UNITED KINGDOM FALKLAND ISLAND TRUST

SHACKLETON SCHOLARSHIP FUND

Evaluation of the potential of the Genus *Salix* for shelterbelts in the Falkland Islands

Port Howard

Malcolm Dawson
N.I.H.P.B.S.
Loughgall
Co. Armagh
BT61 8JB

e-mail malcolm.dawson@dani.gov.uk

WILLOW

Taxonomy:

The botanical family *Salicaceae* is composed of two genera Populus (poplar) and *Salix* (willow), both contain largely northern temperate species with *Populus* more prevalent in the warmer latitudes and *Salix* in the cooler and wetter areas. Both genera have common properties, which distinguish them from other woody species:

- Generally propagation is vegetative i.e. from cuttings rather than seed because they root easily producing adventitious roots from pre-formed initials within the bark.

- Juvenile growth can be extremely rapid and sustained over a number of cutting cycles.

- They coppice well i.e. they regenerate easily after harvest from dormant buds at or below ground level.

Coppice regrowth 6 weeks from harvest

- They are dioecious i.e. the male and female flowers arranged as catkins are carried on separate plants.

Salix is the bigger of the two genera containing over 300 species. These occur from the Arctic Circle to latitude 30°, and further south. Although predominantly a northern hemisphere genus there are individual *Salix* species native in the

of which is *Salix humboltiana* found in Argentina.

Willows have many local names, Sallys or Sallows, Withys and Osiers, however, the botanical name *Salix* derives from two Gaelic words 'Sal' meaning near and 'Lis' meaning water, indicating the adaption of the genus to these conditions. However, although this is true, their roots containing specially adapted aerenchyina cells allowing them to withstand periods of flooding, they do not thrive in areas of standing or stagnant water.

Willows generally have a very long history with ample fossil evidence placing them on earth long before man during the cretaceous period 70-135 million years ago. There is also pollen evidence from pre-glacial times (10,000 years ago) to indicate that willows were native to the Falkland Islands. However, there are none recorded as native today, though introduced willows, predominately *S. viminalis* are present in many gardens in Stanley and the outlying settlements.

The three hundred species contained with the *Salix* genus are divided into three groups.

- Salix: typically upright large trees, up to 30 m, e.g. *S. alba, S. fragilis, S. pentandra, S. triandra, S. matsudana.* Generally they prefer fertile river valley sites and are often seen along watercourses, they are deeply rooted.

- Caprisalix: bush or small tree willows, 3-18 m, e.g. *S. viminalis, S. purpurea, S. caprea, S. cinerea, S. alaxensis.* Often suited to adverse and infertile soils. They have extensive but often shallow root systems.

- Chamaetia: prostrate creeping shrubs rarely above 0.5 m, slow growing but adapted to extremely exposed and nutritionally poor sites e.g. *S. repens*

This diversity in form and distribution in the Northern Hemisphere provides the basis for exploiting a wide range of soils and environmental conditions. These range from *S. alaxensis* found on glacial till in the arctic and often exposed areas of N. America to *S. sitchensis* a pioneer species growing in similar conditions but with a geographical distribution as far south as California. *S. alba* is more adapted to the fertile and sheltered river valleys of central Europe, whilst *S. purpurea* (Europe and Russia) is very hardy, drought resistant and salt tolerant. *S. daphnoides* (Scandinavia) will also withstand dry conditions and is recorded as a sand dune pioneer species. *S. burjatica* (Russia and Siberia), *S. aurita* (N. Europe) and *S. pentandra,* are tolerant of acid conditions and *S. scouleriana* (Alaska – New Mexico) is an extremely hardy species found in wet disturbed areas. *S. matsudana* (N. China) will tolerate dry conditions and is used for erosion control in New Zealand. *S. cinerea* (UK and Europe) is extremely hardy and tolerant of poor soil conditions. These properties together with others and the ability of species to hybridise freely, at least within each of the three sub-genera gives an almost unrivalled opportunity within one botanical family to exploit an extremely wide range of soil and climatic conditions.

Salix burjatica

National Collection:

The origins of the National willow collection, at the Institute of Arable Crops Research, Long Ashton in Southwest England, were to preserve the disappearing basket willow varieties. This remit has expanded widely from that initial objective in the 1920's till today, the collection contains over 100 of the 300 species worldwide and in excess of 1000 hybrids and varieties. Each of these individual accessions to the collection is maintained as a small plot of nine individual stools, which are cut back annually to maintain vigorous juvenile growth suitable for the production of cuttings.

It was from this extensive collection of *Salix* that, with the input of the curator. Mr R Parfitt, selection of the material to be tested in the Falkland Islands was made.

Selection was made on the basis of:-

- Likely ability of the species/hybrid to tolerate acid peaty soils with low nutritional status. This is almost exclusively the conditions found in the Falkland Islands with depths ranging from a few centimetres to several metres and varying degrees of mineralisation depending on the degree to which it had been worked.
- Wind resistance: The exposure to constant wind (mean annual hourly wind speed 8.5m sec^{-1}) together with the poor soil conditions are likely to be the major limiting growth factors.

