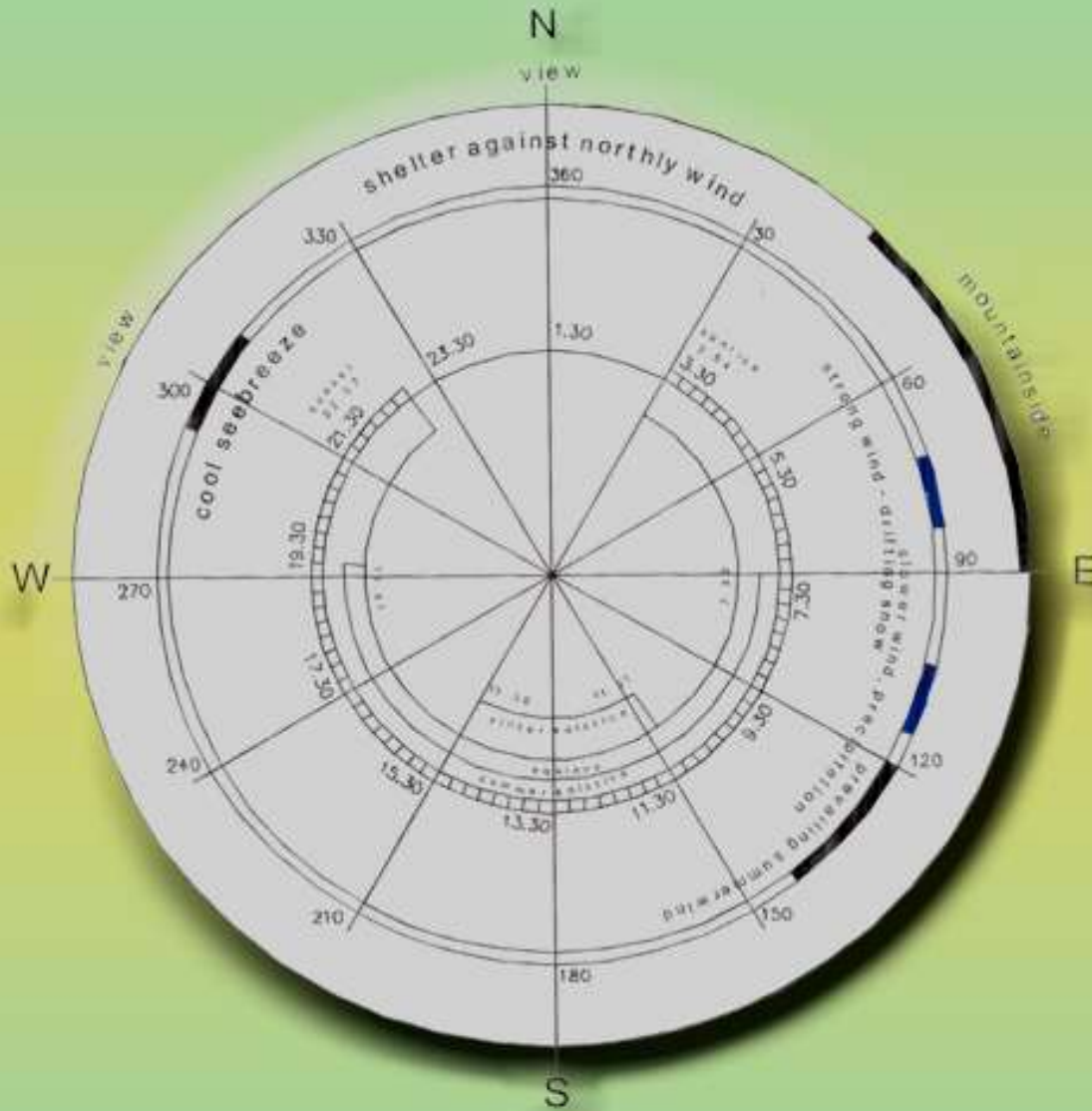


# *Part 3: Weather Effects*





This is an excellent example of a *'livable winter-city'* climate circle used in an environmental survey as the first step in harmonizing urban planning, engineering and architectural design principles to ensure a more livable environment in a proposed new suburb adjacent to Reykjavik

