THE POTENTIAL ROLE FOR TREES AND FORESTRY IN THE FALKLAND ISLANDS

A Report to the
United Kingdom Falkland Islands Trust

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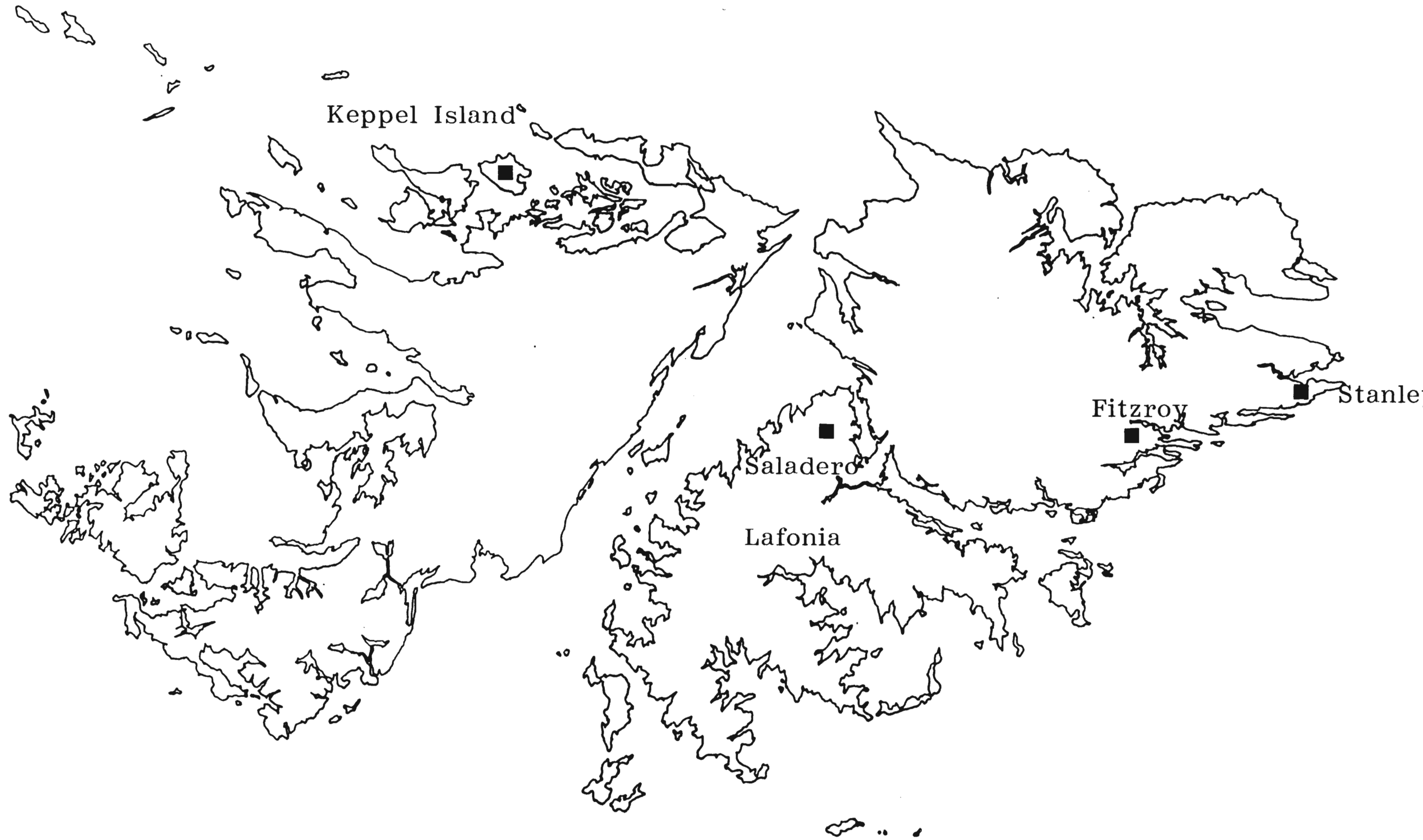


Figure 1 The Falkland Islands, illustrating the locations referred to in the report

THE POTENTIAL ROLE FOR TREES AND FORESTRY IN THE FALKLAND ISLANDS

EXECUTIVE SUMMARY

A. The Aims and Objectives of this report are as follows:-

1. To review all previous reports on the potential for tree planting and forestry in the Falkland Islands.

2. To review results from the UKFIT's tree planting research programme (1989-1995).

3. To consider the recommendations of the UKFIT Forestry Consultant and the discussion document proposed by the Chief Executive, FIG.

4. In the light of 1-3 above to propose a forward strategy for the UKFIT programme and for the future role of trees and forestry in the Falkland Islands.

B. The Conclusions from the report

1. Due to the absence of detailed records it is difficult to assess the reasons for the failure of most past attempts to grow trees in the Falkland Islands. However, the common factors which appear to filter through the previous reports (albeit anecdotal in many cases) are that:- too-dry planting sites, insufficient care and attention at planting, lack of protection from livestock, incorrect species and provenance selection and insufficient knowledge about nutrition are major contributing factors to the failure of most planting efforts.

2. Unlike previous attempts at growing trees on the Falkland Islands, the UKFIT's programme has been based on proper replication and experimental design, thorough documentation and measurement of tree growth and an attempt to address the basic issue of planting technique and nutrition.

It was concluded that trees can be satisfactorily grown in the Falkland Islands, provided that suitable species are chosen and the correct planting technique is used. Soil cultivation at planting and moisture retention are key issues in planting.

Growth rates are promising for species such as lodgepole pine once established although overall growth rates will never be high. The use of other species, particularly those growing at similar latitudes in Chile such as the Southern Beeches (*Nothofagus* sp.), should be seriously investigated and a source of tree supply through the development of an agar culture project with the University of Magallanes, Punta Arenas is being pursued.

3. The consultants' recommendations largely reinforce the view expressed in 2, ie. that trees can be satisfactorily grown in the Falkland Islands and there is potential for shelterbelts and farm woodlands to be developed for socioeconomic, ecological and environmental reasons. This largely supports the Chief Executive's view, although from the trials carried out to date, the case for a commercial forest industry is not yet proven and demands a further development phase. His views on softwood and potential hardwood production are broadly supported by the Consultant and both agree on the need for further work on location, species selection and management regime. Recommentations for future research and development are presented.

4. Small scale farm woodlands could be an integral part of an enhanced rural economy based on agriculture, but with some land devoted to a small forest industry. The agricultural industry, while still based largely on sheep production from wool might benefit from enhanced shelter by permitting diversified

enhancement to income from sources such as cereal and horticulture production and other forms of livestock rearing.

5. Some of the Trust's work has shown already the feasibility of and how supplementary components of the farming industry could be introduced and managed on a sustainable basis using biological means (eg. the use of kelp based products as a fertiliser, though the need for imported mineral phosphate has been highlighted by the consultant and control of tree pests may be required.

6. The Trust's initiative in establishing, with limited resources, a series of trials which have flagged the potential for trees is widely recognised in the Islands. However, to translate these findings into practice a larger effort is required to establish a series of demonstration plots which would address the gaps in knowledge on issues such as establishment, species selection and management, yet would be on a sufficiently large scale to demonstrate that trees can play a valuable role in providing shelter and rural enhancement as described previously. This is properly a role for the Government of the Falkland Islands as it's scale would be beyond that which the UKFIT's resources could sustain. Backed by the Consultant's recommendations it is proposed to advance the situation by recommending that an ambitious and imaginative programme of tree development is forwarded by FIG through the appointment of a forest field officer directed within a programme advised on by a person or body with suitable expertise and on a consultancy basis. It is also recommended that the field officer and programme would be under the overall control of the Department of Agriculture and that the UKFIT would continue to have an advisory input to the programme. This input might also include the initial programme costing and tender specification and evaluation. The UKFIT could also continue to promote and manage its' initiative in establishing links with the University of Magallanes in Punta Arenas, Chile and should use its Port Howard site (established with Dulverton Trust funding) as a location to test a further range of tree species and planting techniques.

In conclusion, past tree trials and reports have been largely inconclusive, and the UKFIT programme and other recent plantings have shown that trees can be established with suitable care at planting. There is a future for trees in an expanded and diversified rural economy, particularly to enhance the diversity of strucure and product from agriculture though commercial planting should not be excluded, particularly following trials with other species. A substantial development exercise should now commence which would need to include planting reasonably large blocks of trees on, say, Lafonia in association with the National Stud flock and as part of a research programme which would be the responsibility of a Forestry Field Officer within DOA and advised externally. The UKFIT can continue to provide a valuable input to the programme. The overall aim is to develop a sustainable rural economy in the Falkland Islands and trees can make a substantial contribution to that goal.

CHAPTER 1 - BACKGROUND - THE NEED FOR TREES

Falkland Islanders have been interested in growing trees in Stanley and in the camp for many years. Although it may be undesirable to clothe large areas in coniferous woodland and tree growth will always be slow in the Falklands, there is a need for shelter for stock and gardens and to improve the visual appearance of Stanley. The potential role of trees in an expanded and diversified rural economy is now seen a viable option.

Now that flocks are smaller and the national sheep flock is going to be substantially upgraded from improved stock imports, the need to reduce losses is all the more important. Strategically placed shelter around clippy pens or in ewe camps could be used over the critical times of lambing and shearing to make a very significant impact on lamb survival and on sheep recovery after stress. Forestry and woodland lots integrated with agriculture could lead to soil improvement and enhance the options for rural industry.

Stanley is developing rapidly, and with new housing and small industries appearing there is a need to landscape the town. Trees are widely recoginsed as the most natural way to achieve this. With many new small settlements appearing, trees have a further shelter and landscape role. There is also an interest in erosion control and rehabilitation of eroded areas. Research has shown the erosion process to be a direct result of the windly climate and trees can play a part in programmes addressing the issue of erosion and creating a sustainable vegetation cover.

Hence, there is a widespread interest in and need for trees to fulfill a number of roles in the Falkland Islands. This report addresses issues concerning the fulfillment of that role.

CHAPTER 2 - REVIEW OF PREVIOUS REPORTS

Reports available and consulted

The following reports and scientific papers were consulted for this review (in chronological order).

DALLIMORE W.H. (1919) The Falkland Islands; Forestry; Tussock Grass *Kew Bulletin* 1919 No 5 209-217.

DALLIMORE W.H. (1920) Trees for the Falkland Islands *Kew Bulletin* 1920, 377-378.

REID, J. (1925) Unpublished reports of forestry trials in the Falkland Islands (FIG archives).

GIBBS (1945) Part VI Shelter plants and experimental forestry. (Unpublished report in FIG archives).

PEPPER J. (1954) The meteorology of the Falkland Islands and Dependencies 1944-1950 FIDS, London.

KNIGHT F.P. (1960?) Reminiscences of forestry and horticulture in the Falkland Islands.

CLEMENT J.T. (1967) Some notes on tree planting. In *Grassland Improvement.* Proceedings of a conference in Stanley 1967.

FITZHERBERT J.S. (1967) Tree raising and planting in the Falkland Islands. *Proceedings of a Grassland Conference*; Port Stanley. Appendix 1. Government Printer, Stanley.

DIMITRI M.J. (1975). Consideration of the natural vegetation and cultivated plants of the Falkland Islands. *Anales de la Sociedad Cientifica* Argentiná **199**, 99-132.

McADAM J.H. (1977) Trees for shelter in the Falkland Islands - a practical guide. Grassland Trials Unit, Stanley.

McADAM J.H. (1980) Tatter flags and climate in the Falkland Islands. *Weather*, **35** (1) 321-327.

McADAM J.H. (1982) Recent tree planting trials and the status of forestry in the Falkland Islands. *Commonwealth Forestry Review* **61** (4) 259-267.

STEWART P.J. (1982) Trees for the Falkland Islands. *Commonwealth Forestry Review* **61** (3) 219-225.