- Dry climate: With average rainfall ranging from 400-500mm drought resistance will be an important property of any successful species. However, soils are generally very moisture retentive and whilst the surface may well be very dry there is access to moisture at lower levels. Rainfall distribution is also important

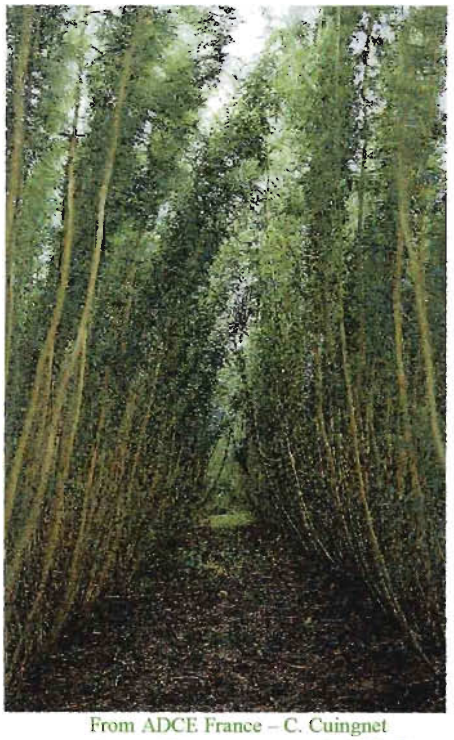
and the highest rainfall is recorded in the summer months (November – February) corresponding to the period of maximum growth of the willow.

Plot size (nine stools) in the National Collection and the practicalities of transporting larger number of cuttings to the Falkland Islands restricted numbers of cuttings to 60 per species. In all forty-five species were selected plus an additional seventeen of amenity value only. These amenity species were restricted to 25 cuttings each, as it was not intended that they should be included in the overall evaluation.

Icelandic Clones:

Contact was made via Dr Alan Lowe (Falkland Islands Tree Advisory Group) with Thorarinn Benedikz of the Icelandic Forest Service and access to a range of *Salix* species and varieties obtained. These were collected in Alaska and have shown promise in exposed sites in Iceland, though it seems likely that the 'exposed sites' in Iceland are in reality not as exposed as some areas in the Falkland Islands. Nevertheless, ten selections were made from six species. The selection parameter used in this case was the proximity of the collection site to coastal areas. It was deemed that coastal selections would be more likely to succeed, and specifically the Kenai and Alaskan peninsulas where rainfall is also lower. The species included in the evaluation were *S. alaxensis, S. hookeriana, S. barclayii, S. phylicifolia* and *S. scouleriana.*

Recognising the fact that *Salix* is an 'exotic' species in the Island's care was taken in the selection of the species/varieties to limit their possibility of escape. Consequently, only male types were included. In the case of the very limited number of female types included they were known to be sterile.



From ADCE France – C. Cuingnet

Energy coppice – Two year old *Salix viminalis*

LISTING OF WILLOWS SELECTION

SPECIES	HYBRID NAME	CLONE NAME	COMMON NAME
Type *S. alaxensis* Small shrub up to 6-8m Arctic regions of N. America			
1. *S. alaxensis*		A493	Dangerous River
2. *S. alaxensis*		A518	Sheridan Glacier
3. *S. alaxensis*		A557	Sheridan River
4. *S. alaxensis*		A664	Haines Lynn Canal
Type *S. alba* Vigorous tree 25-30m Fertile valleys beside watercourses – Europe.			
5. *S. alba*		Liempde	White
6. *S. alba*		Vires	White
7. *S. alba*		Belders	White
8. *S. alba*		Rosewarne	White
Type *S. barclayii* Small shrub up to 3m N.W. United States, Washington – Alaska			
9. *S. barclayii*		A526	McKinley Flats
Type *S. bebbiana* Shrub up to 9m N. America, Russia and Siberia			
10. *S. bebbiana*			Beak
Type *S. burjatica* Small tree to 15m – tolerates poor acidic soils – Russia, Siberia			
11. *S. burjatica*		Pennala E789	
Type *S. caprea* Small spreading tree to 6m tolerates dry conditions – Europe and C. Asia			
12. *S. caprea*		Sutton	Goat Willow Great Sallow
13. *S. caprea* x *S. cinerea* x *S. viminalis*	*S. x calodendron*		
14. *S. caprea* x *S. cinerea* x *S. viminalis*	*S. x dasyclados*		
15. *S. caprea* x *S. daphnoides*	*S x erdingeri*		
Type *S. cinerea* Extremely hardy tolerant of poor soils and salt spray			
16. *S. cinerea olefolia*		Forton Heath	Rusty Sallow

SPECIES	HYBRID NAME	CLONE NAME	COMMON NAME
17. *S. cinerea x S. phylicifolia*	*S x laurina*	Aglaia	
18. *S. cinerea x S. purpurea*	*S. x pontederana*		
19. *S. cinerea x S. viminalis x S. aurita*	*S. x hirtei*	Delamere	
20. *S. cinerea x S. viminalis x S. aurita*	*S. x hirtei*	Rosewarne White	
21. *S. cinerea x S. viminalis x S. cinerea*		Llewellyn	
22. *S. cinerea x S. viminalis x S. triandra*		Othery Moor	
Type *S. daphnoides* Erect tree to 18m – Drought resistant sand dune pioneer – Poland, Russia			
23. *S. daphnoides*		Stewartstown	Violet
24. *S. daphnoides*		Fastigiate	Violet
25. *S. daphnoides acutifolia*		(x caprea) Latifolia	Violet
Type *S. discolor* Small tree to 8m – N. America and Canada			
26. *S. discolor*			American Pussywillow
Type *S. exigua* Shrub to 4m – produces root suckers – moist sanday soils New Mexico to British Colombia			
27. *S. exigua*			Cyote
Type *S. fragilis* Robust tree 15m – fertile soils on river banks – Europe and Middle East			
28. *S. fragilis*			Crack Willow
Type *S. glaucophylloides* Shrub to 5m – sandy shores calcareous slopes and swamps – Newfoundland & Great Lakes			
29. *S. glaucophylloides*		Glenmark NZ 1199	
Type *S. hookeriana* – variable small shrub to tree 10m – coastal Alaska – California tolerant exposed coastal sites.			
30. *S. hookeriana*		A497	Yakutat Cordova Flats
31. *S. hookeriana*		S4	Cordova Flats

