The spread of Douglas-fir into native forests

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Background

A range of introduced conifer species thrive in the New Zealand environment. They express this by not only growing well, but also by regenerating naturally to produce what are commonly known as 'wildings'. In many parts of rural New Zealand opportunities for wildings are increasing, as grazing pressure declines along with numbers of farmed and wild animals, less vegetation is burnt, and as seed sources increase in the form of plantations, woodlots and shelterbelts (Hunter & Douglas 1984; Ledgard 1988). Many people consider wildings as a potential threat to existing land uses, and conservation and landscape values (Ledgard & Langer 1999).

Introduction

Throughout the country, Regional and District Councils are considering land use activities in terms of the requirements of the Resource Management Act. District planners are grappling with the environmental impacts of forestry, and featuring high amongst them, especially in the eastern areas of the country, is the spread of wilding conifers.

The issue of exotic trees invading native forest is not new. In 1979, Geoff Chavasse sent out a nation-wide questionnaire on the topic. Replies varied in detail, but the evidence obtained from the survey was clear. 'Closed standing native forest is not invaded by exotic trees except in very rare circumstances' (Chavasse 1979). Douglas-fir (*Pseudotsuga menziesii*) is most notable by its absence from the report, not even being listed in a table of 'reported instances of native bush being invaded by exotic trees'. The table lists nine conifers, six of which are pines.

Douglas-fir differs from the pines in that it is more shade tolerant, and hence more able to spread under forest light-wells and into regenerating native forests and shrublands before canopies close. There are also recorded situations where the species has invaded mature forest, such as mountain beech (*Nothofagus solandri* var. *cliffortioides*) on the slopes behind Queenstown, Central Otago (Cleary 1982), and on Burnt Face, above Cora Lynn in the upper Waimakariri river catchment, Canterbury (Ledgard 1989; Dickson 2001). These two examples are quite well known and are often cited when the risks of wilding spread are discussed. What is less well known however, is that there are many other examples where Douglas-fir has grown adjacent to native forests for some decades, with no, or very few wildings threatening the long-term persistence of the indigenous cover. Consequently, the common impression is that the species invades native forests more readily than is actually the case.

This article describes seeding characteristics, some studies of wildings along margins where Douglas-fir has been planted adjacent to native forest, and suggests methods for minimising the risk of spread.

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Seeding characteristics

Douglas-fir has similar characteristics to pines that successfully establish as wildings (Richardson *et al.* 1994). These are small seed with large wings, early coning (age < 10 years), and short intervals (< 3 years) between large seed crops. Amongst the common introduced conifers in this country, mean full seed weight of Douglas-fir is the third lightest after Lodgepole and Scots pine (*Pinus contorta* and *P. sylvestris* respectively, Baird 1977). It is the same order for seed wing loading (Author, unpub. data), which takes into account wing width and length relative to seed size, and is a measure of the ease with which seed can be carried by wind. Most trees will not cone before age 12. However, I have found cones on trees as young as age 7, although no full seed was found within these cones. Natural crop-periodicity is irregular, with good seed crops occurring every 1-3 years in Canterbury (Miller & Knowles 1994). When good crop years do occur coning can be very heavy. At Tara Hills near Omarama (annual rainfall 520 mm, 600 m asl) two 13-year-old trees had 800 and 300 cones. A destructive cone sample revealed them to contain a total of 22,250 and 16,600 seeds, of which 41% and 47% respectively were full and therefore presumed viable (Author, unpublished data). Such heavy coning could be related to the low rainfall and/or moderate altitude, as counts over 4 years on 16-19 year-old-trees at Craigieburn (1200 mm rainfall, 850 m asl) revealed an average of only 2,000 seeds/tree with only 8% of these being viable (Author, unpublished data).

Importance of mycorrhizae. The successful establishment of conifer seedlings, particularly those of Douglas-fir, is very dependent on the correct mycorrhizal fungi being associated with their root systems (Chu-Chou & Grace 1987). Many young seedlings can appear unhealthy and chlorotic, only persisting for a few years with little growth, before dying (ephemeral). However, some of these seedlings, after an initial chlorotic stage, can become green very quickly and then commence good growth. This 'greening up' is associated with the roots becoming mycorrhizal (Davis *et al.* 1996).

Habitat preferences

Langer (pers. comm.) studied seedling establishment and early survival of four introduced conifers sown into tussock grassland, open shrubland, and in mountain beech forest under a canopy gap as well as under an intact canopy, in the Harper-Avoca catchment in the upper Rakaia River. At the end of their second spring, 54% and 56% of viable Douglas-fir seed sown had established as seedlings in the open shrubland and grassland respectively, but subsequent mortality was high, so that after 7 years survival was down to 12% and 6 % respectively of viable seed. Under the beech forest canopy gap, <10% of viable Douglas-fir seed was present as seedlings after the second spring, with only

Douglas-fir wildings under a canopy gap in beech forest behind Queenstown. Douglas-fir is more shade tolerant than the pines, and there is a risk of the species invading open native forests and shrublands, particularly following disturbance.

three chlorotic seedlings (0.4% of viable seed) of average height 70 mm, still present after 6.5 years. Under the intact beech canopy, <1% of viable seed was present as seedlings after the second spring, and just one chlorotic seedling (70 mm tall) was still alive after 6 years. Clearly, beech forest was a much more hostile environment for the establishment of Douglas-fir than grassland and shrubland.

Forest invasion

As indicated above, there is a belief that Douglas-fir will invade native forests, especially beech forest, particularly if planted immediately alongside. However, I have inspected a number of Douglas-fir / beech forest interfaces, and found wildings to be generally absent within the forest. If present, they are usually ephemeral, or if more mature, in very low numbers.