LOW A.J. (1983) Tree planting in the Falkland Islands. A report to FIG.

McADAM J.H. (1985) The effect of climate on plant growth and agriculture in the Falkland Islands. *Progress in Biometeorology* **2**, 155-176.

LOW A.J. (1986) Tree planting in the Falkland Islands. *Forestry* **59** (1) 59-84.

McADAM J.H. (1989-1995) Tree planting and establishment in the Falkland Islands - A series of technical reports to the United Kingdom Falkland Islands Trust.

Principal findings

a. Climate

The climate of the Falkland Islands has been described in detail in many of the reports and in other sources (eg. McAdam 1985, Pepper, 1954 etc). From a forestry viewpoint the principal features of the climate are:- the incidence of dry periods; the frequency of frost episodes, particularly in summer, the wind strength and direction.

An analysis of rainfall from a wide range of sites has been carried out (McAdam 1985). The mean annual rainfall at Stanley is 640 mm. Rain can fall on an average of 140 days in the year and the highest rainfall occurs in the summer months with a marked depression in spring. Stanley is, however, in one of the wetter parts of the Islands, with drier areas generally in the south and west. The marked depression in rainfall during the months of September and October and already referred to for Stanley, is also found at other stations where rainfall records have been kept (Fig 2).

The mean winter temperatures are comparable with those experienced in the British Isles and air frosts are uncommon in summer, but it is reported that no month is frost free and ground frosts can occur throughout the year. However, an analysis of the frequency of occurrence of the number of years when lowest minimum temperatures fell below zero in each month over the 30 year period 1951-1980 shows that no air frosts have been recorded in January and February over that period. Ground frosts were recorded in each month, however, (Table 1(b)) and this is an important consideration in the siting of tree plantations.

Table 1 *(a) The number of years out of 30 (1951-1980) when a mean minimum air temperature of below zero was recorded per month and (b) mean number of days ground frost per month per year over the same period).*

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
(a)	0	0	6	23	30	30	30	30	30	29	21	8
(b)	4	3	7	12	19	21	22	22	19	15	9	6

The relatively strong winds which tend to blow almost continuously are the most notable feature of the climate and will influence shelter-belt siting and size. Although the mean hourly windspeed of 8.5 m sec^{-1} does not vary appreciably over the year with only a slight increase in spring and early summer, from a forestry point of view it is more appropriate to consider an analysis of the frequency of a range of windspeeds over the year. Over a 3 year period it was found that from mid-September onwards there was a marked decrease in the frequency of low windspeeds (0-5 m sec^{-1}) and a corresponding increase in the frequency of winds with speeds greater than 11 m sec^{-1}. In October, for example, on average the windspeed was greater than 11 m sec^{-1} for over 300 hours or almost half the month. This is at a time when air humidity is below average, leading to an increased desiccating potential.

Pressure generally decreases steadily from north to south over the Islands, giving gradients for westerly winds and about 50% of the winds are between south-west and north-west with 80% to the west of the north/south line (Pepper, 1954). The frequency of strong winds is greatest from the south-west. This relative consistency in the direction of strong winds has obvious implications in the siting of shelterbelts.

The degree of exposure has often been used by foresters as a guide to its suitability of a site for planting. It has been suggested that the rate of tatter of standard cotton flags may be a indicator of exposure than by purely wind measuring devices. Tatter flags were flown over a two year period at Stanley, Goose Green and Salvador on East Falkland. A full analysis of these data has been published elsewhere (McAdam, 1980). The mean tatter rate over the three sites was 9.8 cm^2 day^{-1}. This was higher than rates recorded for Shetland (9.16 cm^2 day^{-1}), Orkney (7.32 cm^2 day^{-1}) and exposed forestry sites in N. Ireland (7.96 cm^2 day^{-1}) although higher rates have been recorded from experimental plantations in these locations. Tatter was more rapid in summer than in winter. Caution must, however, be exercised in the interpretation of tatter flag data because of apparent differences in the climatic factors contributing to flag tatter in the Falkland Islands and in the British Isles.

It can be concluded that although the Falklands have a windy climate and exposure is high, the conditions (particularly in view of the relatively low rainfall) are not so severe as to predispose the growing of trees. However, the problem of frost (which has been highlighted by Mr Beatty, UKFIT Forestry Consultant) must be taken into account when siting and planning the shape and size of shelter-belts. Ground frost incidence can affect young trees in particular though there is evidence from Table 1 that once trees are large enough to have leaves well above ground, the incidence of air frost damage will be very low. The dry soils and windy exposed location found on the tops of ridges mean that trees would be better established in the valleys, but not on the valley floor where frost pockets are likely. The prevailing strong wind direction is relatively constant from the SW so the siting of shelter-belts and woodlands should be relatively straightforward provided the above climate limitations are borne in mind.

b. Soils

The soils of the Falkland Islands are undeveloped, in a relatively virgin state, acid and peaty and in most of the areas where tree planting is likely, consist of a relatively shallow layer (25-35 cm) of dark brown, fibrous peat overlying a very compacted clay, mineral subsoil. The clay may be sandy or silty, depending on the underlying geology and may include a shallow (5-10 cm) upper zone containing some incorporated organic matter. There is usually dense rooting in the upper layer with little root penetration into the mineral soil below. This is of importance in relation to tree growth as Low (1983 and 1986) and Beatty (1996) have suggested that tree roots must break through this relatively impervious horizon before good growth can occur (as has happened at, say, Hill Cove). This can best be achieved by breaking up the peat/clay transition and encouraging soil mixing before planting and hence subsequent root penetration. This should also help start the whole process of soil mineralisation and development and encourage the enhancement of soil fertility.

c. Previous attempts to introduce trees (from Low 1983)

From the early days of settlement, the absence of indigenous trees and a desire to create shelter resulted in attempts to introduce a wide range of tree species either from South America or from Europe. Dallimore (1919) describes these attempts and their outcomes in the following words:

"Unfortunately in the few efforts that have been made the persons interested have not possessed sufficient technical knowledge to enable them to give the young trees the special attention necessary to enable them to overcome the unfavourable conditions which prevail, neither have they made proper reports upon the behaviour of the various species tried ...".

Probably in the early 1890s, Mr Robert Blake began what Dallimore regarded as "the most determined attempt that has yet been undertaken to establish a plantation of trees" at Hill Cove in West Falkland. This included some *Nothofagus* plants (probably *N. betuloides*) imported from Tierra del Fuego, Austrian pine (*Pinus nigra var. nigra* Harrison) imported from Britain, Austrian pine and Scots pine (*P. silvestris*) raised locally from seed and a poplar (probably *Populus alba*) raised from cuttings obtained from a tree in Government House gardens. Mr Blake appears to have been well aware of the need for sensible site selection, good ground preparation, provision of early shelter (by using gorse hedges) and protection from browsing mammals. The result of his efforts remains today as an irregularly-shaped mixed woodland area, in a hollow at Hill Cove settlement.

In 1919, staff at Kew Gardens were asked for advice on tree planting in the Falklands, and Dallimore (1919) gave detailed guidance on how best to establish trial plantations. Many of his far-sighted prescriptions remain valid today. On his advice, a Scottish-trained forester (Mr James Reid) was employed in the Falklands between 1920 and 1925.

In 1920, Reid took with him from Britain seedlings and transplants of various temperate coniferous and broadleaved tree species, including pines, spruces, alders, birch, sycamore and elm, as well as cuttings of numerous poplar and willow species. Seedlots of many coniferous and broadleaved species were also sent out in 1919-21. Reid established a small nursery in Stanley and raised substantial numbers of trees from seed (particularly Scots pine and Sitka spruce). In general, the planting stock brought out from Britain did not do well. His initial planting trials were made on the south side of Mt Low, in East Falkland, but were soon abandoned because of very poor results. Reid then concentrated his activities at Hill Cove where land had been made available by Mr Blake. It is reported that "... in the autumn of 1925 ground was prepared for planting. Ditches were cut at 15-yard intervals and led into a natural stream which flows through the middle of the paddock. Holes were prepared 3 feet apart, turf being removed and the soil and clay broken up to a depth of 14 inches. In several cases the moor pan was found to be only some four inches below the ground surface and this necessitated breaking up with crowbars and pickaxes. Six acres so prepared have already been planted out with 30,000 conifers of which the Scots pine and Sitka spruce give promising results. All the trees planted were raised at Port Stanley except 1000 Scots pine which were raised at Hill Cove settlement, West Falklands. The nursery at Government House, Port Stanley, has been stocked with 40,000 seedlings, part of which it is proposed to plant out at Hill Cove next spring and the remainder in the following year". Also of interest is the fact that in 1923, Reid obtained plants of *Nothofagus antarctica* and *N. obliqua* from Punta Arenas in Chile. Where these were planted is not recorded, but is likely that some went to Hill Cove.

After 1925, intermittent tree planting attempts continued but it is difficult to obtain a clear picture of what occurred because of lack of records covering the next 30 years or so. It is likely that the first introduction of Monterey cypress (*Cupressus macrocarpa* Gord.) to the Islands occurred in the late 1920s at Weddell Island. There is also no clear indication of when Monterey pine (*Pine radiata* D. Don) was first planted. A plot on Carcass Island dates from the late 1940s, but two large specimen trees at Government House in Stanley were probably planted in the 1920s.

In 1957-58 the Falkland Islands Company imported from Britain several thousand transplants of various coniferous species which were planted in fenced enclosures on spaced-furrow Cuthbertson ploughing at Fitzroy and Goose Green. Mishandling of the plants during transit and particularly at time of planting led to failure at Fitzroy (Clement, 1967). Results were only marginally better at Goose Green where serious browsing damage occurred.

Finally, McAdam (1982) records three further recent attempts to extend tree planting. He raised from seed a wide range of temperate tree and shrub species and in 1977 distributed the young plants to various settlements. He also produced an advisory leaflet on tree planting in the Islands (McAdam, 1977). In the same year, he imported *Nothofagus pumilio* transplants from Esquel in Argentina and planted them at four sites on Mt Usborne. Initial growth of the *Nothofagus* was encouraging, but the trees are thought to have been destroyed by browsing in 1982. Also in 1977, the Sheep Owners' Association purchased a quantity of lodgepole pine (*Pinus contorta*) seed from the Forestry Commission. This seed, of Washington coast origin, was distributed to interested association members, some of whom have since raised and planted out young trees.

In the 1980s interested land owners, often following subdivision, planted small areas of trees on their farms

Following a programme of preliminary research into the potential for biological husbandry, the UK Falkland Islands Trust commenced a research programme into the growing of trees in the Falkland Islands. The findings of this programme are outlined in Section 2 of this report.

d. Tree species suitability

A relatively complete catalogue of the present location and nature of tree growth in the Islands is presented in (Low 1983, 1986 and McAdam, 1982). On the basis of previous reports and current tree survival, the main species which can be recommended for shelter belt planting are:

Monterey cypress	(*Cupressus macrocarpa*)
Lodgepole pine	(*Pinus contorta*)
Monterey pine	(*Pinus radiata*)
Southern beech	(*Nothofagus betuloides*)

Other species meriting trial are:

Corsican pine	(*Pinus nigra*)
Lenga	(*Nothofagus pumilio*)
Nirre	(*Nothofagus antarctica*)
Birch	(*Betula*)

Beatty (1996) has highlighted the importance of provenance selection at planting.

Most farmers have experience of tree planting using pot grown stock, fewer have used bare-rooted trees. A few farmers have attempted good standards of cultivation prior to planting with promising results on lodgepole pine. There have been widespread losses with spruces and there is evidence that weevil damage is a significant contributing factor. Older, isolated spruce may have been damaged by green spruce aphids.