SPECIES	HYBRID NAME	CLONE NAME	COMMON NAME
Type *S. interior* shrub to 5m . Thicket forming (root suckers) – sand bars – N. America, New Brunswick - Alaska			
32. *S. interior*			Sand Bar
Type *S. lassiandra* vigorous shrub to 18m – alluvial silt – western N. America			
33. *S. lassiandra*			
Type *S. matsudana* Spreading tree to 18m – thrives in dry soils – hybrids with *S. alba* used for windbreaks and soil stabilisation – China/Korea			
34. *S. matsudana x S. alba*		Aokautere NZ 1002	
Type *S. nigricans* Small bush to 3m hardy low altitude on river banks – Europe and Siberia			
35. *S. nigricans alpicola*			Dark leaved willow
36. *S. nigricans x S. phylicifolia*	*S. x tetrapla*	Malham	
Type *S. pentandra* Large shrub is small tree to 18m widely distributed in N. and Central Europe			
37. *S. pentandra*		Dark Fench	Bay leafed willow
Type *S. phylicifolia* Small dense shrub to 3m rarely 6m – N. Europe, Russia, Iceland			
38. *S. phylicifolia*		Malham	Tea Leafed Willow
39. *S. phylicifolia*		Brekkuvidir	
Type *S. purpurea* variable shrub/small tree to 5m – very hardy moist clayey conditions – possibly salt tolerant, fine quality basketry. Throughout Europe, Russia			
40. *S. purpurea*		Helix	Purple, Bitter
41. *S. purpurea*		Goldstones	Purple, Bitter
42. *S. purpurea x S. caprea*	*S. x wimmeriana*		
43. *S. purpurea x S. cinerea x S. viminalis*	*S. x forbyana*	Red Root	
44. *S. purpurea x S. viminalis*	*S. x rubra*	Common green osier	
Type *S. rossica* vigorous shrub to 5m. equates to *S. viminalis serotina* in former USSR			
45. *S. rossica*			
Type *S. scouleriana* very hardy shrub to small tree 10m. N. America, Alaska to New Mexico			
46. *S. scouleriana*		A642	Skagway

SPECIES	HYBRID NAME	CLONE NAME	COMMON NAME
Type *S. sachalinensis* large shrub small tree to 6m – Japan			
47. *S. sachalinensis*		Sekka	Dragon Willow
Type *S. spathii* – large shrub – Caucasus – E. Asia			
48. *S. spaethii*			
Type *S. sitchensis* small shrub occasionally to 3m pioneer species surviving extreme conditions on glacial moraines and Sand bars. Alaska to California			
49. *S. sitchensis*		A524	Alaganick River
50. *S. sitchensis*		110/03	
Type *S. triandra* variable shrub, small tree to 10m prefers fertile soils – Europe – Central Asia – basket species.			
51. *S. triandra*		Houghton's Black	Almond leaved willow
52. *S. triandra x S. viminalis*	*S. x mollissima hippophaefolia*	Trustworthy	
Type *S. viminalis* vigorous shrub to 9m – Russia from tundra to desert – steppe. Original basket species.			
52. *S. viminalis*		H Jones	Goose Green
53. *S. viminalis*		Gigantea	Osier
54. *S. viminalis x S. viminalis*		Svalof. Orm	
55. *S. viminalis x S. caprea*	*S. x sericans*	81091	

ORNAMENTAL WILLOWS SELECTED

S. candida - Ornamental shrub to 3m. Striking white young foliage and branchlets – N. America, Canadian Prairies Yukon and Alaska.

S. chaenomeloides - Large vigorous shrub attractive foliage colourful catkin buds and attractive catkins – Japan, Korea and China.

S. x savensis Trinajstic a *S. alba fragilis x S. caprea* hybrid.

S. appendiculata - Small tree to 6m extremely hardy good show of male catkins – Alps and Appenine mountains.

S. appenina – Strong growing large shrub vigour bright leaf colour and male catkins combine in this desirable willow. Italy – Apennine mountains.

S. alba Chermesina Yelverton – Small attractive tree to 6m with bright orange branchlets – Germany.

S. alba sericea Small tree to 8m. One of the most intensively silver leafed willows which retains its leaves to early winter.

S. x erythroflexuosa Tortuosa – Spectacular contorted small tree to 5m branches copper/orange and spirally twisted – Argentina – *S. chysocoma x S. matsudana* hybrid.

S. sanguinea Fransgeal Road and *S. x sanguinea* Redskins – *(Salix alba vitelina x S. fragilis* hybrids) – Variable sized bush or less frequently small tree, dark red juvenile wood and scarlet catkin bud scales. – United Kingdom.

S. x rubens – Golden willow a hybrid of *S. alba x S. fragilis* erect tree to 20m, attractive yellow/orange branchlets.

S. x rubens Pollard crack and *S. x rubens Lanceolata* – (*Salix alba x S. fragilis* hybrids) again with attractive yellow/orange, red twigs in winter.

S. x basfordiana – One of the best *Salix* trees up to 15m strong orange yellow juvenile bark and pendulous catkins. England.

