When pine and eucalypt meet

Its natural range is a mere 4000 hectares on the coast of California, but *Pinus radiata* has made the most of this modest beginning and now covers more than a million hectares of the globe. And this spread is largely due to mankind's intervention.

Our enthusiasm for the radiata or Monterey pine goes beyond the annual need to acquire a Christmas tree. Timber produced by the tall exotic is attractive, easily worked, and, for a softwood, surprisingly strong, and the dark green plantations are now a familiar sight in the cooler high-rainfall regions of the country.

So *P. radiata* owes much of its success to diligent plantings. But the species could well be taking matters a step further — it seems to be making some territorial gains of its own.

Scientists have known for decades that the radiata pine flourishes outside its natural range — and the differences in climate and soils do not seem to provide sufficient explanation for the superior growth and form of these trees when planted as exotics in foreign lands. In virtually every part of Australia where radiata pines have been established — poor soils, suboptimal climates, and all — they grow faster than the local eucalypts that have had far longer to adapt to environmental peculiarities of the region.

In large part, ecologists attribute this rapid growth of radiata pines, away from California, to the virtual absence of competitors (like other pine species) and of their usual pests and parasites — expatriate pines bear a lesser biological burden. This view is supported by the observation that eucalypts too show better growth overseas than in their homeland — those in California cover 6·5 times the area of native radiata stands!

These two photographs, taken within the transect in 1974 (left) and 1981, illustrate the rapid growth of pines in the mixed forest.

Measuring edge effects

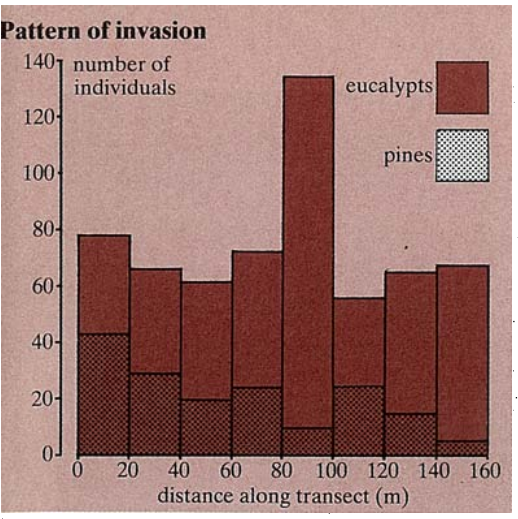
Good yields from pine and the high demand for softwood timber have made it an economic proposition to clear indigenous eucalypt forest and replace it with pine. And the boundaries between these plantations and native forests provide ecologists with a golden opportunity to study what happens when pines and eucalypts come up against each other, in this case on the eucalypts' home ground. Interested in the incursions that plantation pines sometimes make into surrounding eucalypt forest and the implied scenario for competition, Dr Jeremy Burdon of the CSIRO Division of Plant Industry and Dr Graham Chilvers of the Botany Department at the Australian National University decided to exploit one such opportunity. They measured some of the ecological processes near the dividing line between a 43-year-old plantation of *P. radiata* and a dry sclerophyll forest in the Brindabella Ranges in the Australian Capital Territory.

The plantation and the eucalpyt forest met at a ridge-top with the pines on the eastern slope and the native forest to the west. Starting 50 m from the boundary, to avoid a fire-break, in 1974 the scientists marked out a 20- × 120-m transect down the western side of the ridge at right angles to the edge of the plantation. It was re-examined briefly in 1976 and 1978, and again in more detail 7 years after commencement.

Because pines intercept so much light, this eucalypt sapling in a pine forest will only grow quite slowly. Similarly, pines are better at colonizing more open dry sclerophyll forests than the wet sclerophyll type, in which they are less competitive due to their intolerance of shade.

At the time they mapped out the transect they counted 755 trees, of which 22% were radiata pines of various ages. The remaining trees belonged to four *Eucalyptus* species: scribbly gum (*E. rossii*), red stringybark (*E. macrorhyncha*), apple box (*E. bridgesiana*), and broadleaf peppermint (*E. dives*). The botanists found that the pines were most abundant at the plantation end of the transect and that they declined more-or-less logarithmically with increasing distance from the boundary — as might be expected if the pines grew from seeds blown from the plantation.