Many species have been tried in hedges or in gardens - some of the most promising of these are - willows, white poplar, whitebeam, and box.

e. <u>Reasons for tree planting successes and failures</u>

These have been well summarised in Low (1983, 1986) and by Beatty (1996).

Assessing the specific reasons for the success or failure of many tree planting attempts in the Falklands has been made difficult by the general lack of adequate records. Reliable information on such factors as type and source of planting stock, plant handling and planting method, season of planting, protection measures, unusual climatic events and general growth history could seldom be obtained. In this respect, apart from the UKFIT trials, the present situation differs very little from that described by Dallimore in 1919. However, from observations made on site, combined with such limited information as could be obtained from the literature and from local sources, it has been possible to deduce what have in general been the most common factors contributing to planting success or failure. These are listed below more or less in order of importance. It must be emphasised that at most locations where planting took place the results achieved were due to a combination of these factors; and it was possible for favourable factors to outweigh unfavourable ones, or *vice versa* (Low 1983, 1986).

Beneficial factors

1. Selection of a moisture receiving site with natural topographic shelter and above average nutritional status. (Usually achieved by planting in a sheltered hollow or small valley in the vicinity of settlements which in turn are generally found in the climatically more favoured locations).

2. Provision of artificial shelter to supplement or substitute for topographic shelter. eg, by erecting wooden shelter fences or creating gorse hedges).

3. Careful protection by fencing against browsing by domestic stock or by hares (where present).

4. Planting of trees in sizeable plots or belts to obtain the benefit of mutual shelter development and canopy closure.

5. Intensive ground preparation prior to plating.

6. Planting in late autumn or early winter (April-June) rather than in spring. In the "back-end" of the growing season, soil moisture tends to be higher than in spring, desiccating winds are less likely, and yet soil temperature is probably still sufficiently high to permit some root growth of conifers.

7. Selection of the most wind resistant species available particularly for planting along the windward (west) edge.

Adverse Factors

1. Incorrect plant handling in transit and at the planting site. (Has included lengthy storage in unsuitable conditions or containers, and excessive exposure of roots during the planting operation).

2. Inadequate protection against browsing damage, both immediately after planting and in the longer term.

3. Use of species or provenances which did not have good resistance to wind exposure. (eg, Scots pine and inland provenances of Lodgepole pine).

4. Poor choice of planting site. (Wind exposure or soil moisture status inadequate).

5. Planting trees too deep. Use of excessively large planting stock with poor root/shoot ratio. (Liable to lead to heavy losses in a windy climate with low rainfall). Poor matching of planting stock to site conditions.

6. Occurrence of cold desiccating winds soon after planting (particularly after spring planting).

7. Failure to plant trees in sufficient numbers for the development of mutual shelter.

An overview of these reasons highlights the need for well documented trials on planting technique.

f. Summary

An overall summary of the findings from previous reports and observations on tree planting revealed the following key issues:

1. The climate of the Falkland Islands while adverse, does not predispose tree planting. Site selection should bear climatic limitation in mind and care should be taken to avoid dry, windy ridges and frost hollows. Autumn planting is preferred.

2. Soils have poor fertility and are generally underdeveloped. Tree growth would be greatly enhanced by shattering the hard 'pan' or layer between the peaty surface and mineral clay subsoils. Wet, water logged sites, and dry, hard, shallow soils should be avoided.

3. A range of conifers are suitable for trying but further work should be carried out on species of southern beech.

4. Most failures have occurred because of poor site selection, low planting stock quality, inadequate care and attention at planting and protection from stock.

5. Successful plantings have resulted from; good site selection, protection, good planting stock and soil cultivation prior to planting. The whole issue of tree nutrition at planting, for establishment and for adequate tree growth is poorly understood.

   Site selection and protection can be largely taken care of with existing knowledge. However, information on planting stock quality and planting technique needed resolution. Hence in 1989 the UKFIT commenced a trial programme to investigate these.

CHAPTER 3 - THE UKFIT TREE RESEARCH PROGRAMME

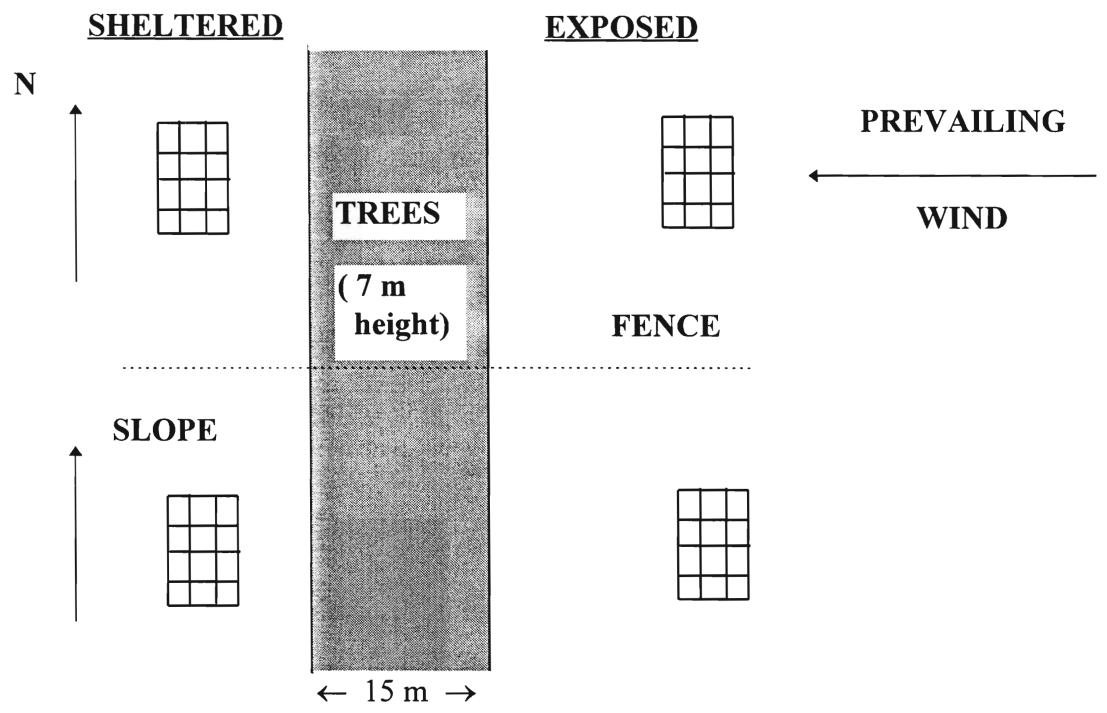
a. Background

The UKFIT has been interested in the introduction of biological husbandry techniques into the Falkland Islands to help ensure the development of a sustainable agricultural industry. Research started initially with an overall survey including soil analysis which showed that the necessary bacterial population, necessary for enhanced soil fertility and tree growth was low. This observation induced complementary trials to determine whether the large resources of kelp in the waters around the Falkland Islands could be turned into an organic fertiliser to assist with both tree planting and pasture improvement. UKFIT conducted a series of field trials and provided a trial "digester" to manufacture liquid organic fertiliser in the Islands.

Although shelter has been widely shown to enhance stock growth survival and performance and increase pasture production and hence sheep nutrition, the effects had not been demonstrated clearly in the Falkland Islands.

The effect of shelter on pasture growth

In a preliminary investigation, a comparison was made between the growth of 'unimproved' (Whitegrass dominant) pasture and 'improved' (*Agrostis magellanica*, *Holcus lanatus*, *Poa pratensis* dominant) pasture in a sheltered and an exposed situation (see diagram on page 15). The shelter was provided by a 15 m wide belt of *Cupressus macrocarpa* (7 m tall) situated immediately behind Government House, Stanley. Plots (0.25 m^2) protected from grazing were pretrimmed in early September and 4 different plots cut on each of 3 occasions throughout the growing season. The plots to the north of the fence were in native, mostly ungrazed *Cortaderia* and those south of the fence were on lightly grazed pasture which had probably been 'improved' many years previously.



Site details of an experiment to compare the growth of 'unimproved' (north of fence) and 'improved' (south of fence) pasture in a 'sheltered' and an 'exposed' situation to the west of Stanley, East Falkland.

The plots were protected from grazing and the dry matter yields (cumulative totals) at each harvest presented in Table 2 below.

Overall yields were greater on the 'improved' than the 'unimproved' and on the 'sheltered' than the 'exposed' plots on all occasions. On the 'improved' plots in spring, the yield was twice as great in the 'sheltered' as in the 'exposed' situations. These results must be treated with some caution as confounding effects such as the higher level of soil fertility in the plots leeward of the trees due to stock habitually sheltering there may have some enhancement effect. However, from experience from other sites of the effects of varying soil fertility on yield, it was thought unlikely that all of the observed differences could be accounted for by factors such as fertility.

		Sheltered	Exposed
	21 Nov	330	210
'Unimproved'	27 Jan	2610	1820
	28 April	2960	1790
	21 Nov	660	310
'Improved'	27 Jan	3280	2620
	28 April	4140	3410

Table 2 *Dry matter yields (kg ha^{-1}) at each harvest (each value is the mean from four plots) from 'unimproved' and 'improved' pasture in a 'sheltered' and an 'exposed' situation.*

In view of the relative harshness of the climate and very low levels of available soil nutrients it is likely that the effects of shelter on spring grass growth would be more pronounced in the Falkland Islands than in other locations. This small trial demonstrates some of the potential benefits which shelter could bring to agricultural production in the Falkland Islands.

b. Objectives

The value of shelter having been demonstrated, and in view of - (i) the relatively limited resources available to it and (ii) the observation and findings from previous work -

- the UKFIT decided to concentrate its efforts on the two main issues where there was a need for research -

1 Planting technique - to determine the most suitable method for planting and establishing trees on a range of soil types.

2 Planting stock quality - to investigate ways of enhancing the quality of stock and range of species suitable for various situations in the Falkland Islands.

c. Planting techniques

The major thrust of the project was geared towards determining tree planting and establishment techniques on a range of sites. The key issues involved are planting technique, shelter provision and tree nutrition. An experiment was designed involving the following treatments:

- Tree species	- 2 (Lodgepole pine and Sitka spruce - largely selected because of local availability)
- Planting technique	- Slit plant (quick and simple - standard UK Forestry technique)
	- Pit plant (as implied - small pit dug to disturb the soil)
- Nutrition	- No fertiliser; phosphate only; kelp compost (in the pit); foliar feed of locally produced kelp extract)

The experimental design incorporated all combinations of three treatments in a fully replicated (3 reps per treatment) design. Each treatment plot contained 5 trees, representing a total of 600 trees per site. The experiment was planted at 3 sites:-

(i) Keppel Island - hard, dry "diddle-dee" camp

(ii) Fitzroy (Britannia) - whitegrass camp

(iii) Stanley (Mkt garden) - impoverished, shallow, wet peat

The Keppel Island site was planted in August 1989 and the other two sites in August 1990.

On all 600 trees at each site the following measurements have been made - tree height; a subjective assessment of general tree health (on a 0-5 scale); number of branches counted; foliage samples taken for chemical analyses of leaf nutrient levels. Measurements have been taken as follows:

	1989 (Jun)	1990 (Jun)	1990 (Oct)	1991 (May)	1991 (Nov)	1992 (Jul)	1992 (Nov)	1994 (Jan)	1995 (Jan)	1995 (May)
Keppel	/	/	/	/		/		/		/
Fitzroy			/	/	/		/	/	/	
Stanley			/	/	/		/	/	/	

The effects of planting technique, shelter, foliar spraying and species on tree height, health and survival are presented in the Tables. Data are presented for two sites in most cases.

One aspect of the experiment detailed above is an assessment of the value of locally produced liquid kelp extract. Previous trials (conducted by the UK FI Trust) had shown that bacterially activated, aerobic digestion is the simplest and cheapest way to produce kelp extract. Over the duration of the project, liquid seaweed extract was produced from the digester and was applied to some trees in the main establishment trial.