From Willows The Genus *Salix C. Newsholme*

S. x basfordiana

S. amplexicaulis Bory – Small erect shrub to 3m purple/brown branches very hardy tolerating dry soil – Balkans.

S. x hagensis, a *S. gracilistyla x S. caprea* hybrid – downy brown branchlets with young leaves tinged brown on their margins.

S. irrorata – White bloom on reddish brown juvenile stems. In male catkins anther colour is striking. A N. American species – Colorado – New Mexico and Arizona.

S. melanostachys Kurome – The main attribute of this species is the magnificent display of male catkins which are sooty black with bright red anthers. Japan, Korea and China.

These were distributed widely among the Tree and Shrub Group on the Islands and other interested individuals. Their cultivation was discussed at a Tree and Shrub Group meeting held on 2nd December 1999, and it is expected that those ornamental varieties and species, which establish well will be made available as cuttings to other interested individuals.

CHECK LIST FOR SUCCESSFUL ESTABLISHMENT OF WILLOW COPPICE

This checklist is a summary of the most up-to-date information on the important aspects to be considered during the establishment of willow coppice. It relates generally to conditions in the U.K. but the basic principles remain relevant to the Falkland Islands.

Land Preparation

Mineral soils are preferred because of the difficulty of obtaining good weed control on highly organic soils. A minimum depth of topsoil (A horizon) of 20 cm is necessary to allow for cutting insertion.

- Deep plough in autumn where appropriate following herbage removal using glyphosate.

- Spring cultivation prior to planting to give an equivalent seedbed to that required for cereals.

Cuttings

Should be prepared from one-year-old healthy and vigorous stems either as whole shoots for machine planting or prepared cuttings for hand planting.

- Whether as whole shoots or as prepared cuttings a minimum diameter of 8.0 mm is required to ensure maturity and adequate reserves for establishment.

- When harvested the cutting material should be fully dormant and cold stored immediately after preparation (-2°C) till just before planting. This is particularly important with late-planted crops (late April – May).

- Planted cuttings should have a minimum length of 20cm and viable primary buds.

20 cm hardwood cuttings

- Prior to planting prepared 20cm cuttings should be soaked for 24 hours to prevent desiccation.

Planting

Is carried out in the early spring but if conditions are adverse and cold storage of the planting material is adequate, it can be delayed to end of May.

- Machine planting is normally used either planting prepared cuttings or more usually using whole shoots, which are cut automatically to length before insertion.

- Planting is done in double rows with 1.5m between the double rows and 75cm between individual rows to give a density of approximately 15,000/ha.

- When planting is completed the site should be rolled to consolidate the cuttings and present a surface which

will maximise the effect of residual herbicides.

Post Planting

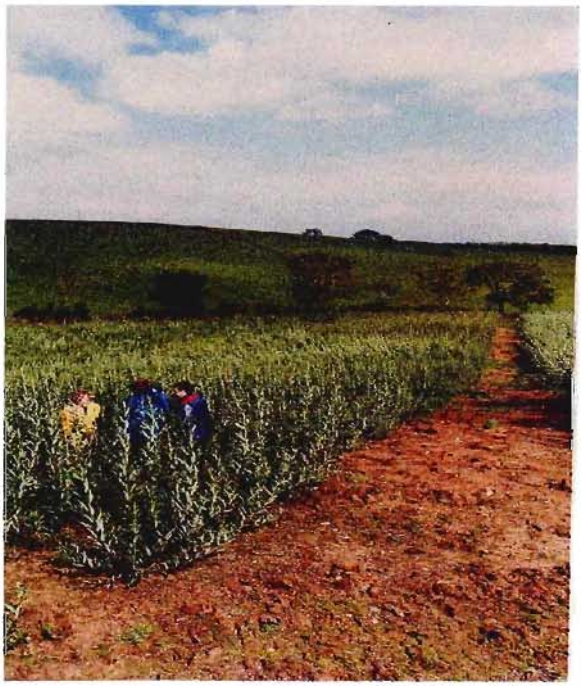
Weed control is the single most important management factor in the successful establishment of short rotation coppice willow.

- After planting the site should be 'sealed' with a residual herbicide e.g. Simazine (4l/ha).

- Individual spot treatment of perennial weeds may be necessary. – Ref. I. Willoughly & D. Clay. Herbicides for farm woodlands and short rotation coppice. Forestry Commission Field Book 14.

Cutting Back

The final act of establishment is the cutting back of the first year's growth in the winter following establishment. This gives a second opportunity to ensure adequate weed control and promote vigorous regrowth the following spring. The material produced at cutback can be used to gap-up plots where there are missing plants.



- Stems should be cut back to between 5-10 cms and the cut should be clean i.e. a flail should not be used.

- Cutback can be followed in early spring with further weed control. Amitrole + Simazine has to be shown to be a successful mix, in mineral soils with adequate spring moisture.

- Where establishment has been good and 2-3 vigorous stems approximately 2.0m tall produced cutback may not be necessary.

Mechanical harvesting using a single row rod harvester

- Harvesting is carried out on a 2-5 year cycle depending on the productivity potential of the site.

Hand harvesting 3 year old willow

SITES SELECTED

Moody Brook

This site is situated on the outskirts of Stanley. It is a fairly dry peat site and it had previously been worked (rotovated). It was reasonably uniform and had been treated with Glyphosate at the end of the previous growing season. Artificial shelter was provided on the north, south and west perimeters using discarded pallets. It is located on the northerly perimeter of a horticultural development including protected crops soft fruit and vegetables being undertaken by Dr B Elsby.

Analytical data.

