SOME NOTES ON PROTECTION FOREST WORK IN WESTERN EUROPE

J. Y. MORRIS*

SYNOPSIS

Much work is being done in Europe to increase the forest estate. In many areas the only land available for planting is situated above the existing timber-line. European techniques in protection forest work are discussed under the headings of environmental research, species introduction, and soil conservation.

The possible application of European methods to New Zealand conditions is discussed and some comparisons are made between mountain lands in Europe and New Zealand.

INTRODUCTION

After attending the Congress of the International Union of Forest Research Organisations in Vienna in September 1961, the writer was able to spend a further two months in Western Europe visiting many of the establishments concerned with protection forests and allied problems. Some observations made then on current European problems and techniques may be of interest to New Zealand workers in soil conservation.

To anyone conversant with European forestry, it comes as a surprise to learn of the amount of current investigation into protection forest problems. It is generally assumed from the literature of a decade or more ago that the only remaining problems were those of maintenance of the large-scale corrective measures undertaken at the end of last century. This, of course, was largely true until some time after the end of the Second World War; but since the mid-fifties the picture has changed.

The change is mainly a result of rapidly increasing industrialization, which has had a twofold effect in many countries; it has led to a depopulation of rural areas with consequent change from intensive to extensive forms of management, and at the same time it has greatly increased the demand for all wood products. As these depopulated areas offer practically the only opportunity to extend the forest estate, it is natural that the greatest effort should be made to bring them into production. At the same time, the number of avalanche disasters in Austria and Switzerland in the last decade has led to a demand for large-scale reforestation of lands above the existing timber-line, because it is in these old abandoned pastures that most avalanches originate. The problems of forest extension in regions so close to the limit of plant growth call for more sophisticated techniques than were employed at the turn of the

* Senior Scientific Officer, N.Z. Forest Service.
century when the problem was more one of forest replacement at much lower levels.

It is proposed to discuss European work under the headings of environmental research, species introduction, and soil conservation.

ENVIRONMENTAL RESEARCH

The gross features of European mountain climate have been known for some time but this information is of limited value for the type of detailed ecological studies which must precede new plant introductions at or above the timber-line. Here it is study of the micro-site which is important in determining limiting factors in plant growth and this type of investigation has benefited greatly from the early work of Geiger and his colleagues at Munich University. Both the Austrian and Swiss forest services have embarked on detailed programmes of microclimatic investigation to aid them in their plant introduction at high altitude. A brief description of the methods used may be of interest.

Without doubt much of the interest which has arisen in microclimatic work over the last ten years has been due to the development of greatly improved measuring devices, especially for temperatures. With the very small electrical resistance elements now available, it is possible to carry out measurements close to the soil and within the plant cover itself — measurements which would have been very tedious, if not impossible, with mercury-in-glass instruments. Another advantage of the electrical system is that it permits a large number of measurements to be made in a relatively short space of time, and the readings can be taken at a considerable distance from the point of investigation. The advantages of this are obvious in mountain country. Instead of the observer attempting to cover a large number of measuring sites in a day (and not being able to record simultaneous readings because of distance), or instead of setting up a network of expensive recorders (which by the nature of their size alone are unsatisfactory for microclimatic work), it is now possible for a single observer, at a distance of three miles from the most remote measuring point, to take upwards of seventy readings in less than a quarter of an hour. The Europeans have been quick to seize on these advantages for investigations in protection forest.

Swiss Forest Service Experiments

The Federal Forest Research Institute has chosen the Dischma Valley near Davos in eastern Switzerland as the site for its experimental work in high altitude reforestation. This valley, which runs nine miles in a south-east/north-west direction, varies in altitude from about 4,500 ft to 7,500 to 8,000 ft. The present timber-line at 6,000 ft is 500 ft lower than normal for the larch/cembran pine forest found here, and this depression has been caused exclusively by the action of man and his animals during the last century. The consequence of this forest depletion has been a steady increase in the number of damaging avalanches which threaten the numerous settlements in the valley. This, of course, is the general situation throughout the central European Alps and is one of the main reasons for renewed interest in high altitude reforestation.
The aim is to restore the zone of the timber-line to something approaching its original state. The most important prerequisite is a thorough knowledge of the environment. Because this experimental area is regarded as representative of a large number of situations which require attention throughout Switzerland it has been possible to concentrate a great effort on a relatively small area. What the Swiss are attempting is to gain an understanding of the distribution of the existing vegetation in terms of the microclimate, to determine from these studies the suitability of the site for plant introduction, and to apply these findings to other areas. Naturally, a detailed study of this kind calls for elaborate instrumentation, and the scale in the Swiss experiments can be justified only by a consideration of the economics of the restoration project.