(i) *The Keppel Island site*

Since Keppel Island became uninhabited in 1991, the trees ceased to be tended regularly and losses were incurred. However, as the planting history of each tree was known in detail, it was felt worth continuing to extract as much information from this site as possible. In July 1992 there were 250 trees still alive, a decrease in survival from 62% to 38% between May 1991 and July 1992 and these were measured. In January 1994 there were 101 trees still alive, twice as many Lodgepole pine (mean height 75 cm) surviving than Sitka spruce (mean height 51 cm). One tree was 180 cm tall. Overall the Lodgepole pine has grown 25 cm since 1992, the fastest growth of any site. In April 1995 it was estimated (Department of Agriculture) that overall 30% of trees were still surviving with a mean height of 73 cm (Lodgepole pine) and 66 cm (Sitka spruce) (Table 3). However, assuming these means to have been reasonably representative, despite good early growth of Lodgepole pine, Sitka spruce appear to have grown well in recent years and 4 to 5 years after planting the Department of Agriculture team also report that overall survival of Sitka spruce seemed to be better than Lodgepole pine whereas early growth of Lodgepole pine had been better than for Spruce. Trees suffered more from competition from grass than any other vegetation type and paraweb fencing had a beneficial effect up to about 5 m from the fence. The site was overgrown and suffering from neglect although cattle still remaining on the island did not appear to be causing an immediate threat.

(a) Mean Tree height (cm)	Sheltered	Unsheltered	Mean
Lodgepole Pine	76	70	73
Sitka spruce	72	60	66
Mean	74	65	70

(b) Mean % Survival	Sheltered	Unsheltered	Mean
Lodgepole Pine	23	25	24
Sitka spruce	25	44	35
Mean	24	35	30

Table 3 *Tree height and survival at Keppel Is (April 1995)*

(ii) Species selection

Individual tree species growth, health and survival since planting are presented for the Fitzroy site (Figure 3) and Stanley site (Figure 4). It can be seen that Lodgepole pine is performing best on the Fitzroy site and that growth has increased at a more rapid rate between 1994 and 1995 than any other year (Figure 3). The overall health of the trees also increased steadily since 1992 so they can be considered to have well established and be growing rapidly and healthily.

On the other hand, Sitka spruce had not increased in height since planting and their health status was gradually declining (Figure 3b) with trees gradually dying off (Figure 3c).

Fitzroy-Species

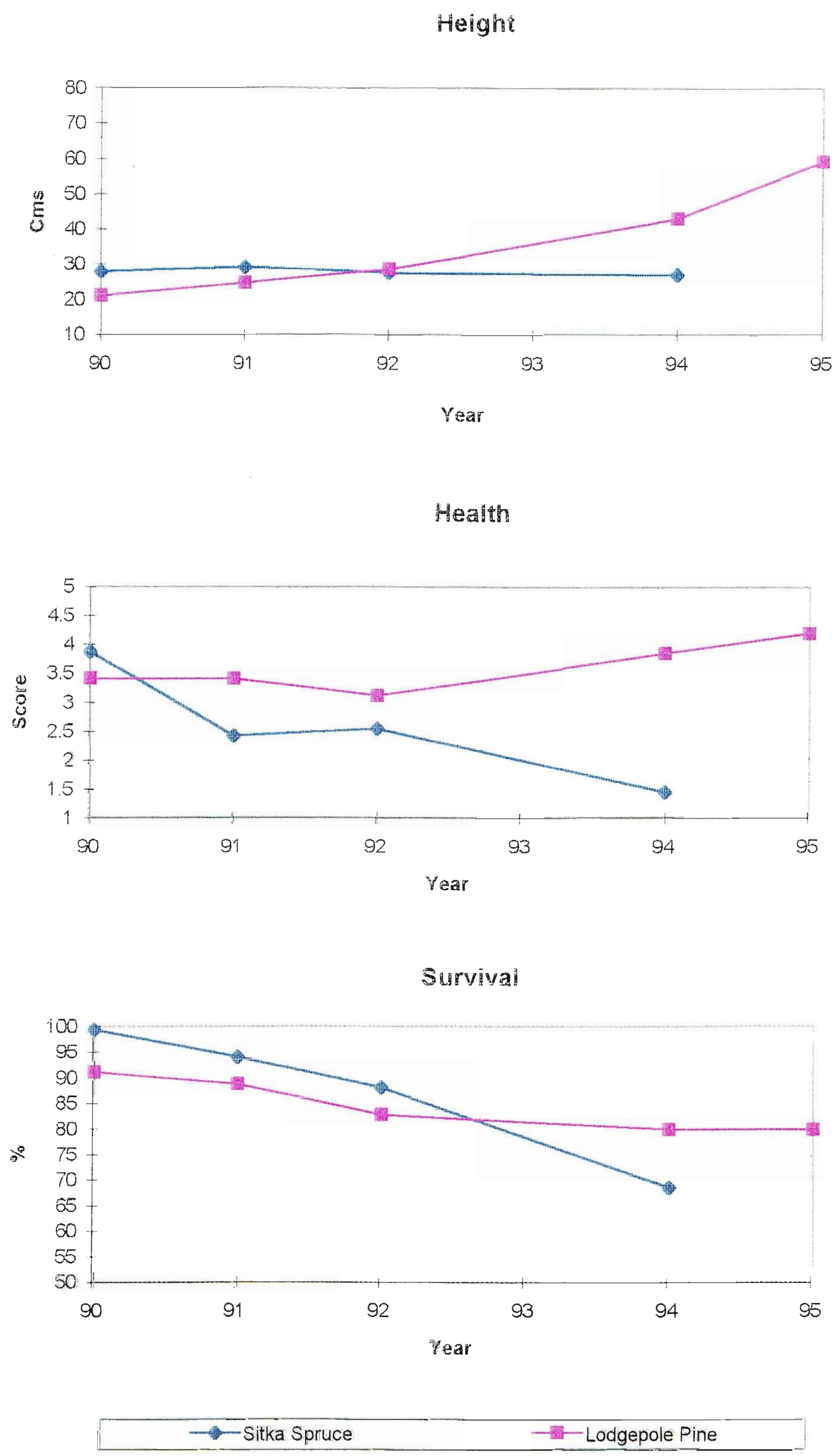


Figure 3 The growth, health and survival of trees planted at the Fitzroy site. Measurements on Sitka Spruce were terminated in 1995.

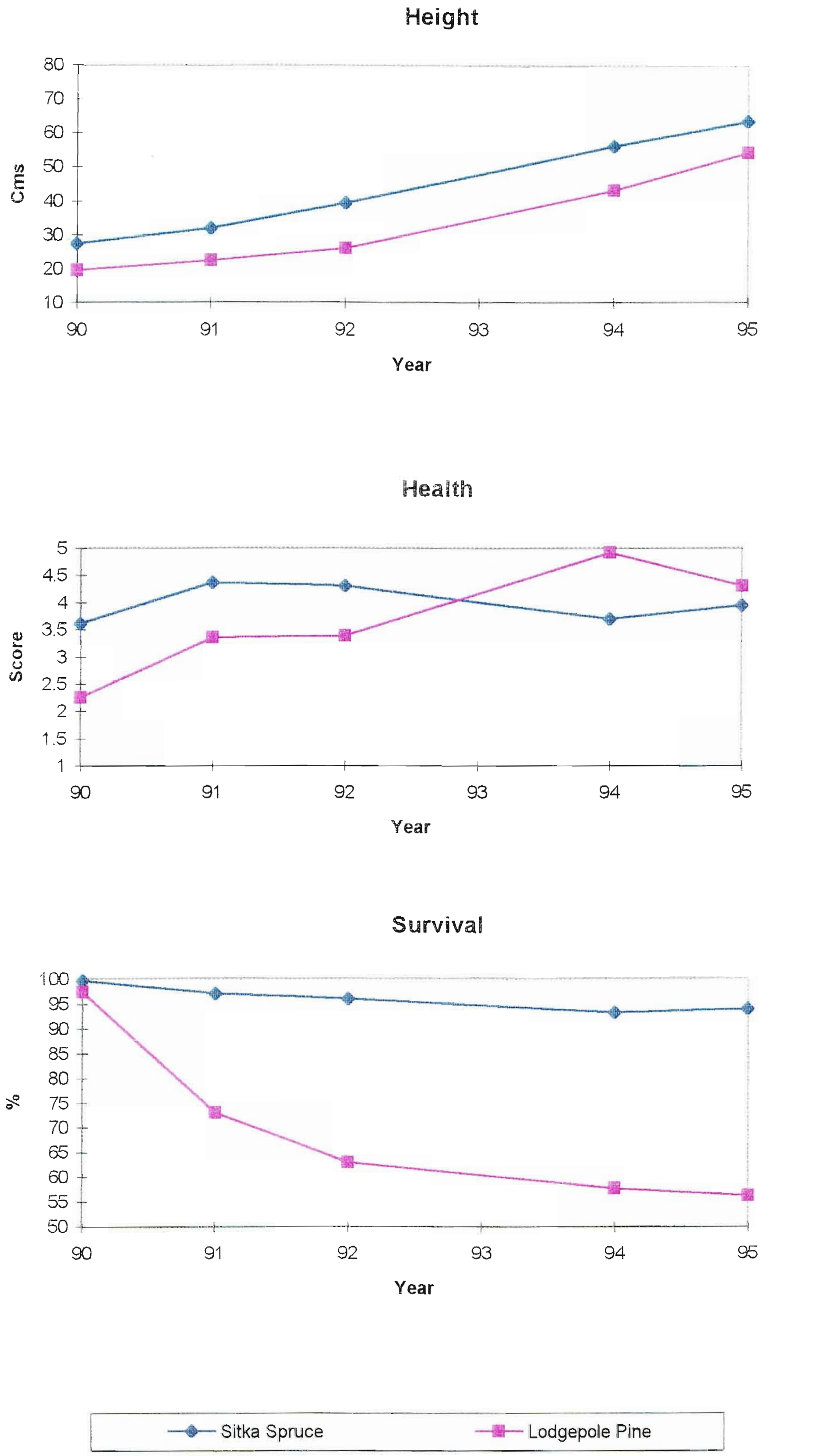


Figure 4 The growth, health and survival of trees planted at the Stanley site.