Ph	4.3
Phosphorus	21mg l^{-1} – index 1 (low)
Potassium	340mg l^{-1} – index 3 adequate
Magnesium	300mg l^{-1} – index 5 adequate

The planted area 40m x 20m approximately was arranged in 57 plots of 20 stools per plot – 4 rows x 5 rows spaced at 0.7 x 0.9m (2.8m x 3.5m). The plots were arranged in four rows of twelve and one row of nine running in an E.W. direction.

A double row of discards using the hybrid *Salix* x *hirtei* Delamere was planted round the site perimeter. Planting took place over the period 22/23 November and 2nd December 1999. Detailed plot layout is given in
Fig. (1).

Local contact Dr Barry Elsby.
Fax 00 500 21206.

Willow site at Moody Brook

Saladero

This is a typical 'green valley' site described as summer moist and winter wet situated on Agriculture Department land. It is topographically sheltered and reasonably level and uniform and by Falkland Island standards it is fertile.

The site had not been cultivated though it had received an application of glyphosate in October. A second application of glyphosate was applied in 18th November in an attempt to control pig vine (*Gunnera magellanica*) which had not been controlled by the initial application. The only other weed evident on the site was arrow-leafed marigold (*Caltha sagittata*).

Analytical data:

pH	4.86
Phosphorous	14 mg l^{-1} index 1 (low)
Potassium	165 mg l^{-1} under 2 adequate
Magnesium	360 mg l^{-1} index 5 adequate

The planted area 40 x 15m is arranged in 46 plots of 20 stools per plot – 4-5 rows spaced at 0.7 x 0.7 m (2.8 m x 3.5 m). Plot numbers 43-46 are multi species/variety plots and the details are recorded in Fig. (2). The plots are arranged in three rows of fourteen and one row of four with a double discard row of *Salix* x *hirtei* Rosewarne White around the perimeter. Planting took place on 24/25 November 1999.

Local contact – John Hobman,
Fax 00 500 42291.

Willow Site Saladero

Port Howard – West Falkland

Again a peat site but because it had been rotovated over a reasonable period of time structure was good. As at the other sites conditions were reasonably damp with only the top 2-5 cms drying out. The site had been rotovated just prior to planting and would have benefited from some consolidation. In the event this was done manually where necessary. Artificial shelter in the form of paraweb had been erected on the site as it was already in use as part of the UK Falkland Islands Trust trial area. No particular herbicide treatment had been given to the area prior to rotovation and there was consequently a potential risk from weed growth – grasses in particular.

Analytical data:

pH	4.48
Phosphorus	16mg l^{-1} index 1 (low)
Potassium	115mg l^{-1} index 2

The planted area approximately 60m x 10 m was arranged in 47 plots of 20 stools per plot except indicated otherwise. Planting density was 20,000 ha^{-1} 0.7 x 0.7m giving a plot size of 2.8 m x 3.5 m. The plots were arranged as one row of seventeen, one row of twenty one and one row of nine as indicated in Fig (3). A double row of discards using the species *Salix viminalis* Gigantea was planted as indicated on the site perimeter. Planting was completed on 30th November 1999.

Local contact Robin.Lee –
rlee@horizon.co.fk

Willow Site Port Howard

Additional Sites

Fitzroy – In addition to those forming the main part of the evaluation trial four 'best guess' species/varieties were selected. These were species of which an extensive knowledge had been built-up of their performance on a wide range of sites and climatic condition and they were deemed to have the best chance of survival on the nutrient deficient peat soils and under conditions of extreme exposure.

Salix x hirtei Rosewarne White
Salix x hirtei Delamere
Salix viminalis Gigantea
Salix x dasyclados

These were in addition to being used as discard rows on the main trial were planted as larger plots (120 stools) on the UK Falkland Island Trust Trial on Fitzroy farm. See Fig (4). This was on a relatively unmineralised peat site which although it had been rotovated some time previously had not consolidated to any extent and was consequently likely to dry out.

UKFIT Site at Fitzroy farm

S. x dasyclados was also planted as a large plot on the farm of Mel Lloyd. In this case the site had been extensively prepared with deep ploughing followed by rotovation.

Cape Pembrook

Two willow species belonging to section of the genus called *Longifoliae* have ability to produce root suckers resulting in the formation of a thicket like growth pattern – *Salix exigua* and *Salix interior*. In addition to their inclusion in the main trial they were planted on eroded areas to evaluate their ability to consolidate and revegetate such sites. Both species were planted on eroded peat and sand sites at Cape Pembrook – Fig (5) and on an eroded clay patch on the grazing trial site SS6 – (Fig 6). Although these are in effect very small plots they are large enough to indicate the potential these two species have in soil conservation and revegetation.

Eroded peat site at Cape Pembrook

Dune Site at Cape Pembrook

Clay patch SS6

FUTURE WORK

Weed Control

This is the single most important management factor in the successful establishment of short rotation willow coppice. The establishment of windbreaks in the Islands has more in common with commercial planting of willow in the form of short rotation coppice as an alternative energy source than with the more traditional single row windbreak system.

In relation to the plots planted at Moody Brook, Saladero and Post Howard it was decided that no residual herbicide application would be made post-planting.

- On these sites there did not appear to be a large residual weed seed problem.
- Being highly organic peaty sites the effectiveness of the normal residual herbicides is questionable.
- In the event of a weed problem the sites are small enough to consider hand control at least till the extent of the problem and the species involved are established.

It is worth reiterating that once weeds have competed significantly with coppice growth for moisture and nutrients the damage has been done and it is difficult to bring the coppice system back to vigorous growth.