Five major climatological stations have been established in the valley, covering the boundary ridges, mid-slopes with both north-east and south-west aspects, and the valley bottom. These stations measure those factors normally associated with macroclimate—screen maxima and minima, soil maxima and minima, rainfall, wind direction and speed, and solar radiation. They serve as a basis for comparison with data from microclimatic studies in the 20 ac inner experimental area, where the first plantings have been carried out. Here recording is more intensive. No less than 150 air and soil temperatures are measured every two hours throughout the growing season from the central recording station. Measurements are taken from 6 ft above ground level to a soil depth of 18 in. Only the fact that electrical resistance thermometers are used makes it possible to cover such a large number of measurements in such a short time. The Swiss hope that, by continuing these readings for a period of two to three years, they will be able to explain the present vegetation distribution in terms of temperature and to discover to what extent extremes of temperature are limiting to plant introduction and development.

Another interesting technique in use is that developed by Volkert at the Forestry Faculty at Hannoversch-Munden to measure mean temperatures over an extended period of time. This technique uses the change in the angle of polarization of sugar solutions which are exposed in glass capsules. As the change in angle is related to a change in form of sugar present and as this change is irreversible and dependent on temperature, the mean temperature over the period of observation can be easily found. This has such useful applications that it is surprising that it is not more generally employed in biological field experiments where mean temperatures are of importance.

The other interesting feature of the Dischma experiment is the work of Dr Nägeli on wind measurements. Nägeli is interested primarily in the distribution of wind over vegetation and has pioneered much of the well-known Swiss work. For the Dischma experiment which, owing to the broken nature of the terrain and its cover, called for a larger number of measurements than usual, he has developed a cheap but efficient anemometer which is made up in the workshop of the Federal Forest Research Institute at Zurich. These little instruments must be sensitive enough to pick-up wind currents in almost still conditions (for wind eddies in apparently still conditions profoundly affect temperature distribu-
tion near the ground), and yet robust enough to withstand the occasional gale. They must also be capable of being read remotely. The cups on the instruments are made from table-tennis balls cut in half and the body is about the size of a teacup. Every five revolutions of the main stem, a trailing wire makes contact with a mercury switch and relays a signal to an electrical counter at the central recording station. The power for the instruments is supplied by a 12 V wet battery and as many as fifty anemometers can be run from a single battery. These machines are made up for a fraction of the cost of commercially available instruments.

Work of the Austrian Ministry of Agriculture and Forestry

In Austria, the Torrent and Avalanche Control Section of the Federal Ministry of Agriculture and Forestry is charged with investigations into high altitude reforestation. Most of the work is centred on Innsbruck, in the Tirol. The field station is at Obergurgl. The techniques used are essentially similar to those in use in Switzerland and will not be further described. The Austrians have, however, carried much further their investigations in the field of controlled environment studies, and much of the climatological information gained in the Obergurgl experiments is used to programme the new phytotron at Patscherkofel near Innsbruck. In Patscherkofel, very detailed experiments are carried out on the reaction of plants to the alpine environment, using laboratory techniques which result in a considerable saving of time. As this falls more correctly under the heading of species introduction, it will be discussed later.

Work at Munich University

Dr Rudolf Geiger, who was for many years Director of the Meteorological Institute at Munich University, can rightly be called the father of microclimatology. His early work paved the way for the great expansion which has occurred in the last decade. While Geiger is no longer actively engaged at the Institute, investigational work into techniques and equipment is carried on under the direction of the new Director, Dr Möller.