		Fertiliser at Planting			
Site	Planting Technique	Zero	Phosphate	Kelp Compost	s.e.m.
a. Height, Growth (cm)					
Stanley	Slit	48.6	80.2*		
	Pit	59.6	74.6	53.4	4.64
Fitzroy	Slit	47.2	46.2		
	Pit	63.1*	62.3*	66.1*	4.87
b. Health					
Stanley	Slit	3.6	4.4		
	Pit	3.9	4.1	3.9	0.28
Fitzroy	Slit	3.7	4.0		
	Pit	4.4	4.3	4.6	0.31

Table 4 *The effect of fertiliser at planting and planting technique on tree growth between 1989 and 1995 and tree health from Fitzroy (Lodgepole pine) and Stanley (Sitka spruce) in January 1995. * indicated treatments which are significantly greater than control.*

Planting Technique	Kelp Extract / Fertiliser	SITE: Fitzroy Applied	Fitzroy Zero	Stanley Applied	Stanley Zero
a. Height (cm)					
Slit	Zero	49.9	44.4	47.3	50.0
Slit	Phosphate	47.7	44.6	77.3	83.2
Pit	Zero	68.9	57.2	59.5	59.7
Pit	Phosphate	66.4	58.2	70.8	78.5
Pit	Kelp Compost	69.5	62.6	51.2	55.6
Mean		60.5	53.4	61.2	65.4
s.e.m.		6.89		5.45	
b. Health					
Slit	Zero	3.7	3.6	3.4	3.7
Slit	Phosphate	3.9	4.0	4.4	4.3
Pit	Zero	4.7	4.1	3.8	4.0
Pit	Phosphate	4.2	4.4	4.0	4.3
Pit	Kelp Compost	4.7	4.5	3.7	4.0
Mean		4.2	4.1	3.9	4.0
s.e.m.		0.43		0.26	
c. % Tree survival					
Slit	Zero	77	73	97	100
Slit	Phosphate	70	83	90	97
Pit	Zero	77	90	93	97
Pit	Phosphate	77	77	93	97
Pit	Kelp Compost	83	90	93	83
Mean		77	83	93	95
s.e.m.		8.9		5.6	

Table 5 *The effect of planting technique, fertiliser at planting and kelp extract spray on tree height, health and survival of Sitka spruce at the Stanley site and Lodgepole pine at the Fitzroy site, January 1995.*

Planting Technique	Kelp Extract / Fertiliser	Fitzroy Applied	Fitzroy Zero	Stanley Applied	Stanley Zero
		SITE			
a. Height Growth (cm)					
Slit	Zero	13.7	12.1	2.6	4.6
Slit	Phosphate	12.2	9.7	7.3	10.5
Pit	Zero	16.4	15.2	8.4	10.7
Pit	Phosphate	15.5	14.2	7.4	10.9
Pit	Kelp Compost	17.3	14.3	3.7	4.1
Mean		15.0	13.1	5.9	8.2
s.e.m.		2.70		2.21	
b. Health Change					
Slit	Zero	0.15	0.37	0.15	0.43
Slit	Phosphate	0.29	0.32	0.27	0.08
Pit	Zero	0.33	0.83	0.28	0.20
Pit	Phosphate	0.15	0.30	0.17	0.32
Pit	Kelp Compost	0.15	0.51	0.20	0.42
Mean		0.22	0.47	0.21	0.29
s.e.m.		0.22		0.185	
c. Change in % Tree survival					
Slit	Zero	3.3	6.7	0	0
Slit	Phosphate	3.3	0	0	0
Pit	Zero	0	-3.3	0	0
Pit	Phosphate	-3.3	-6.7	0	3.3
Pit	Kelp Compost	0	0	3.3	0
Mean		0.7	-0.7	0.7	0.7
s.e.m.		3.72		3.76	

Table 6 *The effect of planting technique, fertiliser at planting and kelp extract spray on incremental growth, change in health status and survival of Sitka spruce at Stanley and Lodgepole pine at Fitzroy between January 1994 and January 1995.*

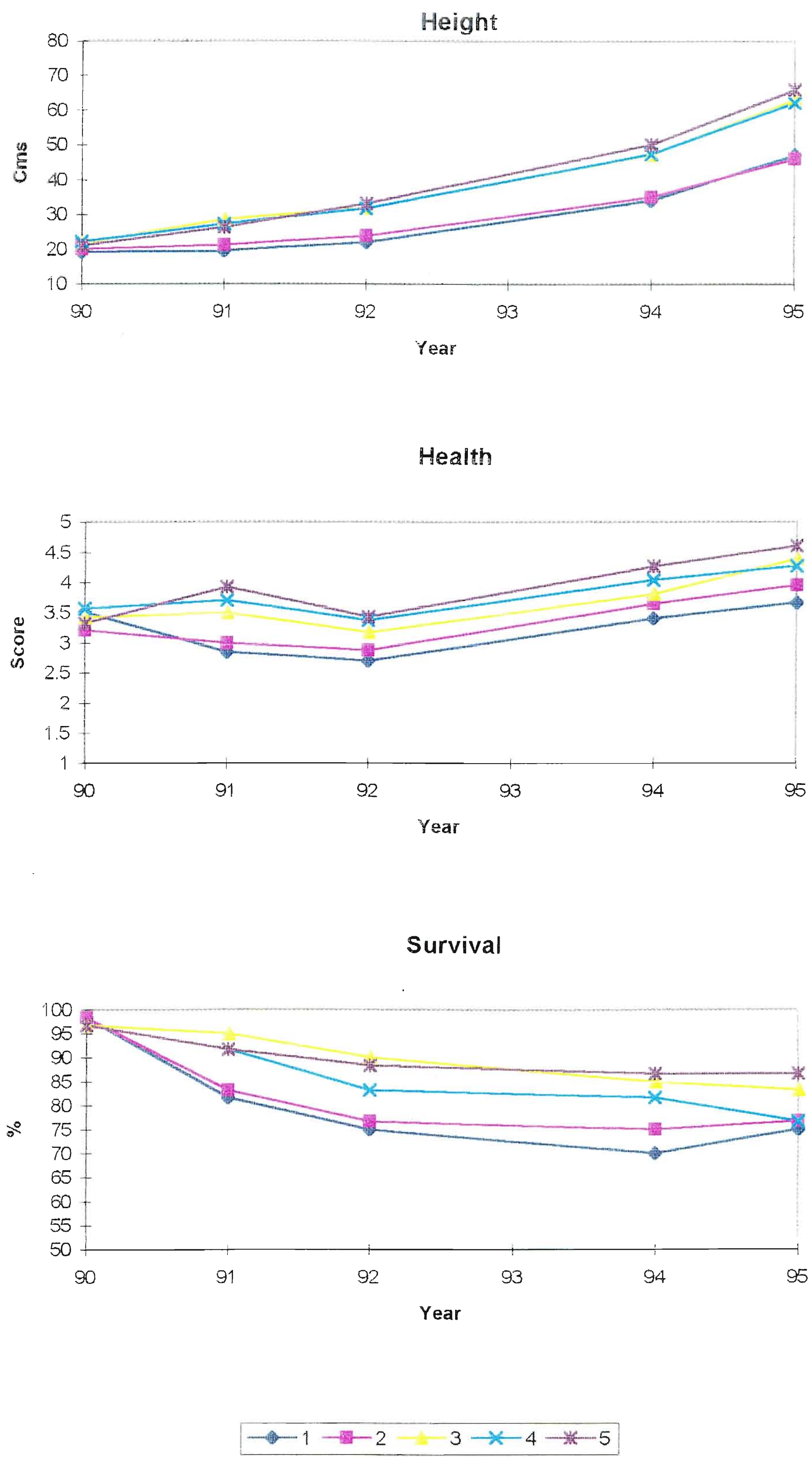
On the wetter, less fertile Stanley site, both species grew equally well and the rate of growth of Lodgepole pine was the same as for the Fitzroy site (Figure 4a). After initial tree losses (up to 1992) few more Lodgepole pines died and those remaining are comparable in health to the Sitka spruce on that site (Figure 4b).

Hence, overall it can be concluded from these sites that once established, Lodgepole pine is a reliable species for any site whereas Sitka spruce only performs best on wetter sites and where there is less competition from grass. However, there is evidence though poorly documented from the Keppel Island site that after about 5 years Sitka spruce may start to grow well on dry sites though original tree losses would have probably been unacceptably high.

(iii) Planting method

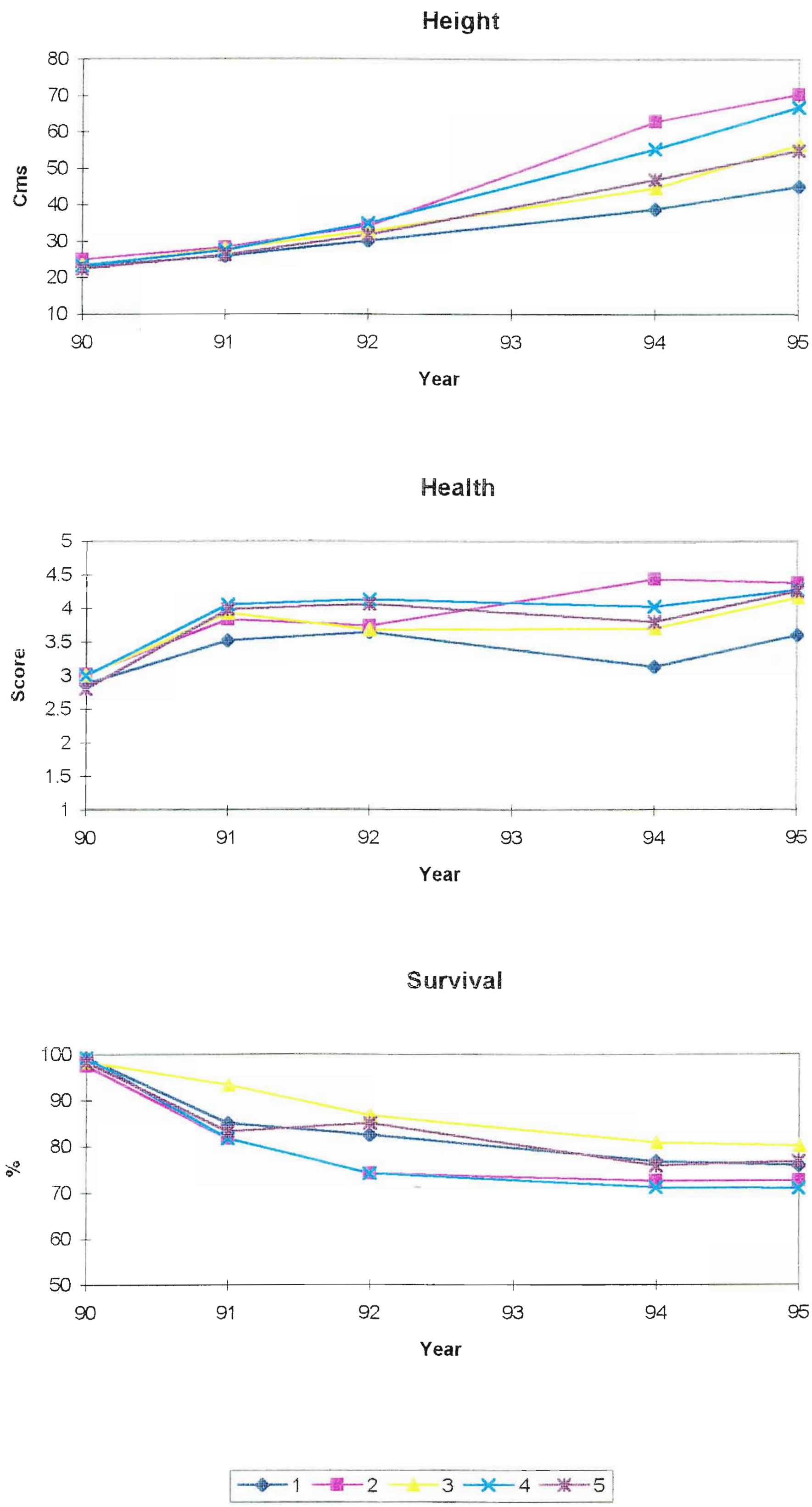
The effect of planting method can be compared from both the Stanley and Fitzroy sites (Tables 4, 5 and 6 and Figures 5 and 6). Overall, tree growth (Lodgepole pine) was significantly greater from pit planted trees than slit planted trees at the Fitzroy site (Table 4 and Figure 5). Five years after planting mean height of slit planted trees was 52 cm and of pit planted trees, 64 cm (Table 4). There was no significant effect of planting method on health, but all surviving trees on this site were healthy. In the fifth year of growth, (94-95) trees grew approximately the same amount from both planting techniques (14-15 cm), (Table 6) the reduced growth from slit planting occurring in the first few critical years of establishment. At the Stanley site, response to pit planting was less clear (Table 4 and Figure 6) and this may have been due to generally poor growth (Table 6 and Figure 4) or the fact that the site was ploughed up initially. Overall this site is less suitable for tree growth. The results highlighted the need for good site selection.

Fitzroy-Effect of Planting Technique



KEY 1 = Slit 2 = Slit + Phosphate 3 = Pit 4 = Pit + Phosphate 5 = Pit + Kelp

Figure 5 The effect of planting technique on growth, health and survival of Lodgepole Pine trees planted at Fitzroy.