Some spot treatment of, in particular grass weeds will probably be necessary on all sites this can best be achieved using Fluazifop-Butyl (Fusilade). After the sites have been cut back in the winter of 2000 the root acting herbicide Amitrole (Weedazole) can be applied prior to bud burst to provide an excellent weed control.

The question of the inclusion of a residual herbicide at this stage can be reconsidered when the extent and nature of the problem is known.

After this stage and until the next harvest it is impractical to consider anything but spot treatment of problem weeds. If the coppice is successful, with effective light exclusion under the canopy – it should provide its own weed control.

Records

At the completion of the first growing season and probably the easiest time to take survival data is at cut back. There is no advantage in taking any more complicated records since, because the various species/varieties root and establish at different rates, the extent of top growth is not a reliable measure of the varieties future productivity or potential. In normal circumstances and under U.K. conditions, survival of 90-95% could be expected. After the completion of the second years growth i.e. the year after cutback more detailed records including dry matter production, growth habit disease susceptibilities etc. can be taken. Dry matter production can be estimated using diameter measurements which can be taken electronically using specially prepared callipers and a computer based yield model — non destructive harvest.

Once data from a number of growing seasons is available selection can be made of those species/varieties, which show satisfactory survival and growth, and the selected individuals can be bulked up for bigger more focused trials. Bulking up would take place on intensively managed nursery sites.

Fertiliser

On normal agricultural soils the addition of fertiliser in the planting years is not considered necessary. Initially the cutting should have an adequate reserve and normal agricultural soils will have sufficient nutrient capital to support at least the first rotation. However, in the nutritionally poor soils of the Islands some thought should be given to fertiliser application after establishment and cut back. In the first instance the recommendations for phosphatic fertiliser given in the new publication – 'Guidelines for shelter belt planting'. In the Falkland Islands (Low A & McAdam J 1999) should be used. Subsequent applications can be determined taking into account species/variety productivity.

POTENTIAL PROBLEMS

Foliar Rust

This is a disease caused by the fungal organism *Melampsora epitea* which produces bright orange pustules on the back of the infected leaf. Varietal response varies but severe infections can lead to premature leaf fall and secondary dieback of infected shoots.

Melampsora epitea

In the UK the adoption of mixed variety plantings has been shown to keep the disease within acceptable limits. On the main evaluation trials the small plots of different varieties will behave in much the same way as a mixture but it should provide initial information on the presence of rust and the relative susceptibilities of the species/varieties. If rust does develop it would be an interesting exercise to establish the pathogen species involved and identify the particular pathotypes present. This would compliment ongoing work within Applied Plant Science Division.

Leaf Beetles

Within commercial plantations of willow in Europe, leaf beetles (*Chrysomelids*) are the only major pest species currently identified as of economic importance. However, unlike most food crops coppice has a high economic threshold of damage i.e. damage is unimportant unless growth is affected. In the UK there are three main *Chrysomelid* species and all have a shiny metallic coloured exterior either brown, blue or green, body length is 5-6 mm.

***Chrysomelid* larvae feeding on willow leaf**

Most damage occurs during mid summer when the emerging beetle larvae feed on the underside of the leaf causing desiccation and leaf fall. It remains to be seen whether either foliar rust or *Chrysomelid* beetles or indeed other pest and disease problems, will present themselves on the trials planted on the Islands but the species/varieties should be carefully monitored to record P & D problems if and as they occur.

UTILISATION

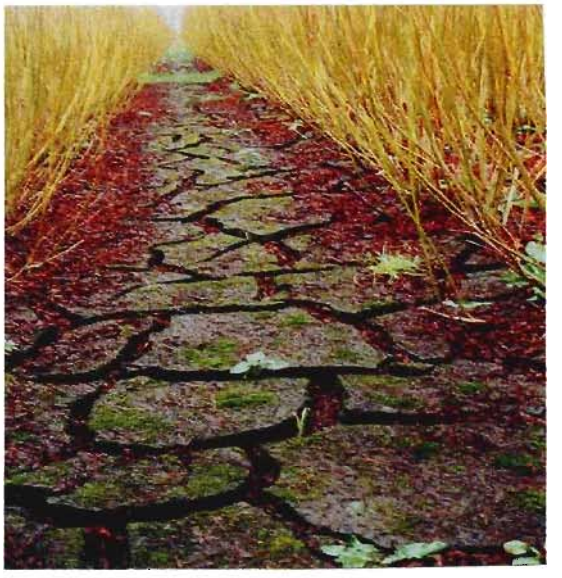
The main objective of introducing *Salix* to the Falkland Islands was to evaluate the potential of a wide range of species/varieties as windbreaks. Either as quick growing windbreaks behind which other more permanent species could establish or as front line windbreak species in themselves. Whilst this was the primary objective willows have many other potential primary and secondary uses – soil conservation, browse for animal feeding bedding for intensive poultry systems, biofiltration for treating a wide range of wastes, as a renewable source of energy for heat and or power production and simply in an amenity context.

Many of these uses have immediate and practical application but two, energy production and bioremediation have particular relevance.

Bioremediation:

In an environment, which remains relatively unspoiled, there is a need to address the questions of effluents/wastes, from whatever source either domestic or industrial. Although the pressure of population numbers is not a problem it is increasingly unacceptable to discharge untreated waste into the environment.

