Agro-forestry test project in New Zealand combines timber production with pasture for sheep under the trees. Monterey pines shown here are six to seven years old.

California conifers thrive in New Zealand

Paul C. Smith

New Zealand, small and isolated in the South Pacific midway between the equator and the south polar icecap, consists of two major islands and a much smaller third one totaling some 103,000 square miles. The North Island is geologically younger, with soils of volcanic origin. Soils of the older South Island are granitic. The Southern Alps, rugged backbone of the South Island, rise abruptly from sea level to more than 12,000 feet in less than 20 miles from the west coast.

The population is slightly more than 3 million people and 60 million sheep. The strongly agricultural economy includes a thriving forest products industry that today exports over $100 million worth of wood products annually and is growing.

Such was not always the case. English settlers, beginning in about 1840, cleared native forests for agriculture, removing large areas of the podocarp and beech trees that had originally covered two-thirds of New Zealand. By the 1900s, with a timber shortage imminent, and because of the slow growth and recovery of native species, government foresters began to look for suitable non-native (exotic) species upon which to build a forest products industry.

Among the many exotic species introduced by early settlers were a number of conifers native to California, primarily Monterey pine (*Pinus radiata*), Douglas-fir (*Pseudotsuga menziesii*), bishop pine (*Pinus muricata*), and shore pine (*Pinus contorta* var. *contorta*). New Zealand occupies the same latitudes south of the equator as those occupied by California and Oregon in the northern hemisphere. This location, coupled with the country's marine climate, provides an ideal environment for species drawn from California's coastal forests. Today, exotic forests account for 80 percent of the country's wood supply, providing raw material for the sawmilling, plywood, and papermaking industries.

The most successful of these has been Monterey pine, which occurs naturally in California in only three separate areas along the central coastline within 125 miles of each other. The species has never become a commercially important timber tree in the United States, mainly because of its limited occurrence and unimpressive quality. However, because of its outstanding and almost continuous growth rate and its adaptability to most of New Zealand's soil and climatic conditions, Monterey pine is the keystone to that country's exotic forest plantation program. In addition to its value as a timber crop, the species is used in erosion control, dune stabilization, and agro-forestry programs on private lands.

Rotations of 25 to 30 years are generally employed throughout the islands. Approximately 900 Monterey pine seedlings are planted per acre (about 6- by 8-foot spacing). During the early stages of the rotation, two or three precommercial thinnings reduce the stocking to about 80 crop trees per acre. As a result, the average crop tree size at harvest is 25 inches d.b.h. (diameter at breast height) and 120 feet tall. Volumes from such a silvicultural regime can be expected to yield as much as 7,500 cubic feet per acre.

The initial stocking density minimizes branch diameter size and reduces pruning costs. Pruning operations, called "lifts," may be applied as many as four or five times during the early stages of the rotation and may reach a total height of 36 feet on crop trees. The resulting increased quality, New Zealanders feel, makes their timber products more competitive on the export market.

Monterey pine has also played an important role in minimizing severe erosion conditions — for example, in the East Cape region of the North Island. During the late 1800s large areas of this steep, rugged district were cleared of native forest to provide pasture and grasslands for sheep and cattle.

The unstable soils contain a high percentage of bentonite mudstones, argillites, and montmorillinite clay, and rainfall ranges from 50 to 100 inches per year depending on the elevation. Whole slopes — as much as 80 to 100 acres — have slipped off and disappeared down the major river drainages. Erosion in all forms from sheet wash

to earth flows and landslides has filled the drainages with soil and rock, causing severe and frequent flooding downstream.

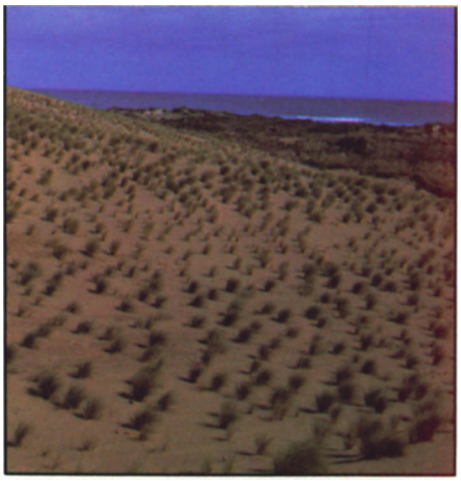
By 1950 the situation in the East Cape had become a national problem, causing the Forest Service to initiate a reforesting program on 14,000 acres of the most seriously disturbed areas. The main species used in the program, which is being expanded to include almost a quarter of a million acres, has been Monterey pine. Lesser amounts of Douglas-fir, Corsican pine (*Pinus nigra*), and some broadleaf species, namely poplars (*Populus* spp.) and eucalypts (*Eucalyptus* spp.), were also employed at the outset. Initial stocking levels called for 900 trees per acre for the pines and 1,200 per acre for the fir.