Without doubt the most important contribution to forest climatology by this Institute has been the study of temperature conditions in a mountain forest in southern Bavaria. This experiment, which ran for three years, showed what could be done in the field of temperature measurements using the then new thermistor elements. Briefly, the experiment concerned changes in air and soil temperature associated with forest cover and change in altitude on the slopes of the Grosser Falkenstein mountain. From one central recording station, Baumgartner and Hofmann measured seventy temperatures in the air and in the soil at six different sites, the most distant of which was two miles from the control station. Total time required to take these measurements was about ten minutes. Using this technique it was possible to take more than 2,500 readings in a single day.

This technique revolutionized climatological studies where difficulties of distance and terrain occur. Nowhere is this better illustrated than in mountainous country. The technique had the advantage that, while initial investment may be a little higher than that required for conventional equipment, maintenance was
reduced owing to the longer life of elements and the minimum
requirement for labour. The most obvious advantage in mountain­
ous country is, of course, that measurements can be taken in
places difficult of access in winter as the observer does not need
to visit the observation point. The adoption of such techniques
could undoubtedly lead to a vast improvement in the number of
meteorological observations in New Zealand protection forests.

SPECIES INTRODUCTION

Although Europeans were quick to seize on the possibilities
of exotic tree species for their production forests, there has been
a curious reluctance to investigate their use in the protection
forests where indigenous species were hard put to maintain any
sort of cover. No doubt their thinking on this subject was influenced
by the success of the techniques of the late nineteenth century
when the “local seed is best” rule applied. That this technique has
much merit is shown by the many thousands of acres of successful
plantations at high altitude throughout the European Alps. There
are signs now, however, that on the most difficult sites the limits
of tolerance of the indigenous species are possibly being reached.
Whether this is because of changing climatic conditions at the
timber-line (and in Europe proponents and opponents of this
theory are as well-balanced as elsewhere); or whether the forester,
encouraged by earlier successes, is trying to push the local species
too far, is not known. Certainly there has been a conspicuous lack
of success in many areas which were not expected to pose any
great problems. Reaction to these failures has varied from partial
abandonment of local species and investigation of exotics, to a
minutely detailed investigation of the indigenous species with a
view to separating those varieties or strains most suited to the job.
This latter approach is that favoured by the Austrians in their
work in the Tirol.

Austrian Experimental Work

The Austrian approach to species introduction is rather different
from that of other European countries. While others tend to look
at exotics as possible replacements for the indigenous species, the
Austrians are making very detailed studies of the ecological require­
ments of the indigenous species, with particular emphasis on
larch and cembran pine. This does not mean that they have no
faith in the ability of exotics to do the job. What they maintain
is that there are innumerable sub-types, varieties, or even sub­
species of the common alpine species which are adapted to widely
differing ranges of environmental conditions, and that it should
be possible amongst this host of types to find those best suited to
their particular needs. The first task is to determine the factors
which limit plant growth at high altitudes and then, by duplicating
these in growth chambers, to sort out the strains which are capable
of withstanding the severe conditions. Having decided on this
course of action, the Federal Ministry of Agriculture and Forestry,
in conjunction with the University of Innsbruck, has embarked
on an extensive research programme with the phytotron at
Patscherlkofel.

The Patscherlkofel project is probably unique in its choice of
location for a controlled environment laboratory. The phytotron
is situated at over 6,000 ft on a mountain slope above the city of Innsbruck and its only means of communication with lower levels is by cable-car. The stone building which houses the laboratory is large and in itself constitutes a major building effort in such a location. Besides a top floor, which houses offices and laboratories, the building has a large basement where the machinery is located. It is possible to simulate practically all facets of the mountain microclimate. There are three main growth chambers with temperature range from -40° C to +50° C, and artificial lighting equal in intensity to that experienced at high altitude. There is a small wind tunnel where wind speed can be controlled through a range from zero to 65 miles per hour and with temperature regulated to duplicate natural conditions. Equipment also exists for giving separate control of root and shoot temperatures so that it is possible to simulate the condition, often found in nature, of the root region being frozen while air temperatures, under the influence of intense incoming radiation, are high enough for photosynthesis to occur.