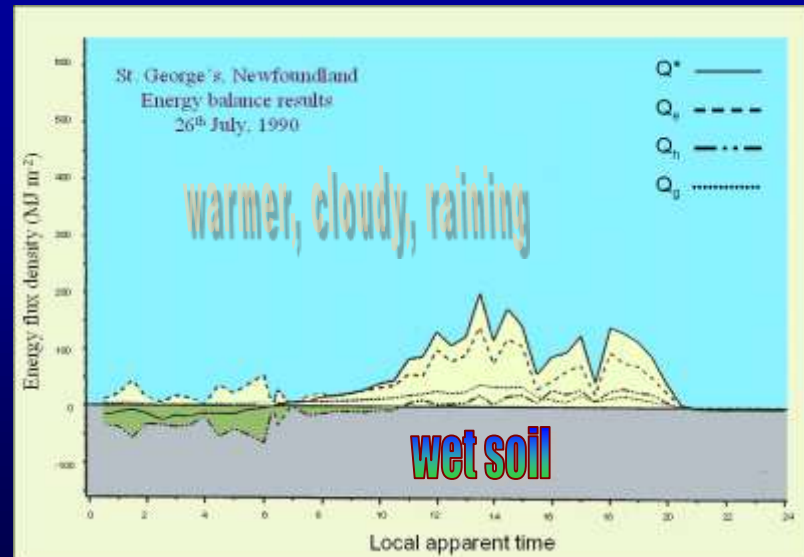
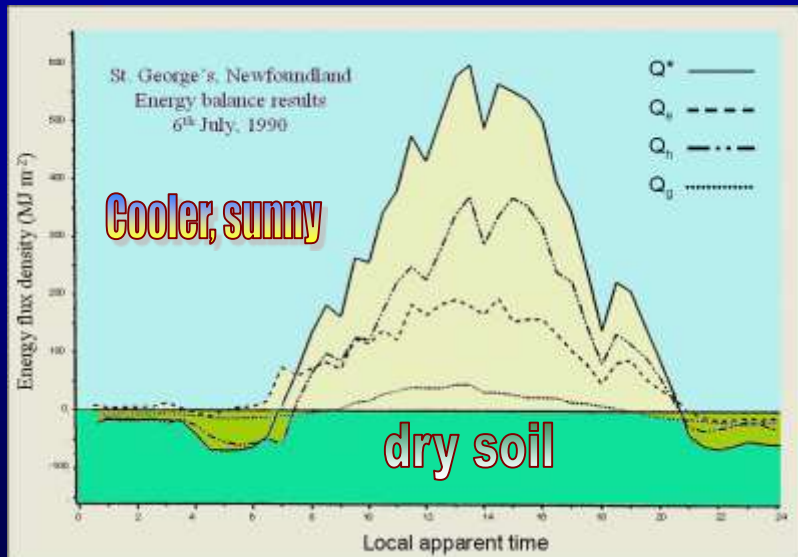
BATTERIÐ  
ARKITEKTAR



Energy flux measurements for 2 days St. George's, Newfoundland hints that a sunny but cooler day has a higher net radiation. By inference, it explains why a cooler and sunnier day in Iceland is much more comfortable than the warmer, misty weather of the Scottish Highlands and the Hebrides.



$Q^*$  = net radiation  
 $Q_e$  = Latent heat of evaporation  
 $Q_h$  = sensible heat  
 $Q_g$  = soil heat flux





Since 874AD, Iceland may have lost 3 million hectares of soil and vegetation - equivalent to at least 1.6 billion tons of CO<sub>2</sub> i.e., 500 times more than current emissions. The height of the rofabarð hints at the enormous loss of topsoil eroded by wind, water and soil frost. The photo was taken on a windy day. Can you see the clue that tells you the direction of the prevailing the wind ?



This rofarbard was mechanically smoothed out and seeded by members of the Lions Club at Gunnarsholt. But it is still a reminder of the original depth of topsoil and illustrates how devastating erosion by wind, water and loss of tree cover across much of Iceland. The consequence of this erosion on a massive scale is that Iceland has the largest desert in Europe.





A typical example of eroded lands near Mt. Hekla (*top left*), restoration to heath (*bottom left*); and gradual restoration to productive grasslands below a native birch woodland. At the time of settlement, native birch woodlands covered 25% of Iceland. Today the natural birch forest covers less than 1%.





**A few kilometers south of Mt Hekla, seeded lyme grass provides enough protection from wind, drought and erosion for native vegetation and even pastures to take hold.**





**This pine plantation in northern Iceland suffered severe mortality due to long periods of drought. By contrast the native flora, particularly woolly Icelandic willow is naturally colonizing gaps in the plantation.**





Bolholt is one of the farmsteads abandoned in the late 19th century due to drifting sand. The sand desert was first restored to grassland, then planted with black cottonwood, lodgepole pine and birch between 1991 and 1996.