In 1974, measurements of trunk diameters of the pines and eucalypts revealed that small pine saplings easily out-numbered small gum saplings, indicating that the exotic species was enlisting more young



Eucalypts in a transect adjacent to a pine plantation showed no gradient in abundance, but the number of pines in each 20- × 20-m block declined with increasing distance — indicative of wind dispersal.

recruits to its population than the native trees. So-called 'nearest-neighbour tests' also showed that trees tended to cluster near others of the same species and this pattern was particularly evident in pines. The scientists wondered whether this clustering of pines owed anything to reproduction by older cone-bearing pines in the transect, with shed seeds falling close to the parent tree. Or was it merely due to filling of 'vacant' spaces or preferred sites by pines in the native forest? They waited until 1981 to find out — and the answer is of special interest, since prospects for the invading pines look much brighter if they can reproduce independently of parent plantations.

When they returned to the transect area in 1981, the scientists again mapped the trees and re-assessed the age structure of the pine population with greater precision, adopting a method for estimating tree age that had been developed by Dr Mark Dawson and his colleagues in the Department of Forestry at the Australian National University.

From back projections of tree ages, the scientists could now plot the total number of pines in the transect over time. They found that the first stray pine became established in about 1955 and that the number of pines in the area had increased, at varying rates, ever since. A particularly spectacular increase was apparent in 1981. In that year, they detected 94 freshly germinated pine seedlings — more than the sum total established during the previous decade!

Pines make good their escape

Considering the plantation was clear-felled in 1977, the continued establishment of seedlings demonstrates, without doubt, that the plantation escapees were responsible for a further generation of pines, and hence their clustered distribution. But the pines don't have it all their own way. The sudden 'hiccup' in their abundance in 1981, when all the trees were aged and counted, represented the current crop of seedlings. However, the population explosion was short-lived, as these subsequently suffered massive mortality. A further check 18 months after the 1981 census showed that most of the hopeful young seedlings had disappeared, just as those of previous years had done. This pattern is confirmed by the age structure of the population: many 0- to 1-year-old trees, but considerably fewer trees in older age classes.

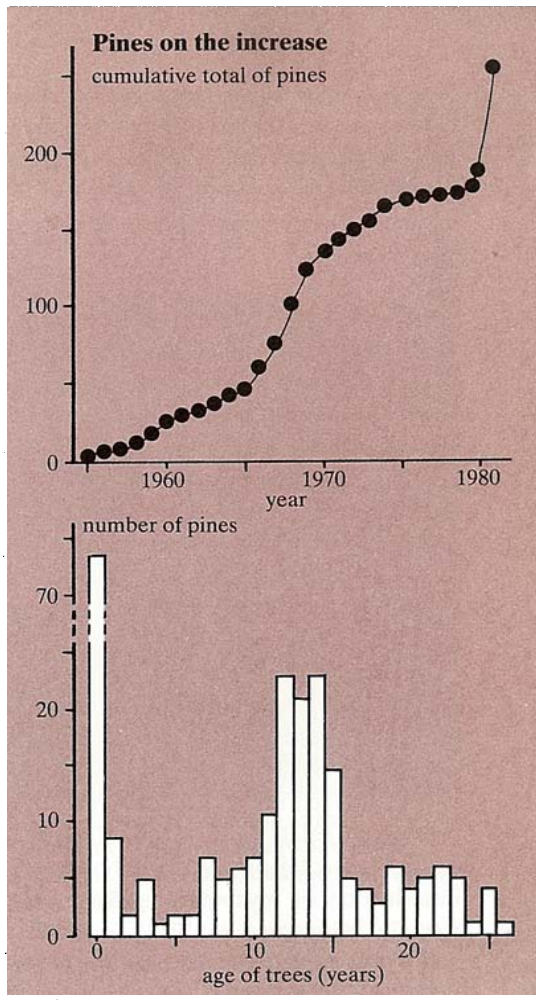
So how do pines and eucalypts compare? Are the upstart exotics making territorial gains at the expense of local eucalypts?

Spectacular growth

In terms of growth rate, the pines win hands down. Back in 1974, the scientists suspected that the pines were outdoing the eucalypts in this respect, but even they were surprised at the actual values. Total cross-sectional area of the trunks of all eucalypts (measured 1 m above ground level) increased by 6% between 1974 and 1981; for pines the figure was 266% — enough to curdle the sap of any eucalypt. It could be argued that this difference between the two species is to be expected, since the eucalypt forest includes mature trees whereas all the pines are still of an age where active growth is the norm. However, even eucalypts and pines of similar 1974 trunk diameter showed marked differences in growth between then and 1981 (see the chart on page 12).