One interesting feature of the equipment is the lighting. This is a problem where conditions at high altitude must be simulated. In most growth cabinets it is unusual to find light intensities of more than 4,000 to 5,000 foot-candles. This is no way approaches the 15,000 foot-candles found at high altitudes in clear conditions. To duplicate these conditions as closely as possible, the Austrians group a number of Xenon lamps, each of 5,000 foot-candle intensity; but even so they find it impossible to achieve higher intensities than 12,000 to 13,000 foot-candles. For this reason they plan more growth cabinets using natural light.

Much of the work of those using the phytotron will be routine testing of cold resistance of different plants, but an interesting series of experiments has been begun by Dr Tranquillini, the physiologist in charge, on the relative photosynthetic efficiency of different provenances under adverse conditions. Tranquillini uses a gas analyser of extreme sensitivity in these experiments and has pioneered a whole new field in the understanding of the plant/environment relationship at high altitude.

This sort of approach to problems of plant introduction, although apparently academic, can result in enormous savings when compared with the cost of plantation trials on even a small scale. Using this technique, it should be possible to screen seedlings from a large number of provenances in a very short time. In this way it will be possible to reproduce within the seedling tree's first growing season the most extreme conditions which are likely to be encountered over a very long period. There is thus a considerable saving of time as the investigator is not forced to await the vagaries of nature. By working with seedlings rather than larger plants, one has the opportunity of selecting those species or provenances which can survive the most critical period in the life of the plant and thus, other things being equal, perpetuate themselves following establishment. This, of course, is looking a considerable way ahead, but any project of restoration in mountain lands must be considered a long-term one. There is every reason for thoroughly investigating all avenues of research and making sure that the research technique adopted is the one which is going to give the most information.

This Patscherkofel study is an important one for all countries interested in high altitude reforestation and is being watched with
great interest by other Europeans. It could well serve as a guide to workers here, who, while they may not be able to duplicate the equipment on such a scale, can at least profit by an interchange of information.

**Experiments by the Swiss Forest Service**

While the Swiss continue to use the traditional species and methods in their mountain work, they are considerably ahead of other European countries in their investigation of the possibilities of exotics. This was the one country which had nursery stock of exotic species specifically imported for high altitude work. Dr Fritz Fischer of the Federal Forest Research Institute at Zurich is in charge of tree breeding at the Institute, and his is the task of selecting or breeding new species or strains for reforestation above the timber line. The Swiss have a foot in both camps, so to speak, for, while they have intensified investigations into the use of spruce at high altitudes, they have also insured against loss by acquiring seed of three North American alpine species, *Picea engelmanni*, *Abies lasiocarpa*, and *Tsuga mertensiana*. Fischer spent a year in the United States in 1955 and made the selection of species himself. Surprisingly, the Swiss have passed over lodgepole pine even though they were looking for a species for their most difficult sites. Fischer contended that it apparently approached the European mountain pine (*P. uncinata*) too closely in form and requirements to be of much use. This contention may be correct for Switzerland but the species would seem worth a try in the light of the different behaviour of the two species under New Zealand conditions. It cannot be that lodgepole pine reserves its vigorous habit for our conditions alone, for even in Iceland it outstrips all other species under the harshest conditions.

An intensive study of single-tree progeny from some three hundred selected Norway spruce is also under way at the Institute. Seed from these trees is sown in the nursery at Zurich and, after germination, half the resulting seedlings are transported in pots to an area above timber-line where it is hoped to introduce the species. In this way it is possible to relate success or failure of the seedlings to climatic factors alone. Thus the climatically suited types select themselves by their performance on the test site. Once these have been selected, breeding will be done from this stock alone. This technique is an advance over the old plantation trials but it still does not allow for the occasional abnormal year and thus could give quite invalid results where sufficiently long-term meteorological records are not available. Obviously such an experiment has to be continued for a long enough term to ensure that all conditions are covered.

**French Experiments**

Intensified investigation into both indigenous and exotic species has resulted from the recent establishment of a branch of the central Research Station at Grenoble. This branch is specifically charged with research into all aspects of mountain land management. Bouvarel, who is in charge of tree breeding at Nancy, has plans for the introduction of North American high altitude species for comparison with the local species of the French Alps. Fourchy, the Director of the Grenoble branch station and author of a book on the ecology of larch, plans a further work on cemb'ran pine.
As so little information is available on any of the high altitude tree species of the world, this cannot but be helpful to New Zealand workers.