Monterey pine is now being planted at closer spacings than before to ensure earlier crown closings, lighter branching, and a better selection of crop trees when thinning. Final stocking is carried at 150 stems per acre. Douglas-fir plantings have been curtailed because of the species' slow growth rate; greater numbers will be used as areas stabilize. Corsican pine plantings have been suspended altogether, but eucalypts and poplar are still being planted under special circumstances. Of the area reforested to date, more than 62 percent is under Monterey pine, 22 percent Douglas-fir, and 7 percent broadleaf species.

Monterey pine is also being employed for dune stabilization on the Aupori Peninsula at the north end of the North Island, which is primarily a sand spit 7 miles wide and 50 miles long jutting into the South Pacific. To stabilize the shifting sands and increase the productiveness of the area, the New Zealand Forest Service is developing forested barriers along the southwestern coast of the peninsula.

First, the Forest Service plants rootstocks of marram grass (*Ammophila arenaria*), a sand-binding beach grass also used in northern Europe to hold barrier dunes along the coast. After one year lupine is sown, and trees are introduced two to three years later. The developing tree roots bind the soil and protect the surface from wind erosion. The leading edge of the plantations is about 200 to 300 yards from the ocean.

Zones, each 220 yards wide and parallel to the shoreline, have been delineated within the forested areas. The one closest to the shore is designated as protection forest. No cutting is allowed except for salvage operations. The second, 220 yards inland, is the protection-production forest in which limited harvesting is permitted. All remaining stands over 440 yards from the beach area are production forests, managed under normal procedures.



About 1,200 seedlings per acre are planted in the protection zone to achieve fast crown closure over the area. The remaining areas are stocked at a standard 6- by 8-foot spacing, or 900 trees per acre. Final stocking of crop trees will amount to about 150 per acre in the protection zone and 80 to 90 per acre elsewhere.

A third undertaking in which Monterey pine is widely used because of its rapid growth is agro- or farm-forestry. This concept of multiple land use, which combines timber production with that of grazing livestock on the same area, is being widely tested throughout New Zealand and many parts of Australia.

Seedlings are planted 6 feet apart in widely spaced strips on established pasture land. Spacing between these rows ranges from 15 to 25 feet and amounts to 300 to 500 trees per acre. One or two years after planting, when the trees are 4 to 7 feet tall, sheep can be safely introduced into the

Above: Stand of 30-year-old Douglas-fir in Canterbury Plain survived 105-mile-an-hour winds that destroyed Monterey pines.

Top right: Sand-binding marram grass is planted first to stabilize dunes on Aupori peninsula, North Island. Monterey pine will be added in three or four years.

Right: Entire slopes have slipped down the river drainage at the Tarndale Slip in the East Cape, North Island. Monterey pine has been planted to control further erosion.

Net Productive Stocked Exotic Forest Area

Forest	Area	Percent
	1,000 acres	
Species		
Monterey pine	1,297	82
Douglas-fir	116	7
Other species	168	11
Total	1,581	100
Ownership		
N. Z. Forest Service	928	59
Industry	457	29
Private non-industrial	156	10
Other government agencies	40	2
Total	1,581	100

area. Care is taken not to overstock or overgraze the area to prevent browsing and debarking of young trees. During the first two years following planting, the open areas are used for producing hay, since the necessary mowing equipment can pass between the widely spaced rows of trees.

Thinning and pruning of the established trees by the end of the third growing season are necessary for both pasture growth and wood production. With the wide spacing between rows, failure to prune remaining trees could result in the elimination of as much as 65 percent of the pasture. The final stocking goal of crop trees is about 65 to 70 per acre, yielding an estimated 5,500 cubic feet of wood per acre.

An added advantage of this system for stockmen on the Canterbury Plain of the South Island is an increase in the survival of lambs in the early spring. Young unpruned, unthinned rows of trees shelter ewes and newborn lambs from the cold winds and rains.

As insurance against the risks associated with a monoculture economy, New Zealand foresters are also looking for species with many of the advantages of Monterey pine plus more tolerance for cold, high-altitude sites or adverse soil conditions. These requirements eliminate almost all other conifers being tested in the country, except the bishop pine.