KEY 1 = Slit 2 = Slit + Phosphate 3 = Pit 4 = Pit + Phosphate 5 = Pit + Kelp

Figure 6 The effect of planting technique on growth, health and survival of Lodgepole Pine and Sitka Spruce trees planted at Stanley.

(iv) Fertiliser at planting

The good growth response to phosphate in the slit planted trees at Stanley (in 1994) was further enhanced when the data was re-analysed for Sitka spruce alone in 1995 (Table 4). Trees were significantly higher in this treatment and were higher than any other treatment. Overall, by chance, these trees were taller at planting and this has, to some extent, followed through. Early response to fertilisers at the Fitzroy site had disappeared five years after planting and growth in the fifth year (94-95) was similar over all treatments (Table 6). At Fitzroy composted kelp in the pit at planting was beneficial resulting in trees approximately 3 cm taller overall (Table 5) and between 94-95 these trees grew slightly faster (by 1 cm per annum) where kelp had been applied than where no kelp was applied (Table 6).

(v) Foliar fertiliser application

Lodgepole pine at Fitzroy had grown better in 1995 where foliar kelp extract was applied twice previously (1992 and 1994) than where it was not (mean height 60.5 vs 53.4 cms respectively and mean growth 15.0 vs 13.1 cms respectively) (Tables 5 and 6). This result was only significant at the 6% level of significance - still not sufficient for biological significance (5%) but decreasing towards this level consistently (14% in 1993, 12% in 1994). Hence it is anticipated that if these trends continue, foliar applied kelp extract will be significantly increasing growth of Lodgepole pine on this site approximately six years after planting.

On the Stanley site, foliar application did not increase Sitka spruce height (Tables 5 and 6) and although trees were actually slightly smaller where no foliar kelp extract was applied, this can be attributed to different sizes at planting and was not significant. Lodgepole pine responded better than Sitka spruce to foliar extract at the

Stanley site, indicating that Lodgepole pine with its longer and upward facing needles which prevent rapid runoff is more suited for foliar uptake of liquid-applied nutrient.

(vi) Shelter netting

Observations at the Keppel Island site indicated that survival and growth of trees was better immediately in the lee of shelter webbing. Overall, at the other two sites, growth was only slightly better in the sheltered than the unsheltered trees but this is reversing an earlier trend of either no response at all or a negative response to shelter at the Fitzroy site (Table 7). Trees at the Fitzroy site were significantly healthier in sheltered than unsheltered plots four years after planting. This may be due to absence of browning and scorch of leaves from the wind which would reduce the health score.

	Stanley		Fitzroy	
	Sheltered	Unsheltered	Sheltered	Unsheltered
Tree height (cm)	66.2	60.4	57.2	56.7
Tree health	3.97	3.94	4.5	3.9*
Tree Survival (%)	91	97	84	75
Growth 94-95 (cm)	7.6	6.5	14.8	13.3

Table 7 *The effect of artificial sheltering on tree growth, health and survival at Fitzroy (for Lodgepole pine) and Stanley (Sitka spruce) five years after planting (1995) and on tree height increment in the fifth full year of growth (1995), at Stanley and Fitzroy. Results with a * show significant difference at 5% level of significance.*

At the Stanley site, trees have responded well to shelter and four years after planting were, on average, 6 cm taller in sheltered than unsheltered plots (Table 7).

(vii) Conclusions from establishment trials

- Lodgepole pine is a better species to use than Sitka spruce over a wide range of sites in the Falklands.

- Pit planting is strongly recommended for adequate tree survival and growth on dry, hard sites. On wet sites early survival is better following pit planting. Trees which have been slit planted seem to subsequently grow satisfactorily once established.

- Where trees are pit planted some form of moisture retention such as provided by kelp compost should be used, its beneficial effects are carried into the second year after establishment and beyond

- The growth promoting benefits of liquid kelp extract are being seen on Lodgepole pine.

- The benefits of paraweb netting as a minimal shelter provision are becoming more important as trees get taller and offer more wind resistance.

d. Planting stock quality

Most of the early reports highlight the need to use the correct species and quality of planting stock. The UKFIT programme has encompassed a range of trials and initiatives geared at enhancing the quality of stock planted.

(i) Reports were obtained on small groups of hardwood trees (chosen from willow, maple, sycamore, ash, oak and beech) planted at four sites on east Falkland.

(ii) Willow variety trial. Willows appear to do particularly well in gardens in the Falkland Islands. In UK a considerable amount of selection work has gone into producing a wide range of varieties of hardy willows suitable for wet soils. The Department of Agriculture for N Ireland holds a substantial reference collection of these willows at its Horticulture and Plant Breeding Station. Approximately 600 plants of 10 varieties from that collection which might show promise in the Islands were planted at Keppel Island and some varieties are being tried at Fitzroy and Coast Ridge.

Of the six varieties of willows tested *Salix dasyclados* (from Northern Ireland) has proved most successful with 90% of cuttings surviving and growing (if long cuttings were used). One *Salix dasyclados* plant had put on over one metre of growth each season and on average plants grew over 60 cm. The smaller *S. dasyclados* cuttings grew well (average 50 cm) though more cuttings died initially (55% survival).

(iii) Macrocarpa seed establishment. *Cupressus macrocarpa* - locally known as 'macrocarpa' - is one of the most successful trees found growing in the Falklands and one which might be regarded as a 'traditional' component of the landscape (though it is of course not native to the Falklands). In exposed conditions however macrocarpa grows very slowly. The species also grows well in New Zealand where it is a valuable forestry tree and the Forest Research Institute of the Ministry of Forestry in New Zealand has, for many years, been selecting seed from and breeding 'elite' trees. These show rapid growth and good growth characteristics. To enhance the macrocarpa stocks in the Falklands and to see if these improved strains will do well locally, seed of the best selections from the macrocarpa bred in New Zealand were purchased. Seedlings from these were raised at Stanley for comparison with 'local' macrocarpa (ex Hill Cove) and UK purchased (ex Forestry Commission seed).

Of the 3 varieties grown, growth of the plants from the New Zealand hybrid seed was better than from the other two varieties. The plants were grown on in pots and eventually planted out as part of additional tree projects (Dulverton Wood (see later).

	Seed Source		
	Local (FI)	**Forestry Commission**	**N Z Hybrid**
Height (cm)	34.0	29.8	44.1
Stem diam. (mm)	6.2	5.1	7.9

Table 8 *The size of transplants of Cupressus macrocarpa grown from 3 seed sources.*

(iv) Eucalyptus trial. Eucalyptus can tolerate a wide range of conditions and there is high variation within the species. Seed of eight species of Eucalyptus were donated to the Trust. These were planted out at the Market Garden in blocks and their growth assessed.

There was a wide range of variation in size, health and survival amongst the 8 varieties of Eucalyptus. *Eucalyptus globulus* was tallest and had good survival but the plants were rather spindly and suffered wind burn. Although, for example, *Eucalyptus gunnii* was low growing, plants were much more hardy and healthy and in the long run this may well be the best combination of attributes to use in the prevailing conditions. Eucalyptus may have potential as as an ornamental tree.

(v) *Nothofagus in the Falkland Islands*

Previous work by McAdam (carried out in 1977 and reported in 1982) had indicated the potential for *Nothofagus* in the Falkland Islands.

Nothofagus pumilio transplants (50-60 cm tall) were flown in from a well established forest nursery in the Southern Andes at Esquel, Argentina. By prior agreement with the nursery, the roots of these plants had been well washed and they were planted out within 12 hours of leaving the nursery. Twelve trees were planted at each of four sites which had been fenced off for an agronomy experiment on the southern slopes of Mount Usborne, east Falkland. Details of the site and results from the trial are presented in Table 9. The conclusions which could be drawn are that this species can grow on relatively exposed sites, the growth rate being faster at lower altitudes and on the better soil types. Thus the importation of hardy trees from well established forest nurseries on the mainland of southern South America should be seriously considered.

These sites were subsequently abandoned in 1982 and it appears that the fencing eventually deteriorated and the small, unprotected trees grazed out by stock.

Site No	Position and aspect	Soil	Vegetation	Mean plant ht (m) with s.e. Planted 10/76	5/78	5/80	5/81
1.	Fertile valley slope	Some organic matter with a high proportion of mineralisation and unimpeded drainage	Hard whitegrass camp	0.56 ± 0.02	0.99 0.02	1.41 0.04	2.10 0.07
2.	Undulating	Peaty with some mineralisation and partially impeded drainage	Hard whitegrass camp	0.53 ±0.01	1.01 0.02	1.36 0.01	1.96 0.05
3.	Low lying damp	Peat with little evidence of mineralisation and severely impeded drainage	Soft whitegrass camp	0.55 ± 0.01	0.79 0.03	1.00 0.03	1.14 0.07
4.	Elevated peat bank	Deep undifferentiated peat with no mineralisation and no drainage	Peat bog	0.57 ± 0.02	0.62 0.03	0.81 0.04	0.99 0.09

Table 9 *Description of experimental sites with heights of Nothofagus pumilio trees 1976-1981 trees planted in October 1976*

e. Alternative sources of planting stock

To date trees used in the Islands are either imported as whole plants (rarely now) or raised as seed in the Market Garden. There is a considerable forest industry around Punta Arenas (largely explotive) and it would be advantageous to compare conditions and benefit from experience in that region. Hence the Trust's tree/grassland consultant visited Punta Arenas for approximately two weeks in 1995 to establish a link with the University of Magallanes in Punta Arenas. Most of the time was spent at the Institute of Patagonia which is now the Faculty of Natural Sciences in the University and at the small Chilean agricultural research station (INIA - Kampenaike).

The most interesting and valuable contact made was with the small Forestry Department at the Institute (Professor Rosenfield) which is able to produce excellent quality trees. Seedlings of southern beeches (*Nothofagus* species) which grow well in those latitudes have shown considerable potential in the Falkland Islands (see previous section) and merit further trials.

These trees are cultured from seeds or from buds and are grown in small containers of sterile agar (a type of jelly) and hence would satisfy the strict phytosanitary regulations concerning plant imports to the Falkland Islands (they would have no soil on their roots). There is now regular shipping contact between Punta Arenas and the Falkland Islands and trees could be imported in this fashion at approximately one third of the current cost. The Trust proposes to help assist the University in a small project to produce trees for eventual export to the Islands. These trees will probably cost 60-80p each. Eventually this information could be passed on to existing and potential nurseries in the Falkland Islands so that they could consider commercial arrangements with the Institute.

If a regular supply of good quality trees reared under the proper controlled conditions can be realised from Punta Arenas, it would considerably enhance the prospects for tree planting in the Islands. The current problem of seasonally when importing from Britain would be overcome and the opportunity to select and source trees of good growth form would be realised.

f. The Dulverton Wood project

Background

In 1992 the Trust considered that the establishment trials had advanced to a point when a start should be made on establishing a sustainable woodland for demonstration and development purposes. A two hectare site was chosen on a well managed farm in West Falkland. However due to the Trust's overall financial commitments, with a call on funding for other projects, it was decided to seek sponsorship to help start the woodland. After submitting the case a grant was obtained from the Dulverton Trust to allow the first 500 trees to be planted on the site in 1993 under controlled conditions and in small groups. The trees were planted using the pit and kelp technique, the most promising of the techniques to emerge from the Trust's trials on planting and establishment. The site was bordered by gorse hedge on three sides and only minimal additional shelter was provided.

