. In some cases of cyclical succession the composition of a forest may not be returned to its pre-disturbance state for several hundred years. In the long term, disturbance may not destroy forest structure but help to maintain it.

The parallel which can be drawn between plantation forestry and successional changes in natural communities is that changes in structure and composition are very common and the disturbances caused by harvesting plantation trees are often less severe than some natural calamities.

DIVERSITY AND STABILITY

Perhaps most of the arguments centred around natural and plantation forests deal with the relationship between *diversity* and *stability* within communities. Both of these terms have been widely discussed and neither is easy to define in precise numerical terms. Despite many attempts to devise suitable indices for measurements of diversity, it is still true to say that on balance the number of species present is as good a measure as any (Williamson, 1972). Diversity within natural communities around the world is very variable; notably the tropics are associated with high diversity of species in small areas and the polar regions with low diversity. Stability is perhaps best defined as the capability of a community to maintain its present structure after a disturbing influence.

The important point is that high diversity is not always associated with high stability within communities. On the one hand, as has been pointed out above, most ecosystems are not stable, in a structural sense, but dynamic changes in species composition and numbers are always taking place. On the other hand, there are examples of communities where diversity is low but stability is high. There are many forest ecosystems around the world where there is single species dominance and some can be considered as virtually "monocultures". Examples include the *Nothofagus* forests in parts of the South Island of New Zealand (Chapman, 1958), the pine and oak forests of eastern United States, the coniferous forests of eastern Canada, the white pine forests of north-western Pennsylvania and south-western New Hampshire, the old-growth red pine forests of north-western Minnesota (Spurr and Barnes, 1973). The European boreal forests are often characterised by single-aged single species (Jones, 1945) as are the Douglas fir forests of Alberta (Tande, 1979) and parts of Oregon (Franklin and Dyrness, 1973). *Pinus radiata* in its native habitat in California occurs in well-defined pure stands, with the amount of understorey depending on the soil and aspect, in the coastal summer fog belt (Forde, 1966).

It is, therefore, not uncommon to find natural communities which are formed from single species dominants in uniform age classes.

CLIMATE

One important variable in ecological processes is *climate.* Richards (1952) considered that high diversity and stability in tropical rain forests could be attributed to high, evenly distributed rainfall and constant seasonal temperatures in these areas. At higher latitudes seasonal changes in day length and temperature are more important in determining growth rates and species success. It appears that the harsher the environment the more limited the resources and the more severe the competition between species, which results in lower diversity. The physiognomic character of an ecosystem is thus closely constrained by climate. For example, Bellamy *et al.* (1969) hypothesised that, in the environmentally unfavourable habitat of the English Pennines, the low stability and diversity of the alpine flora was related to both the low productivity rates and the seasonally changing fluctuations in the environment, such as water level.

In the long term the influence of climate may be responsible for changing the nature of vegetation. Holloway (1964) reviewed his climate change hypothesis and concluded that to date there was no evidence to suggest that it was invalid. He had attributed the present structure of forests in the South Island of New Zealand to large climatic changes in temperature, precipitation, and exposure during the period 1200 to 1400 A.D. Although Holloway's hypothesis has been critically discussed, no evidence has been provided to seriously dispute it. Relationships between vegetation composition and climate have also been explored using pollen analysis (*e.g.,* Pennington, 1969).

As climate changes occur, the composition of natural forests will change and it is unreasonable to expect the *status quo* to remain indefinitely. However, with plantation forests where rotation time is reasonably short (of the order of several decades) there is little risk that the species will become unsuitable within any one rotation because climatic changes usually occur over much longer periods.

PRODUCTIVITY

In tropical and subtropical regions, productivity is higher than at higher latitudes and this is often associated with greater diversity. In ecosystems an approach to the climax state is usually associated with a larger amount of standing biomass and lower productivity (Odum, 1972). However, it should be emphasised that diversity is not directly related to productivity (Whittaker and Woodwell, 1972). Much of the evidence suggesting that mixed cropping produces higher yields comes from agricultural work but Harper (1967) concluded that there is as much evidence against this proposition as for it.

MANAGEMENT

In mature ecosystems, most nutrients are bound up in living or dead biomass and tight, closed cycles of nutrient exchange exist (Whittaker and Woodwell, 1972). When disturbance occurs there is a disruption to both the biomass in the ecosystem and the structure of the site. For example, Gadgil and Gadgil (1978) showed that the release of nutrients from a clearfelled *P. radiata* site was probably due more to the removal of mycorrhizal roots than to the physical effects of the operation on the soil. The removal of biomass from plantations can be likened to the effects of fire in natural ecosystems. It is not difficult to replace the nutrients by the addition of fertilisers, but it is more difficult to retain characteristics such as humic content and physical properties of the soil, the retention, mobilisation, and fixation of nitrogen and the hydrological properties of the site. It is the manager's role to ensure that these site characteristics are not irreparably damaged and, provided caution is taken in forest operations, there is no reason to suppose that deterioration in the ecosystem will occur. Will and Ballard (1976) described the statement that continuous growing of *P. radiata* on a site causes deterioration of the soil structure as a "popular misconception". Fire should not always be viewed as an ecological catastrophe and short-term measures to prevent erosion may not be the most successful in the long term for preventing dramatic slipping.

CONCLUSIONS

This brief review has attempted to correct some of the ecological misconceptions used to criticise plantation forestry. It does not, however, cover other important considerations such as the recreational, economic, pathological, and entomological aspects. It seems reasonable to conclude that there is little ecological harm in plantation forestry with exotic species provided sufficient care is taken in the management of the ecosystem to avoid irreparable damage. Most of the plantation species grown tend to be pioneer types in that their persistence is dependent on continued disturbance. It has been stressed that ecology is still a relatively new science and there is an urgent requirement for more ecological research so that a firm basis for prediction of management effects on ecosystems is established. This will be achieved only by a better understanding of ecosystem dynamic processes.

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