Bishop pine, like Monterey pine, is a member of the Closed-cone pine group. It grows in scattered stands along the coast of California and Baja California. Stands south of latitude 38° 42'N are referred to as the "green strain"; those to the north in Humboldt and Mendocino counties are the "blue strain" or blue-needle source.

Both strains were unknowingly introduced into New Zealand during the early 1900s. Unfortunately, green bishop was more widely planted: its slow growth and poor form almost led New Zealand foresters to reject the entire species.

Studies conducted by the Forest Research Institute (F.R.I.) at Rotorua in recent years have shown that blue bishop, when grown on low-altitude sites (1,000 to 1,800 feet in elevation), was on the average 16 percent shorter than Monterey pine at ages 25 to 35 years. In a comparison of 45-year-old stands, blue bishop was also 15 percent lower in volume. But on high-altitude sites (2,000 to 3,000 feet) bishop was 23 percent taller than comparable Monterey stands. Bishop pine is also believed to produce larger volumes of wood at such elevations.

A tree improvement program established in 1973 by F.R.I. employs experimental trials at various elevations, some above 3,300 feet. Growth and malformation of selected sources of bishop pine are being compared with Monterey and shore pine. Seed sources include both the green and blue strains and come from both northern California and New Zealand.

The Forest Products Division of F.R.I. has found that the strength of bishop pine is similar to Monterey when the wood is green and becomes better as it dries. Work at the University of California's Forest Products Laboratory shows that the species is also equal in strength to ponderosa pine and in some respects to Douglas-fir.

Douglas-fir has been grown in New Zealand as an ornamental for more than 100 years and in forests for over 80 years, but no large areas were planted until the 1920s. To date some 116,000 acres, or 7 percent of the exotic forest, have been established with this species. Most plantations (90 percent) are in state forests, mostly on the North Island.

Despite its apparent acceptance, New Zealand foresters are uncertain about Douglas-fir's role in future programs, mainly because of its relatively slow growth (45 to 55 years to maturity). Another major drawback seems to be the species' susceptibility to Swiss needle cast (*Phaeocryptopus gaeumannii*), which is more prevalent and damaging in old stands.

One advantage Douglas-fir has over Monterey, however, is its ability to withstand severe winds with only minor damage. This was dramatically demonstrated during a severe storm on the South Island in 1975, when winds gusting to over 105 miles per hour destroyed almost 27,000 acres of exotic forest. Most was Monterey pine. Douglas-fir stands in the region sustained some top damage and minimal blow-down but generally survived the storm intact. As a result, Douglas-fir plantations are currently being expanded in the region.

The species is also being planted at altitudes where snow damage has proved a problem for other exotics. The Forest Protection Division of F.R.I. is testing it for possible use as a control measure in troublesome avalanche areas of the Southern Alps.

Trials have shown that seed from low-altitude (coastal) California Douglas-fir grows best under New Zealand conditions. Of the seven superior sources selected, five are from California: four from north coast sites, and one from the Santa Cruz area.

In a country where one can drive for miles and see nothing but unbroken forests of Monterey pine, the Forest Service has planted screens of more aesthetically pleasing Douglas-fir.

Recently interest in the coast redwood (*Sequoia sempervirens*) has revived. At the turn of the century some areas on both islands were planted to redwood, but all except a few plantings failed and the species was dismissed as unsuited to New Zealand conditions.

The few stands that did survive, however, thrived and developed trees of excellent size and quality. The grove at the F.R.I. in Rotorua, which occupies 15 acres of an original 30-acre plantation, is now almost 80 years old, has specimens averaging 180 feet and 60 to 65 inches d.b.h., and produces 19,000 cubic feet of wood per acre. Foresters are reexamining redwood as a possible commercial species for New Zealand.

Forest hydrologists at F.R.I. see the possibility of using the redwood in erosion areas such as the East Cape, where its longevity and ability to sprout could minimize the loss of root strength and significantly reduce the time needed to restore stands of reasonable size on cut-over sites.

What will be the future role of California forest species in New Zealand's exotic forestry program? Most certainly Monterey pine will continue as the major exotic species. Bishop pine and Douglas-fir will probably see expanded use, and redwood, depending on the outcome of present and future studies, may enjoy a rebirth.

In the last 75 years, New Zealand has achieved the primary goals of its earlier exotic forestry program — that of averting a timber shortage and establishing a sound wood products industry. There is now more time to consider how the country might use those proven exotics to best advantage and avoid the previous, almost complete reliance on a single forest species.

Today the concern is more with excess rather than a shortage, and the search is for new markets, both domestic and foreign.

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