Survival over the first year was good (90%) and average tree height was 49 cm and health score 3.9 (on a score of 0 = dead; 5 = very green and healthy). By June 1994 the trees were still reported as looking healthy and well. However, severe weather conditions in early spring of 1994/95 resulted in a very high loss among the trees. A detailed assessment of the location of surviving plants was made and it appeared that there was a need for more windbreak protection for *macrocarpa*, though Beatty (see below) is of the opinion that trees may have been planted too deeply. Approximately 220 additional trees were replanted in spring 1994/95, and of these 80% were alive by the following autumn (1995). Further severe weather - heavy snow and cold have affected these trees similarly. The site was assessed in detail by the UKFIT Forestry Consultant, Malcolm Beatty, in January 1996 and he concluded that:-

1. On examination, many dead trees had a strip of live bark on the north side. Generally the plants used had root systems out of proportion to the stem size and foliage carried. The replacement plants had the same characteristics, and had consequently ben planted very deep in an effort to give the plant stability. When I visited the site there had been a period of very wet weather, the planting holes were very wet, and if these conditions persists I expect the trees to die or thrive only slowly due to waterlogging. To reduce the problem I replanted some trees and cut the tops off to improve the root/shoot ration.

2. There was a suggestion that initial survival was better on the dry ground than on the peaty area .

3. I am satisfied that the primary cause of death was the unusual winter conditions. However, the poor match of planting stock to the site conditions coupled with deep planting probable contributed. In my opinion trees could grow on the site. There would be merit in comparing the performance of trees with reduced tops and transplanted to a more appropriate planting depth, and undisturbed plants. The wetter ground may be more appropriate to willows or poplars, depending upon pH.

4. Use of the post hole borer to excavate planting holes is a commendable idea with further potential. Care is required in replacing soil so that top soil and organic matter is not buried; that a large diameter borer is used so that a good volume of soil is disturbed; that the mineral soil at the side of the hole does not become polished so that the hole becomes a sump; and that trees are planted at the right depth.

From discussions with Mr Beatty, Rodney Lee and some of the interested persons at Port Howard, it is worth persevering and replanting the site - incorporating the suggestions on improved planting techniques and trying a range of species such as those produced in Punta Arenas, Chile. Mr Beatty also concludes that there is good opportunity for further tree planting around Port Howard for landscape reasons; the steep, sheltered valley sides would be ideal.

The site is a good, high profile location and successful planting would serve as a good advertisement for tree planting in the Falkland Islands and would reflect the Trust's contribution.

g. Summary

The UKFIT programme of research has been based on properly replicated experimental design and detailed documentation and measurement of trees so that factors contributing to success and failure can be clearly seen and recommendations can be soundly supported. Within the limited resources available, the programme has concentrated on addressing issues of tree planting, nutrition and species selection.

The programme has demonstrated the value of shelter in improving pasture growth and has concluded that trees can be satisfactorily established provided that detailed attention is paid to planting technique, site selection and tree nutrition. Growth rates in the early years of a plantation, although slow, are satisfactory and sound healthy tress can be established. The importance of nutrition has been highlighted and promising results have been obtained by foliar feeding with kelp extract. Lodgepole pine is a suitable conifer for shelter planting and species such as eucalyptus and willow may be of ornamental value. *Cupressus macrocarpa* which has been traditionally associated with the Falklands can play an important role with the use of more promising strains recommended. Trials have shown that Southern Beeches, indigenous to southern Chile, can grow in the Falkland Islands and should be considered. Within the Trust's programme, links have been established with the University of Magallanes in S. Chile with a view to sourcing a supply of a range of species and strains.

A project to establish a small demonstration woodland, showed initial success but was decimated by severe weather. The sites should be relocated and used to promote the Trust's programmes.

In conclusion, the UKFIT programme has stimulated great interest in trees in the Falkland Islands, has shown that trees can be grown and do have a future role within an expanded rural economy. The importance of deciding on the next stage in the programme, necessitated the views and opinions of a consultant forester.

CHAPTER 4 - RECOMMENDATIONS OF A FORESTRY CONSULTANT ON THE UKFIT PROGRAMME

Mr Malcolm Beatty, a qualified forester from Forest Service, The Department of Agriculture for N Ireland visited the Falkland Islands in January and February 1996 to comment on the UKFIT trials, have discussions with Government officials and others and to recommend the way ahead for the tree programme.

Experiments at Fiztroy and Stanley

Fitzroy

1. The Fitzroy experiment was visited on 24 January.

2. The site is described as "hard camp": in forestry terms this would be a good site, mainly dry. The entire site had been ploughed with a Cuthbertson double mouldboard plough many years prior to setting out the experiment. The vegetation within the experimental area was short, and did not appear to be competing with the trees. The Lodgepole pines were straight, provenance unknown but possibly north coastal British Columbia (see Plate 1).

3. The Sitka spruce were almost all grazed flat, forming a dense cushion especially in pit planted positions. Hare damage is suspected. Some dead spruce were found. When the plants were examined bark damage was evident at and up to 50 mm below ground level. The damage was consistent with feeding damage to the bark, leaving woody tissue undamaged (see Plate 2). Some small white grubs with a brown head were discovered in the vicinity, and identified by Mr A Kerr as a weevil, *Malvinius compressiventris*. The damage was similar to weevil damage in the UK, and is a likely cause of death in young plants. Some pines had been damaged within the last year by large mammals (cattle or horses) tearing branches off. Possibly this happened during snow.

Plate 1. 6 year old Lodgepole pine trees at Fitzroy UKFIT trial site. (Some browsing damage has occurred) Photo. M. Beatty.

Plate 2. Tracks in bark typical of weevil damage, Fitzroy site. Photo. M. Beatty.

4. The treatment plots are too small for the fertiliser treatments to have any further significance, and due to the restricted space available for the trial, the unsheltered plots benefit from the shelter given to "sheltered plots".

5. For the future, this experiment should be re-fenced against hares and made secure against large grazing stock. I expect that the Sitka spruce plants will then reappear, and at that stage would benefit from pruning to a single stem, except on the outside edge. If there is doubt about the effect of hares on this experiment then only half should be fenced.

6. Given the small plot size the phosphate effect should be re-examined as part of a large scale planting trial.

<u>Stanley</u>

1. The Stanley experiment was visited on Friday 2 February. It is located on north facing, sloping peaty ground to the west of the market garden. Immediately below the experiment is a potato field. This site had also been ploughed prior to planting. The Lodgepole pine are performing better than the spruce at this stage. The upper foliage of the spruce appears bronzed, but the underside is the normal blue. The trees are wide spreading but short. Needles are perhaps a little short. I have no explanation why the spruce are not doing better in relation to the pines (see Plate 3). In discussion, Mr Miller said that he does encounter both magnesium and boron deficiencies in the market garden. I suspected frost damage but if this was so there was no evidence on the potato crop.

2. Samples of foliage should be taken for analysis of N, P, K, Mg and B.

Plate 3. Sitka Spruce, Stanley UKFIT site. Trees possibly showing some nutritional problems. Photo M. Beatty.

Plate 4. Healthy, sheltered Lodgepole pine plants, Dunnose Head. Photo M. Beatty.

UKFIT Action Points

1. Re-fence Fitzroy experiment.

2. Collect foliage samples at Fitzroy and Stanley for examination of major nutrients and some minor ones such as B and Mg. A protocol should be provided so that the analysis can be carried out in Stanley which is very well equipped.

3. Maintain and extend Port Howard planting.

4. Advise HMG Falklands of the necessary steps to secure rigorous testing of shelterbelts. UKFIT could offer to assist HMG in evaluating tenders or work in progress.

CHAPTER 5 - A FORWARD STRATEGY

(a) Forestry consultant's recommendations

Mr Beatty's report has outlined the following prospects for tree planting in the Falkland Islands:-

1. At this stage the main justification for a tree planting programme is the likely benefit to agriculture resulting from shelter. These benefits will be:

   a) reduced losses at lambing;
   b) reduced losses at shearing;
   c) improved pasture to the north of shelter.

   If shelter could be provided economically and reliably there would be significant opportunity to intensify agriculture, in contrast to the present extensive system. There are important obstacles and considerable speculative investment will be required. However, the scale of possible benefits is likely to justify the expense of initial work.

2. Tree planting, and forestry even more so, is capital expensive and there are long intervals between investment and benefits appearing. The skills required are different to those available within the farming or nursery industries. Before encouraging farmers to participate in tree planting on a scale which would make significant differences to their business (and which would be expensive) large scale trials should be laid out. The trials should systematically examine the options for establishing trees in the Falklands, using the best practice solutions from the UK or other regions which have successfully created new forests. However, the possible solutions should also be applied to woody species found in South America about the same latitude and from similar growing condition as in the Falklands themselves. The purpose of such a trial would be to:

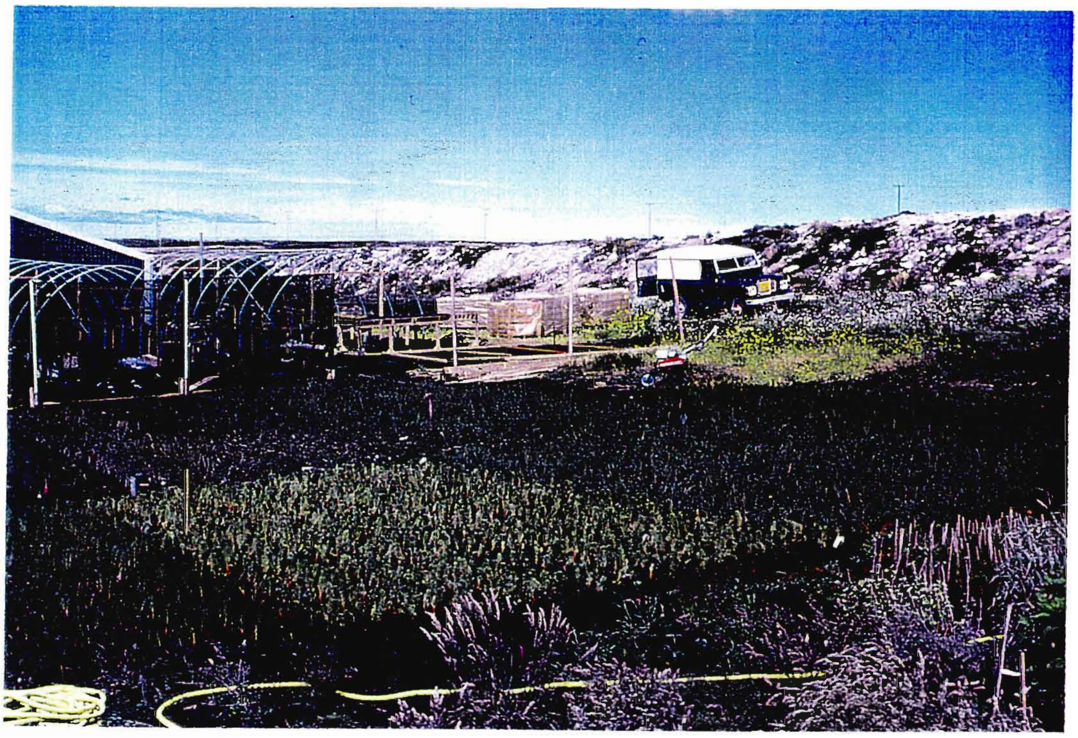


Plate 5. Tree nursery, Stanley Growers Ltd, Stanley. Photo. J. McAdam.

Plate 6. The plantation at Hill Cove, West Falkland. Photo. J..McAdam.

i) confirm the extent to which experience elsewhere can be applied in the Falklands;

ii) gain practical experience in large scale tree plating within the islands at a scale needed to make a difference to farming results;

iii) establish realistic ranges of costs and benefits to help decide if further investment is worthwhile.

3. In practical terms the solutions are likely to involve the following:

cultivation or subsoiling of thin peat over mineral soil;
protection of young trees against weevils; hares and rabbits; sheep, cattle and horses;
the use of small tress 200-300 mm tall with well developed root systems planted in a locally sheltered position;
adequate nutrition found after applying a range of nutrients;
species and provenance trials.