The southern French Alps are closer to our own eastern mountains in topography, geology, and, to a certain extent, climate than any other mountains in Western Europe. The climatic similarity is certainly superficial, as the climate is basically a Mediterranean one, but there are marked similarities in appearance, with both countries exhibiting abundant erosion features and depleted vegetation. The local foresters could not understand why New Zealand should have difficulty with plant establishment in regions where the rainfall was as high as 50 in. annually. Under the same conditions of rainfall they would expect rapid invasion of the open sites by larch and spruce. Their surprise is probably justifiable and should probably serve as an indication that we, in this country, should look very closely at effective precipitation data in our eastern mountain areas where the “nor’wester” is common. Obviously there must be affinities with mountain climates in other parts of the world, but just as obviously there are certain features of our alpine climates which we are a long way from understanding. If ever we hope to succeed with plant introduction, we must first solve the riddle of the mountain climate.

Italian Investigations

In the north of Italy, so far as could be ascertained, no work is being done in the introduction of new species for use above timberlines. Full reliance is still placed on the traditional species. Much work is being done, however, on species introduction for regions at altitudes which we would consider high. The lands concerned are abandoned pasture lands at altitudes up to 5,000 ft in the low mountain country surrounding the Italian lakes. Here Douglas fir and Japanese larch are giving very good results in a fairly high rainfall zone. This is not strictly introduction for erosion control but it is still soil conservation for, if left unmanaged, these old pastures are invaded by scrub species and become a high fire risk in autumn. As the area of these lands is quite important, the Italian Forest Service is making a very big effort to have them brought under more effective and more productive control.

ESTABLISHMENT PRACTICES

In no area visited did conditions approach in any way those found on the average planting site in New Zealand mountain country. Generally there was a sole of grass even if this was a little thin at times, but only where this was thick and the slope gentle were trees planted without some form of slope correction. Once the slope cover had begun to break up the practice was to contour-terrace and plant on the terrace. These terraces were sometimes continuous, sometimes staggered, and were neither elaborate nor expensive. They were often seen on country which would be classed as good planting conditions in New Zealand but, according to local foresters, made all the difference between success and failure. Apparently their studies have shown that moisture retention in dry areas, and soil consolidation under both wet and dry conditions, are the important effects of these terraces.
Time of planting varies regionally, autumn planting being favoured in those places subject to dry spells in the early spring. This applies particularly to southern France and north Italy. Autumn planting allows consolidation before the onset of dry conditions. In areas where rainfall distribution is more regular, there appears to be no preference shown. The once common practice of direct seeding with larch and mountain pine on snow cover at the end of winter has now disappeared completely. Survival under this system is insufficient to warrant the expense in seed and results in no way compare with those using planting.

All species are planted open-rooted, with the exception of cembran pine, in which the roots are balled. Nursery practice differs little if at all from that for lowland forests. The one difference is the frequent location of small nurseries close to the planting area. There are two reasons given for this. The first is that, by raising stock on the spot, transport costs are cut. The second is that the plants are raised in an environment close to that in which they will spend the rest of their lives. These were no doubt good arguments before the days of tree breeding and growth depressants but, if New Zealand experience is any guide, better results can possibly be obtained by careful provenance selection and improved nursery practice at lower levels. The one argument in favour of these high nurseries has been that they allow stock to become sufficiently hardened off before planting. If this can be satisfactorily achieved at lower levels where conditions for growth are more favourable, then it is doubtful if there is any advantage in persisting with high-level nurseries. Obviously an investigation of this problem would be worth while.

