

zie/Waitaki Basin, using the 'Q-sort' method to identify preferences and attitudes. This technique requires stakeholders to evaluate the relative acceptability of each land use, and to place them in a sequence from most acceptable to least acceptable. The survey team also asked stakeholders to explain their thinking as they made the evaluations, and followed this up with a series of more general questions about attitudes towards land use and management. Subsequent factor analysis of the sequences selected by the stake-

holders, combined with analysis of their comments, will enable researchers to identify overall patterns of attitudes and preference in the community.

The Q-sort responses are being used to narrow down the range of technically feasible options to a smaller set of composite scenarios representing the views of groups of stakeholders. The team will model these scenarios in detail over the coming year, with particular emphasis on their likely economic and social effects at the regional and individual property lev-

els. These predictions will be presented back to a sample of stakeholders in the following year of the project. The project will culminate with the development and evaluation of a generalised planning method for application in similar planning situations elsewhere in New Zealand.

Dr David Evison (NZFRI, Rotorua) is the Programme Manager for the project and Dr Simon Swaffield (Head, Department of Landscape Architecture) is responsible for Lincoln University's contribution.

## High and dry – The Tara Hills experience with trees

Tim Broad, AgResearch

Tara Hills High Country Research Station carries out research to improve the sustainability of agricultural systems on South Island high country.

The 3340 hectare research station is located at the southern end of Mackenzie Country, in the upper Waitaki Valley, 8 km from Omarama and 110 km from Timaru.

The climate is typical of much of the South Island eastern high country with hot summers and cold winters. The combination of low rainfall, high altitude and inland location makes Tara Hills an extreme farming environment. Frosts and heavy snow falls occur at any time of the year, with snow falling on an average of 11 days. The region can experience severe and persistent westerly winds that peak over spring and summer, and there is a mean daily wind run of 243 km.

Average annual rainfall at Tara Hills is 532 mm but over a 30-year period this has varied from 338 to 782 mm. Precipitation is spread evenly throughout the year but high evaporation rates (mean 850 mm per year) reduce the effectiveness of summer rain and there is often a soil moisture deficit on the flats from November to April. Temperature and evaporation rates decrease with altitude and are modified by aspect; so on low-altitude sunny faces the soil moisture is below wilting point for much of the growing season, whereas shady aspects, especially at higher altitudes, have a later start in the growing season but do not dry out to the same extent.

The mean daily temperature on the flats is 15.8°C in January and 1.3°C in July. On average 120 days of screen frost occur each year, and 160 days of ground frost. Sunshine averages 2080 hours a year – 49% of possible.

When purchased by the Government in 1948, the property was in a run-down state. The land was typical of large areas of the South Island high country which



Tara Hills, looking north to the foothills of the Barrier Range.

had been severely over-grazed by sheep and rabbits. The initial objective was to demonstrate how the country could be rehabilitated.

As pasture production improved stock numbers were raised to a peak of over 11,000 stock units. These have been reduced in the 1990s to about 7000. By 1966 the conservation and re-vegetation programme was well advanced, and the emphasis shifted to tackling a wide variety of problems encountered in hill-country farming.

Forty years ago tree planting started. A feature of the forestry work was the strong collaboration with the then New Zealand Forest Service and the Forest Research Institute (FRI).

The original plantings were all *Pinus ponderosa* and *P. nigra* on the dryland flats. In 1960 and 1961 four and a half hectares were planted in *P. contorta* and *P. ponderosa* for provenance trials. The *ponderosa* pines are now a valuable seed source.

In 1975 and 1976 further tree species were planted to test survival and growth on irrigated pasture. They were mostly eucalypts, pines, Leyland cypress, cedars, Douglas firs, birches, alders, poplars and willows.

Following from this, starting 17 years ago, an additional effort was put in with a wide variety of trees planted for shelter on the irrigated flat land. The aim was to research the most appropriate trees and layouts. This effort was spearheaded by Nick Ledger of the NZFRI at Rangiora.

From 1978 on tree planting concentrated on the shelter belts with some eucalypt, conifer, and broadleaf species planted in small plots designed for plantation treatment. The main objectives were:

- to select species and design layouts that reduce wind speed over irrigated pasture so that moisture is conserved and pasture growth is improved;
- to create windstill areas for lambing and post-shearing shelter;

- to demonstrate species and layout combinations suitable for sheltering irrigated Mackenzie Basin pastures.