Willow, particularly the bush types which produce extensive shallow root systems, can provide an excellent active bioremediation system removing nutrient elements from wastes. This has two major implications. The waste can provide the nutritional requirement of the crop whilst the crop can actively 'detoxify' the waste removing sensitive elements such as phosphates and nitrates and some heavy metals. This is particularly relevant where, as in the Islands, soils are nutritionally poor. Also, in a climate where rainfall is low, the added water in the waste could prove as valuable as the nutrients in promoting growth of the willow. The bioremediation system would also have the secondary advantage of producing a source of energy, which is both renewable and environmentally sensitive from a greenhouse gas perspective. Coppice grown for energy is carbon dioxide neutral i.e it uses at least as much carbon dioxide in its growth as it produces in its combustion.



***Salix viminalis* being used for bioremediation of canal dredgings in Holland**

Energy Crop:

Where willow windbreaks are considered as primary front line shelter they will be planted as shelterbelts i.e of sufficient width to provide mutual protection. In this case they will require to be managed on continuous basis to ensure that they remain in a juvenile state and as a consequence retain their vigorous growth. This will entail coppicing (cutting back to ground level) on a regular basis. Ideally the windbreak would be divided into two in a linear direction and the two halves harvested sequentially. Thus the shelter element is never lost from the system.

Small (100 kW) combined heat and power unit at Enniskillen College, Co. Fermanagh

In this way the windbreak also produces a secondary energy product in the form of the coppiced wood. Once this is dried, and drying in the open should be effective in the Islands with low rainfall and constant wind, the chipped wood can be used in purpose designed boiler systems as the primary energy source for heating. Wood chip from the harvested coppice wood can also be gasified in a combined heat and power system, however, settlement size would generally be too small to justify the capital investment necessary. As a rule of thumb, one kilogram of dry wood has an energy content of 19-20MJ, this compares with 44.2 $MJkg^{-1}$ for light oil and 32.6 MJ kg^{-1} for coal.

Acknowledgements

In the first instance I am indebted to the United Kingdom Falkland Islands Trust – Shackleton Scholarship Fund for giving me the opportunity to undertake this project. It provided a unique opportunity not only to assess a potentially useful shelter genus for the Islands but to widen the experience with willow generally by assessing a significant collection in a very challenging environment in the Southern Hemisphere.

There were many others whose efforts combined to make; (i) my travelling easy – the staff of Falkland House in London and (ii) my visit successful in terms of establishing willow on the Islands. In this latter context the interest and encouragement from the Agriculture Department staff, in particular Bob Reid and Aidan Kerr, the help of the Rod Parfitt in selecting from the National willows collection and preparing the cuttings and Thorarinn Beneditz of the Icelandic Forest Service for providing material from their programme, are all gratefully acknowledged. Finally, in practical terms, without the help and enthusiasm of Timmy Bonner of the Agriculture Department in Stanley, I could not have achieved what I did in the time available.

SITE: PORT HOWARD - W. FALKLAND
DISCARDS: *Salix viminalis* Gigantea ---------- double row ---------- single row

		S. interior	**18**	*S burjatica* Pennala E789	**1**
		S.bebbiana	**19**	*S.* x *sericans* 81091	**2**
		S x hirtei Rosewarne White	**20**	*S.*x *mollissima hippophaefolia* Trustworthy	**3**
		*S.*x *dasyclados* (9 only)	**21**	*S. glaucophyloides* Glenmark	**4**
		Vacant	**22**	S. *x* calodendron	**5**
		Vacant	**23**	*S. spatheii*	**6**
		S.daphnoides acutifolia	**24**	*S. matsudana* x *alba* Aokautere	*7*
		S. sachalinensis Sekka	**25**	*S.cinerea olefolia* Forton Heath	**8**
		S. x *purpurea* Goldstones	**26**	*S. lassiandra*	**9**
		*S.*x *hirtei* Delamere	**27**	*S. daphnoides* Fastigiate	**10**
		S. sitchensis	**28**	*S. alba* Vires	**11**
		S. exigua	**29**	*S.* x *pontederana*	**12**
S. nigricans Alpicola	**47**	*S. discolor* (9 only)	**30**	*S.* x *forbyana* Red Root	**13**
S. x *tetrapla* Malham	**46**	*S.*x *rubra* Common Green Osier	**31**	*S.* viminalis Gigantea	**14**
S. x *laurina* Aglaia	**45**	*S. caprea* Sutton	**32**	*S.* rossica (9 only)	**15**
S. alba Rosewarne	**44**	*S. fragilis*	**33**	*S.* x *cin* x *vim* x *cin* Llewllyn	**16**
S. triandra Houghtous Black	**43**	*S. viminalis* Orm	**34**	*S.* purpurea Helix	**17**
S. x *wimmeriana*	**42**	*S. phylicifolia* Malham	**35**		
S. alba Liempde	**41**	*S. pentandra* Dark French	**36**		
S. alba Belders	**40**	*S. cin.* x *vim.* x *tri.* Othery Moor	**37**		
*S.*x *erdingeri*	**39**	*S. daphnoides* Stewartstown	**38**		