At Burnt Face, where wildings are present within the mountain beech forest, there is a history of grazing (mostly by sheep) up until the 1980s. The understory vegetation is still sparse, and has only started to recover relatively recently. In three 50 m x 2 m transects running at right angles to the Douglas-fir beech forest margin, numbers of wildings have risen from < 1/m² in 1989, to 6.1/m² in 1996, to 10/m² in 2001 (Ledgard 1989; Dickson 2001). Seedling numbers dropped off quickly with increasing distance from the Douglas-fir margin – from an average of 25/m² within 5 m of the forest margin in 2001, to < 2/m² at 46-50 m. In 1989 and 1996, the majority of seedlings were chlorotic and appeared ephemeral (94% in 1996), but by 2001 this figure had reduced to 40%, and the remaining seedlings were green (probably mycorrhizal), and therefore more likely to survive.

In the Blue Mountains, I inspected five sites where mature Douglas-fir had been growing alongside silver beech forest for 35-75 years. At four of these sites, wilding numbers were low and appeared to be mostly ephemeral. A few were up to 25 years old, but still struggling to emerge from competing native understory vegetation. At the fifth site, where the native forest understory was the sparsest, there were some locations where wildings were more common. Here, the maximum density of Douglas-fir wildings within 5 m of the forest margin was just over 20 individuals/m², whereas at 46-50 m from the forest edge numbers were down to less than <1/m². The vast majority were chlorotic and < 50 mm tall.

In Ashley Forest, the situation was similar to that in the Blue Mountains. At one site, alongside 25+ year-old Douglas-fir there were very few wildings in the beech forest, and none were greater than 50 mm tall. At another site, wildings around 12 years old were present growing through 2-3 m tall manuka scrub. The lack of younger wildings indicated that further invasion was less likely, possibly because the scrub had thickened up. At a third site, Douglas-fir had been planted in amongst mature beech about 25 years ago. Survival was probably around 50%, but the majority were well suppressed with mean diameters of <100 mm (trees in a fully stocked stand of the same age should have mean diameters of >2000 mm). A few trees, possibly planted in the larger light-wells, had grown above the beech canopy and were coning. Beneath these Douglas-fir trees, young individuals of beech and fir were growing together, but the fir seedlings looked chlorotic and unthrifty.

The field sites described above indicate that two major determinants of wilding presence in native forests are likely to be the degree of canopy closure and the vigour of the understory vegetation. In vigorous, closed canopy forests the risk of invasion appears minimal. However, where canopies are more open and the understory is sparse, the risk of invasion is much higher. Such situations occur most frequently after disturbance and in regenerating forest communities. Chavasse (1979) concluded similarly – 'The evidence is that, with very few exceptions, exotic forest trees have invaded native forest only where it has been severely modified in some way – by grazing, burning, logging, tracking etc., including where some erosion has occurred.'

In brief, if Douglas-fir seed or seedlings are present when native plant communities suffer disturbance, then wildings may establish, and possibly dominate, before the native species recover sufficiently to become the dominant cover. More studies are needed to determine the factors involved in such sequences.

Minimising the risk

The indications are that there is a risk of Douglas-fir invading native forests subject to disturbance. There are basic precautions which can be taken to minimise that risk. Along a Douglas-fir / native forest interface, most seed blowing into a native forest is likely to come from trees along the edge of the plantation. Therefore, planting a less spread-prone species (such as Lawson cypress or ponderosa pine) along the plantation margin should reduce the risk of spread (Ledgard & Langer 1999). One should also avoid siting Douglas-fir on exposed, seed 'take-off' sites (such as ridges) immediately upwind of native forest, where seed can be blown far further than just the fringe areas.

Finally, even though the risk of wilding invasion of healthy native forests is low, inspections alongside Douglas-fir margins should be made periodically, and any wildings present removed. This is especially important where the native forest has been disturbed.

The Future

Although the risks of wildings invading intact native forests is not high, it is my impression from many observations over recent years, that the frequency of Douglas-fir wildings is increasing in open shrublands and unimproved grasslands – to above the native treeline in places. This may be due to the higher levels of ambient spores of the mycorrhizae associated with Douglas-fir, resulting in an increased likelihood of young wildings becoming infected with the correct mycorrhizae in their early years. The increasing percentage of green, healthy wildings at Burnt Face between 1989 and 2001 (Dickson 2001) supports this hypothesis. It may also explain why Douglas-fir was hardly mentioned in the nation-wide survey carried out 25 years ago by Chavasse (1979). Whatever the cause, Douglas-fir wildings appear to be establishing more readily around parent stands than they did in the past, and foresters must plan to take the appropriate precautions to avoid any risk of unwanted spread.

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Calendar

The following conferences, expos, courses and other events will be of interest to readers. Details are brief, so please contact the organisers for more information.

24-30 March 2003
International Expert Meeting on Planted Forests
Role of Planted Forests in Sustainable Forest Management
Contact: Don Wijewardana, Ministry of Agriculture and Forestry, P O Box 2526, Wellington, Tel: 04 4989870, fax: 04 4989891, email: don.wijewardana@maf.govt.nz. Website: www.maf.govt.nz/mafnet/unff-planted-forestry-meeting/

27 April-1 May 2003
ANZIF Australian and New Zealand Institute of Forestry Conference, Queenstown

8-13 August 2003
XXII IUFRO World Congress, Brisbane
www.iufro.boku.ac.at

21-28 September 2003
XII World Forestry Conference
Forests, Source of Life
Quebec, Canada
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