Fifteen years down the track AgResearch has a great asset, from both the animal welfare (shade and shelter) and the timber production point of view.

Corsican pine (*P. nigra*) has been the most promising species planted, as it is the most likely timber production tree to survive and grow (albeit slowly) in the extreme conditions. Ponderosa pine has shown potential as well, and it is favoured in some sites because it is less of a problem with wilding spread than either Corsican pine or *P. contorta*.

Early in 1993 considerable silvicultural work was carried out on the recent plantings, with the objective of increasing quality timber production, improving permeability of the shelter, and providing firewood.

Future plantings are planned by AgResearch on Tara Hills to expand the role of the tree in land care, and to measure interactions between soil, animal and plant in this environment. Up to 250 hectares are being brought into the programme.

A comprehensive report on the trees on Tara Hills was produced by Nick Ledgard



Tara Hills, July 1993. Looking south to Ewe Range.

and Gordon Baker in November 1992, and updated by AgResearch in 1993. The findings of the report can be extrapolated to other high, dry and cold locations – especially in the North Otago and South Canterbury regions. Copies of this report, which is extensively illustrated in colour,

are available for \$75.00 each (inclusive of GST, postage and packing) from Tim Broad, AgResearch, Invermay Agricultural Centre, Private Bag 50034, Mosgiel; Telephone (03) 489-3809; Fax (03) 489-9024.

## Introduced species and regimes for high-country forestry

Nick Ledgard\*

### The tree environment

The high-country environment governs which tree species will survive and grow. Soils are often shallow, stony and infertile but it is the climate which mainly determines survival. It has both continental and oceanic influences and is hence characterised by variability, particularly in temperature. Unseasonal temperature fluctuations are common with frosts occurring at any time of the year. Winds are frequent, gusty and often strong. The rainfall gradient is steep, ranging from 500 mm/year to more than 8000 mm/year over a distance of less than 40 km. While these extremes contribute to most failures, the high-country climate, with its mild day temperatures, cool nights, and evenly distributed and adequate moisture, is generally favourable for the growth of hardier woody species over most of its area. Aided by increasing restrictions on burning and declining grazing capacity for

farmed stock and wild animals, the high country will almost inevitably witness an increase in woody species. In many situations introduced conifers will be a definite component of this increase, due to their hardy and vigorous character.

### Species choice

Introduced trees have been planted in the high country since the early days of pastoralism in the middle of last century. A wide range of species were planted and those that still continue to grow (mainly around homesteads) represent the survivors of what might be called an "historical" trial. With the exception of Naseby Forest in inland Otago (which now occupies 2500 ha), large-scale plantation forestry has not been practised. Although good growth rates for some introduced species were recognised many decades ago (Morrison, 1919), the area occupied was less than 1% of high-country farms in 1978 (Kerr et al, 1979). A survey of all introduced trees in the Canterbury region (1.8 million ha) in the early 1980s found intro-

duced trees to occupy less than 1500 ha (Ledgard and Belton, 1986).

Although many species have been tried in the high country, the most successful have been the conifers. The main species now present are Corsican, ponderosa and radiata pine (*Pinus nigra*, *P. ponderosa* and *P. radiata* respectively), Douglas fir (*Pseudotsuga menziesii*) and European larch (*Larix decidua*). Other less frequently found conifers are lodgepole, Scots, maritime and Bishop's pine (*Pinus contorta*, *P. sylvestris*, *P. pinaster* and *P. muricata*). To date there is little evidence to favour Bishop's pine over radiata on cool high-country sites. The New Zealand Forest Research Institute Ltd (NZFRI) has tested many conifer species in their Craigieburn experimental area (Ledgard and Baker, 1988) and in the Mackenzie Basin (Ledgard and Baker, 1992).

The two most favoured species for commercial forestry are Douglas fir for moister (>800 mm), sloping (less frosty) sites, and Corsican pine for flatter, drier sites (Ledgard and Belton, 1985; Belton

\* NZFRI, Rangiora, Canterbury.