Numerically, pines have also increased (up 89) while the eucalypts collectively showed a decline (down 29). Taking into account the subsequent mortality of pine seedlings, the gains made by pines would probably just balance the loss of eucalypts. This presents a fairly stable picture, but with some replacement of eucalypts by pines.

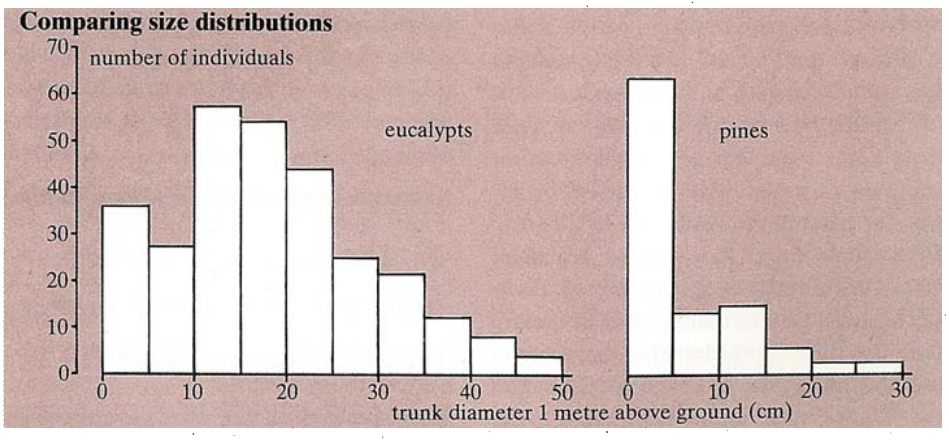
Judging by the number of pines and eucalypts in various size classes, more young pines than eucalypts are being recruited into the populations. Continuing the military analogy, that augurs well for the invading force — the pines.



Since initial colonization of the study area in 1955, the number of pines has increased more or less steadily. The chart (showing the age structure of the pine population in 1981) suggests that the sudden surge in abundance in that year (shown in the graph) will be short-lived, since few 0- to 1-year-old pine seedlings graduate to older age classes.

As far as recruitment is concerned, pines again outclass eucalypts. Between 1974 and 1981, a higher proportion of pines (63%) than eucalypts (49%) succeeded in the difficult transition from the less-than-1-m class to large size classes. Also, more pines than eucalypts appeared within the transect area during that time.

Visual observations confirm these demographic statistics. In photos taken at



the same spot in the transect, eucalypts appear much the same in 1981 as they did in 1974, while pines are considerably larger, with some approaching the heights of the dominant eucalypts and threatening to surpass them.

Eucalypts could have the last laugh

Does this mean we face an epidemic of pines? The scientists are at pains to emphasize that any implied threat should be seen in proper context.

Firstly, four decades after the pine plantation was established, the edge effect of pine incursion effectively peters out within half a kilometre of the plantation. Only occasional pines are scattered further afield, perhaps aided in their dispersal by birds or vehicles. Dr Dawson and his co-authors attribute this slow start to historical changes in ecological constraints on pine populations. Rabbit plagues during the first half of the century exerted heavy grazing pressure on palatable vegetation (rabbits do eat pine seedlings) until checked by the introduction of myxomatosis. They were virtually eliminated in 1954/55, which is about the time that colonization of the described Brindabella transect area by pines first began.

Although this could perhaps be taken as a warning that pine incursions may accelerate in the 'absence' of rabbits, other controlling factors also come into play. Feral pigs seem to be increasing in number in the local area, judging by the incidence of droppings and sightings. Pigs jeopardize seedling establishment by turning patches of litter and soil. They may actively seek out pine seedlings to eat, and the scientists found several trampled ones. Perhaps the biological burden is slowly returning to haunt *P. radiata*.

But the native eucalypts, being host to a range of foliage diseases and plant-eating insects, seem to bear the brunt of the burden. This is reflected in their slower growth. Pines are also being recruited into the metre-and-above height classes at a much faster rate than eucalypts — and these larger trees are relatively secure from mammalian enemies.