On extremely eroded sites such as gully sides, or in New Zealand mobile scree slopes, a rather special establishment technique is used. This is the willow cordon technique which is extremely effective but rather expensive. Terraces up to a yard in width are established along the contour. Along these a light layer of spruce slash is laid and on top of this willow cuttings about 2 ft long and 1 in. in diameter are placed with their tips pointing to the outer edge of the terrace. The whole is then covered with soil so that just the tips of the cuttings are exposed. Spacing between terraces depends on the steepness of slope and grass seed is usually sown between them. Once the willows have become established, more valuable trees are introduced under their cover. The whole process may take five to six years but it ensures that failures are few in the final plantation, where it would have been impossible to introduce the final crop species in the first instance. Techniques such as this have some application on a limited scale in our mountains where the aim is to protect lines of communication or establish nuclei of desirable species. The first step must be selection of willows capable of growing in the mountains, from the considerable number of species and varieties offering throughout the country.

SOIL CONSERVATION

Traditional methods of torrent and slope correction continue to be used throughout Europe but with ever-increasing interest in the development of less expensive techniques. Labour is becoming so scarce and so expensive that it is no longer possible to do things
in the old style. For this reason the old masonry dams in the torrent beds have given way to concrete structures and masonry terraces have been replaced by stone-filled gabions.

It is in the field of small engineering works that the greatest changes have taken place in the last decade. In particular, in a very unstable region near Gap in the south of France, local staff were using check dams of expanded metal mesh with supports of 2 in. piping driven and filled with concrete. These were doing a good job in very difficult country and have the advantage of being easily transported and erected with no demand on skilled labour. Another technique used in the same region was the fabrication of heavy gabion works using ¼ in. reinforcing steel spot-welded to form a mesh about 4 in. × 4 in. instead of the normal galvanized chain mesh. These were extremely solid and could be filled with large boulders. If they were carefully placed with the ends of the stones projecting through the mesh they offered considerable protection to the metalwork against abrasion. This type of work was being used mainly as protection to bridge abutments and the like, but its adaptation to construction of check dams should not be difficult. If offers major advantages in that only the steel work must be transported to the site.

Besides this work on the corrective side, there has been a big increase in preventive measures in the last decade. Particularly in France and Italy, where the depopulation of mountain lands has been most marked, the authorities have been faced with the problems posed by abandoned high country lands. The official approach to remaining land occupiers has been to try to persuade them to form co-operatives for the processing of their dairy products and to assist this by direct subsidy and, indirectly, by technical assistance in planning, roading, building, etc. In this way the farmers are persuaded to concentrate their efforts, collectively if need be, on the better soils thereby releasing the more impoverished parts of their holdings for tree-planting. The scale of subsidies is sufficient to encourage most farmers to take advantage of the assistance offered, and, once they have seen for themselves the advantages to be gained by pooling their resources for the purchase of mechanical equipment, sprinkler irrigation, fertilizers, etc., they do not often delay joining the nearest group. This will not surprise anyone who has seen or read of the hardships under which these people have existed for the last century or more. From all accounts this system is working with mutual benefit to farmers and foresters in both France and Italy.

CONCLUSIONS

The first and most obvious conclusion after visiting European protection forests is that, although there are parts of Europe with local erosion problems of a serious nature, there is nothing to compare with the state of affairs accepted as normal in New Zealand. It follows that we have much to do to solve our own problems and that we cannot rely entirely on overseas methods.

The second conclusion is that, until we have a much more complete picture of the environment of our mountain country, we are working in the dark in so far as the introduction of new species is concerned. There is obviously something different about
our mountain conditions or we should surely have seen already more successful signs of acclimatization of exotic species. What these differences are will be discovered only by intensified investigation.

The successful introduction of plant species is one of the keys to the rehabilitation of depleted mountain lands. After seeing the way in which this problem is being investigated in Europe, one is forced to conclude that considerable effort must be expended to ensure that the most suitable species and provenances are obtained. Controlled environment facilities probably offer the best method of investigation, even though initial costs may be relatively high.

The final conclusion concerns exchange of information. We are faced with a problem in our mountain lands which probably has no parallel in temperate countries. Overseas visits have shown that we cannot rely directly on corrective measures employed in other countries. If there is value in sending New Zealanders overseas, surely there is just as much value in having overseas experts visit this country. People in a new country tend to look at things in a different light from local experts, who often are unable to see the wood for the trees. New Zealand could hardly help but benefit from a symposium on soil erosion under the auspices of some international body. While we may not be able to claim leadership in any branches of forest science, there can be few countries which offer such opportunities for study of the problem of soil erosion.