All plots 4 x 5 stools spaced at 0.7 x 0.7 m
Planted 29/30.11.99

SITE : MOODY BROOK - STANLEY → E

DISCARDS: *S.* x *hirtei* Delamere ---------- **Double Row**

1 *S. cinerea Olefolia* Forton Heath	**2** *S. matsudana x alba* Aokautere	**3** *S. cinerea x vim.* x *tri* Othery Moor	**4** *S. sitchensis*	**5** *S.* x *hirtei* Delamere	**6** *S. daphnoides* Fastigiate	**7** *S. sachalinensis* Sekka	**8** *S. exigua*	**9** *S. fragilis*	**10** *S. lassiandra*	**11** *S. discolor*	*S. in*
13 *S. scouleriana* A642 25	**14** *S. alaxensis* A664 19	**15** *S. alaxensis* A557 8	**16** *S. barclayii* A526 8	**17** *S. alaxensis* A518 11	**18** *S. hookeriana* A497 17A	**19** *S. alaxensis* A493 23	**20** *S. daphnoides* Stewartstown	**21** *S.x Pontederana*	**22** *S.* x *sericans* 81091	**23** *S. spatheii*	*S. be*
25 *S. sitchensis* A524 4	**26** *S. hookeriana* S.4	**27** *S. phylicifolia* Brekkuvidir	**28** *S. viminalis* H. Jones	**29** *S. viminalis* Gigantea	**30** *S.* x *dasyclados*	**31** *S. rossica*	**32** *S. purpurea* Goldstones	**33** *S. alba* Liempde	**34** *S. alba* Belders	**35** *S. Phylicifolia* Malham	*S. vi* O
37 *S.* x *laurina* Algaia	**38** *S. pentandra* Dark French	**39** *S.* x *hirtei* Rosewarne White	**40** *S. triandra* Houghtons Black	**41** *S. discolor*	**42** *S. glauco-phyloides* Glenmark	**43** *S.* x *wimmeriana*	**44** *S.* x *forbyana* Red Root	**45** *S. cin.* x *vim.* x *cin* Llewellyn	**46** *S.* x *mollissima hippophaefolia* Trustworthy	**47** *S. nigricans* Alpicola	*S. pi* H
49 *S.* x *calodendron*	**50** *S.* x *erdingeri*	**51** *S. caprea* Sutton	**52** *S. burjatica* Pennala E789	**53** *S. alba* Rosewarne	**54** *S. alba* Virens	**55** *S.* x *sericans*	**56** *S.* x *rubra* Common Green Osier	**57** *S. daphnoides Acutifolia*			

All plots 4 x 5 stools spaced at 0.7 x 0.7 m - Planted 22/23/11.99 & 2.12.99

SITE SALADERO

Discards S. hirtei Rosewarne White ---------- **double row**

S. alaxensis A493 23 S. scouleriana A642 25 S. alaxensis A518 11 S. sitchensis A524 4	*29* **S. matsudana x alba** Aokautere	**15** **S. daphnoides** Stewartstown	**1** *S. viminalis* Gigantea
S. hookeriana S4 S. barclayii A526 8 S. hookeriana A497 17A S. phylicifolia Brekkv.	**30** *S x wimmeriana*	**16** *S. cin. x vim. x tri.* Otherymoor	**2** *S. rossica*
S. alaxensis A518 11 S. alaxensis A518 11 S. hookeriana A497 17A S. hookeriana A497 17A	**31** *S. nigricans* Alpicola	**17** *S x rubra* Common green Osier	**3** *S. cin x vim* *x cin* Llewllyn
S. alaxensis A664 19 S. alaxensis A557 8	**32** *S. x calodendron*	***18*** *S. exigua*	**4** *S. phylicifolia* Malham
	33 *S. x tetrapla* Malham	**19** *S. sitchensis*	**5** *S. alba* Rosewarne
	34 *S. fragilis*	**20** *S. x erdingeri*	**6** *S. alba* Belders
	35 *S. cinerea* *Olefolia* Forton Heath	**21** *S. caprea* Sutton	**7** *S. x forbyana* Red Root
	36 *S. spatheii*	**22** *S. discolor*	**8** *S. x hirtei* Rosewarne White
	37 *S. sachalinensis* *Sekka*	**23** *S. daphnoides* *Acutifolia*	***9*** *S. purpurea* Goldstones
	38 *S. daphnoides* Fastigate	**24** *S. glaucaphyloides* Glenmark	**10** *S.* x *hirtei* Delamere
	39 *S. interior*	**25** *S. x mollissima* *hippophaefolia* Trustworthy	**11** *S. viminalis* Orm
	40 *S. lassiandra*	**26** *S. triandra* Houghtons Black	**12** *S. x laurina* Aglaia
	41 *S. bebbiana*	**27** *S. burjatica* Pennala	**13** *S. alba* Liempde
	42 *S.* x *pontederana*	**28** *S. alba* Vires	**14** *S. purpurea* Helix

STATEMENT OF ACCOUNT – SHACKLETON SCHOLARSHIP VISIT 15.11.99 – 5.12.99

London – Bristol (Train) Bristol – Reading (Train) Reading - London Heathrow (Bus) Overnight – Bristol	Making selection from National Willows collection (I was already in London for a meeting)	32.00 24.00 7.50 56.00
Cuttings from National Collection		249.10
Belfast – London Heathrow	Connect with flight to MPA	39.45
AVIS Hire Car	To collect cuttings from Bristol and deliver to Brize Norton.	42.00
Petrol	To refill hire car	11.50
D.H.L. Transport	Air freight from Iceland for cuttings.	120.00*
Wilson & Co.	Air freight and handling to MPA.	329.38
Accommodation Stanley (Kay McCallum)	15 days full board	330.00
Accommodation Port Howard Lodge	2 Days Port Howard for two people (M. Dawson and A. Kerr).	180.00**
London Heathrow – Belfast		39.45
Rebooking Fee	Delayed flight from Falklands. Required rebooking of London Belfast flight.	31.00
Return fare to MPA		**1491.38** **992.00** **£ 2483.38**

* estimate - invoice not received – airway bill attached.

** DOA Stanley paid for Air fares to Port Howard (2 x £94), 1 paid for accommodation.