Perhaps the greatest potential threat to the species' empire-building tendencies is fire. In the recent (summer 1983) spate of fires that swept through large areas of southern Australia, pines fared very badly. Several plantations destroyed by fire will need replanting. In contrast, eucalypt forests are already showing signs of recovery from the fires — thanks to the accessory buds that lie under the bark of eucalypts and are now giving rise to epicormic shoots on the trunks and main branches of the scorched trees. To the eucalypt, fire is a mere setback; to the pine it represents a holocaust. So in mixed eucalypt–pine stands, periodic fire could kill pines without causing permanent harm to the eucalypts. Dr Ian Noble and Dr Ralph Slatyer, of the Department of Environmental Biology at the Australian National University, point out that the long-term prognosis for the pine component of these mixed stands after fire depends on their capacity to regenerate from seed — at present, an unknown quantity.

It seems more certain that the area will continue to undergo conversion from a pure dry sclerophyll forest to a mixed stand of eucalypts and pines in which the invasive pines could eventually emerge as the dominant species. That is, it will unless one of the potent factors described above — fire, pests, or disease — succeeds in halting or reversing the present trend.

An uncertain future

The incursions of pine into eucalypt forest have intrigued ecologists because it is unusual for a *Pinus* species to confront dominant native trees and meet with success. Although our native forests, subject to the periodic influence of fires and drought, have been described as 'always recovering from disasters', they are essentially undisturbed ecosystems. Environmental disturbance of some kind is usually considered a prerequisite for the establishment of an exotic species, but *P. radiata*, at least for the moment, is defying this conventional wisdom. The scale of pine establishment seems quite out of proportion to the amount of disturbance caused by such factors as the presence of pigs and rabbits.

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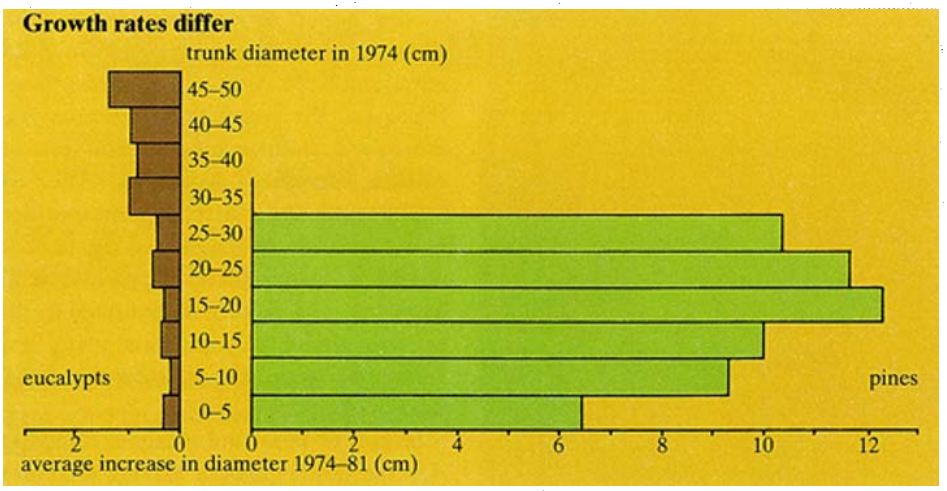

For all size classes suitable for comparison, average increases in trunk diameter show that pines are growing much faster than the eucalypts.

Its success has not escaped the notice of conservationists, who are concerned at the inroads the 'weed' is making into native forests. Although expensive, it would still be quite practicable to intervene on behalf of native trees and curb the progress of wayward pines, since most invasive trees still occur within half a kilometre of plantations.

Studies by Dr Dawson and his colleagues show that the densest pine invasions occur at dry sites with poor shallow soils. Wet sclerophyll forests seem better able to resist migration of trees from adjacent plantations, with few or no incursions eventuating. These forests are probably too shady for young pines; but, conversely, pines in more open native forests, once they equal eucalypts in height, intercept much more light and scientists consider this an important reason for their spectacular growth in mixed exotic–native forests.

Steve Davidson

More about the topic

Preliminary studies on a native Australian eucalypt forest invaded by exotic pines. J.J. Burdon and G.A. Chilvers. *Oecologia*, 1977, **31**, 1–12.

Further studies on a native Australian eucalypt forest invaded by exotic pines. G.A. Chilvers and J.J. Burdon. *Oecologia*, 1983, **59**, 239–45.

Temporal variation of *Pinus radiata* invasion of eucalypt forest. M.P. Dawson, R.G. Florence, M.B. Foster, and A. Olsthoorn. *Australian Forest Research*, 1979, **9**, 153–61.

The effect of disturbance on plant succession. I.R. Noble and R.O. Slatyer. *Proceedings of the Ecological Society of Australia*, 1977, **10**, 135–45.