4. The design of trials must be statistically sound, bearing in mind the likely interaction between plots in terms of shelter and nutrition; the use of planting stock containing a high degree of natural variation; and the necessity to ensure that the trials continue to give reliable indications over a very long time. These considerations indicate that treatment plots and experimental areas will be large, and almost certainly outside the scope of the UKFIT working on an *ad hoc* bases from the UK. For example, each plot should be 30 m square. In the case of a straight forward experiment of 3 factors at 3 levels, laid out along a shelter-belt, each replicate will occupy 300 x 30 m. If grazing responses are also to be addressed then each replicate will occupy a space of 300 x 300 m, or 9 hectares. Normally there are at least 4 replicates, requiring measurement of 900 tress and a total area of at least 40 ha.

5. Some saving of time and effort can come from anticipating good practice in terms of establishment techniques and applying a probable excess of nutrition to species and

provenance trials. However, it will be necessary to test ground preparation and nutrition investigations on a narrow range of species and provenances, including mixtures of these.

6. The range of trials is likely to include:

Species Sitka spruce (Alaskan, QCI, Vancouver Island provenances);
Lodgepole pine (Alakan, Skeena River, Peuget Sound, plus 2 interior provenances from BC);
Corsican pine, var maritima;
Pinus radiata;
Pinus maritima;
Cupressus macrocarpa
Nothofagus betuloides, 3 provenances;
N. antarctica, 3 provenances;
Betula pubescens, 3 provenances;
Betula pendula, 3 provenances.

Ground Preparation direct planting, cultivation (mounding, post hole boring, combinations of ploughing and tining). Tining (subsoiling) should be tried alone at planting spacing and also at planting spacing with cross tining at planting spacing). These treatments should be split for weevil control.

Nutrition The major nutrients (N, P and K) are worth investigating. Some preparatory work on a literature review of the forest nutrient status of soils derived from similar parent material elsewhere may be worthwhile, as well as drawing upon agricultural studies in the Falklands. In the context of establishing farm shelter-belts and broad-leaved planting stock some liming studies may also be worthwhile. A good return on investment would be expected from study of fungal associations and trees in the Falklands.

(b) <u>The Gurr report</u>

In a report for Executive Council on the discussion of the "Future of Falkland Landholdings Ltd" (Nov 1995) the Chief Executive of the Falkland Islands Government has actively encouraged the development of forestry. He rightly states that the case has been proven that trees can be grown (albeit on an experimental basis) and further work must be done on scale, location, species and management regime.

The comments made in this report, particularly those by the UKFIT Forestry Consultant satisfactorily addresses some of these issues and provide an informed comment on the way ahead for the development of a role for trees in the Falkland Islands.

The consultant's recommendations largely support the view that trees can be grown in the Falkland Islands and that the potential is largely in the area of shelter-belts and farm woodlands. These can be grown and developed to provide the infrastructure for a diversified rural economy which would be socio-economically and environmentally sustainable. The consultant does not feel that the information is yet available or the conditions suitable for the large-scale development of a commercial forest industry.

From Mr Beatty's discussion with Mr Gurr.

"It was quite clear that Mr Gurr fully understood that significant trials on tree plating would be necessary before any large scale scheme could take place. His determination to attempt sensible development was encouraging".

"I advised him of the various papers and reports written about tree plating in the Falklands. He was particularly struck by the idea that the ecology of soils and plants in the Falklands might be at an arrested rather than at a climax stage of development. [There is certainly good evidence that trees can grow and reproduce in this climate; however, initial growth will be slow, followed by a period of more rapid growth as trees modify the site. This would occur, for example, as soil microflora and microfauna colonise tree growing areas and consequently the efficiency of nutrient cycling is improved].

The consultant's report supports the approach taken by the Trust, ie, that the enhancement of soil fertility is the basis to all the developments in agriculture and rural industry. This will be a slow process in the Falkland Islands but the establishment of trees will greatly speed up the natural process of soil development.

The Trust's programme along with the consultants recommendations provide the basis for a future research and development programme to carry forward the tree planting initiative.

The report on the Future of Falkland Landholdings refers largely to the land on Lafonia and in the SE of the Falklands generally. This land area has a relatively uniform and undulating topography and the report addresses the issue of diversifying from the traditional income mainstay of sheep farming. Such diversification might include an expansion of the use of beef cattle (particularly apt in view of public health concerns over intensively reared beef), horticulture, cereal production to provide livestock feed all integrated with tourism and recreational use of an improved access countryside. Trees, by enhancing soil quality, providing shelter and producing an industrial product for local use are essential prerequisites to this view of an expanded local economy. The importance of retaining the 'green clean' image of the Falkland Islands would be very important in this scenario and the maintenance of an environmentally sustainable forest and agricultural industry must be stressed. In this context the consultant had hinted at the potential role for locally produced materials such as kelp fertiliser.

The consultant has outlined the details of trials which need to be planted on Lafonia to carry forward his suggestions and meet the requirements of the FLH report.

(i) Considerable land area is required and ideally trials should be restricted to a few sites so that adequate supervision is obtained. The obvious candidate is FLH land in Lafonia. My opinion is that the precise location in Lafonia is not critical, apart from the need to monitor grazing responses adequately. If, at some future date, the shelter-belt trials indicated that larger scale planting was desirable, then the technology for establishment is the same. [It would make sound practical sense to incorporate such trials into the future planned location of the National Stock Flock so that, (a) The stock could benefit from the shelter and pasture enhancement, (b) The site would be directly under Government control].

(ii) A major issue is the protection of the investment in tress against damage or loss due to insects, animals and fire. The latter is potentially catastrophic and would certainly influence the composition and structure of planting to minimise the fuel load on the ground and flammability of the woodlands. At the planning stage considerable thought needs to be given to mechanisms of maintaining low levels of flammable vegetation outside the plantings, access to water and labour for fire fighting inside plantations and ensuring that experiments are sufficiency robust to withstand the loss of a proportion of plots or replicates. This will required establishment of surplus replicates initially.

(iii) I consider that at this stage it will be essential to use pesticides during planting operations and possible for a few growing seasons thereafter, until the stem of young trees is sufficiently thick to tolerate weevil attacks. The quantities involved are not large on a per hectare basis but care must be used in handling the chemicals and disposing of containers. The people applying pesticides must be well trained, supported and equipped for their own health and welfare, to avoid damage to plants and to avoid environmental damage. Later, reliable biological control methods may become available, but I saw such frequent evidence of the widespread nature of this pest that I do not consider that suitable controls exist at present.

(iv) Forestry expertise at graduate level is essential, and desirable at Chartered status, supported by adequate assistance and skilled labour.

Options are:

(a) to appoint a forestry graduate with experience in research, afforestation, good communication skills and the ability to train support staff; or

(b) invite research proposals and negotiate a management fee with a UK based (or similar) institution. FIG should agree to provide agreed infrastructure and meet programme costs (eg accommodation, travel, execution of option in the Falklands which are difficult to control from the UK and where better value for money will probably result from local sourcing). This option appears to be more of a partnership with both parties to the contract having an incentive to achieve fruition. The likely bidders are:

Forestry Commission;
UK universities (Aberdeen, Edinburgh, Oxford, Bangor)
Coillte Teoranta, Dublin.

(v) DANI does not currently have the resources to contribute to undertaking Forestry research in the Falklands, although there would be good sense in DANI participating in the tree planting trials on the agronomy side. There would therefore be merit in the forestry bidder being prepared to work with Dr McAdam.

(vi) The institutional option may appear more expensive than recruiting a direct employee, but taking the full costs and results of the project into account may not be. It would significantly reduce the risk of the project failing through lack of experience or specialised advice. As an initial step the above institutions should be invited to submit proposals based upon available literature and this report. The most promising should be invited to visit the Islands before submitting a tender, at their expense if there is sufficient interest.

(Beatty, M.H., 1996)

The whole issue of the cost of this programme to FIG in terms of resourcing materials, staff to operate the programme on the ground and constancy advice is a complex issue and will require an initial response from FIG before it can be progressed. As the consultant suggests, UKFIT might be involved at this stage in helping draw up the specification for tendering and costing the option for FIG.

(c) The UKFIT programme

In his report the consultant states; "There was clear support for the idea of tree growing from farmers and others at a scale and in locations appropriate to the Islands. I have no doubt this was due to the work of UKFIT in identifying the role which trees could play and in perservering with the various trials which must have been difficult to manage at such a distance".

He goes on to add; "However, the scale of work which is now envisaged under a tree planting initiative is too great for UKFIT to conduct under the present arrangements. It is more appropriate for FIG to fund directly, albeit it may which to use the expertise within UKFIT to act in an advisory or part supervisory role to assess the progress of trial periodically". (Beatty, 1996).

The future role of UKFIT in the tree programme might be seen as:-

1. **Act in an advisory capacity and be represented on a steering group for the Falkland Islands Government tree development programme.**

2. **Act as a costing and tendering agent for the next stage of the FIG tree programme.**

3. To continue to use the Dulverton site as an area to plant a range of tree species and which would remain as tangible evidence of the Trust's contribution to the tree initiative.

4. Developing the links with outside bodies to source and arrange the import of materials which would aid and enhance the development of a local forest industry.

To expand on these:

1. Throughout his report, Beatty also indicated some areas of research which require to be carried out as well as the main body of the trial programme. Most of these need to be considered to fall within the remit of the Government Forestry Programme with the UKFIT having an advisory role and supervisory role. The cost of provision of this advice and supervision should be borne by FIG. Hence, the overall position is that the situation be advanced by commencing an imaginative and ambitious programme of tree development under FIG through the appointment of a Forest Field Officer directed within a programme advised by a person or body with suitable expertise and managed by a small, appropriate steering group. It is in this latter context that the UKFIT can perform a valuable role.

2. As stated in the previous section (5b) of the report, the issue of costing the programme and deciding on how it might be managed in terms of personnel and direction might be carried out by UKFIT in conjunction with FIG. UKFIT has built up an expertise within its consultants (McAdam, Stickland, Beatty) of costing experimental programmes and identifying sources of outside advice and expertise. It is proposed that FIG might use this expertise and the contacts which UKFIT Consultants and Trustees have to involve UKFIT in the next stage of the programme. Before this can proceed a positive response to the

proposals summarised and outlined in this and the consultant's report must be received.

3. The Consultant (Mr Beatty) is of the opinion that the Dulverton site at Port Howard is a good one (Section 3f) and that a combination of planting technique and poor weather has resulted in the failure of trees to establish. However, the site should be perservered with and be used as a demonstration ground for tree species, planting technique and perhaps to illustrate some of the principles of soil enrichment and sustainability referred to earlier. Hence, the site could have an educational value as well as performing an adjunct to the mainstream government programme.

While providing a valuable input to the FIG programme as detailed above, it is considered advisable that the Trust maintains an identity within its programme. Such an identity and permanent reminder of the role which the Trust has played in stimulating the programme might be achieved through the retention and use of the Dulverton site as detailed above.

4. The Trust is in a unique position to use its expertise and contacts to identify, promote projects and arrange the import of materials which would aid and enhance the ongoing government tree programme in the Islands. One example of this is the initiative in contacting the Institute of Patagonia in Punta Arenas, Chile and arranging for an initial purchase of trees produced by the Institute's programme. Other examples might include the extenisification of sources of natural rock phosphate and other fertilisers. It is proposed that the Trust should continue in this role with some funding assisted by FIDC recognising the importance to the local industry which these contracts and initiatives can bring.

It is clear that although the overall thrust of this report is that the tree programme must now expand to a scale beyond that which UKFIT could sustain and is rightly the responsibility of FIG, there is a very valuable

role which UKFIT can play. This role, if advanced along the lines of the 4 points above would recognise the background role which the Trust has played to date and would greatly contribute to the advancement of tree plating and the establishment of a forest industry in the Falkland Islands. In this role the Trust would maintain its identity and overall *modus operandi* of advancing projects and ideas complementary to but distinct from normal Government sources.