## Successful New Woodlands

The positive aspects of Iceland's weather is reflected in the growth of young plantations such as the birch on old glacial flood plain gravels (*right*). View across Markarfljót to Stóra Dimon through the fine trees in the Múlakot Arboretum (*bottom left*), and the first thinning of a 15 yr old experimental poplar plantation at the Gunnarsholt.



Aðalsteinn Sigurgeirsson



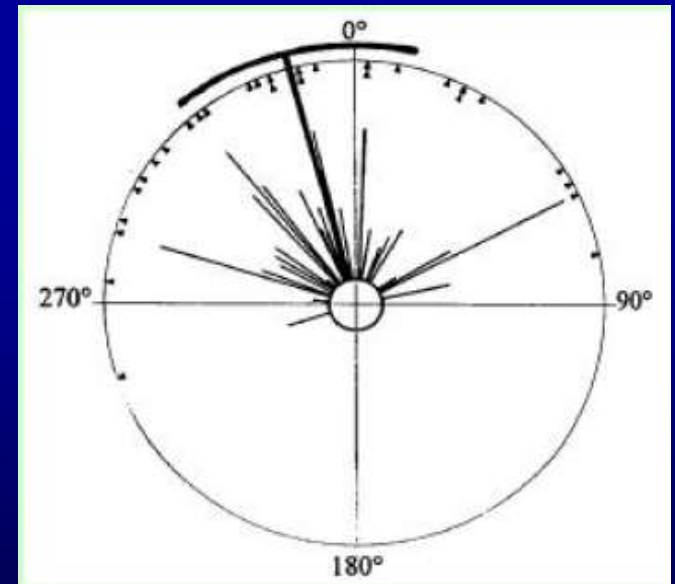
Aðalsteinn Sigurgeirsson



Pröstur Eysteinnsson

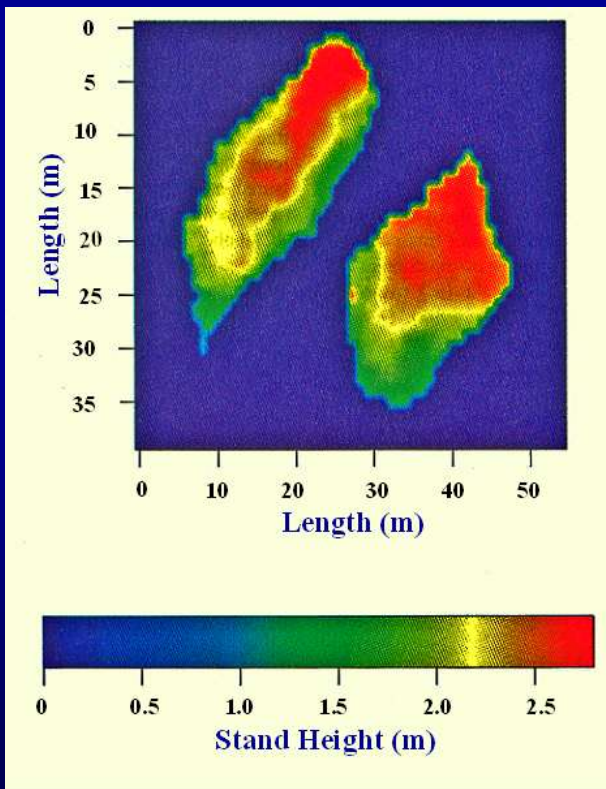
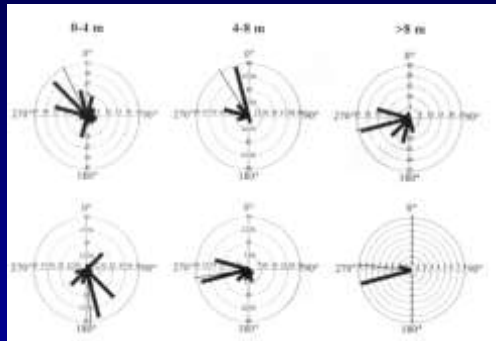


The Gunnarsholt experimental poplar plantation at 10 years old (*top*) and thinned at 14 years old (*bottom*). The circular statistical diagram shows the direction of crown deformation of a sample of 7 yr old trees caused by winds generally from the southeast. As the plantation grew taller the deformation became less noticeable.

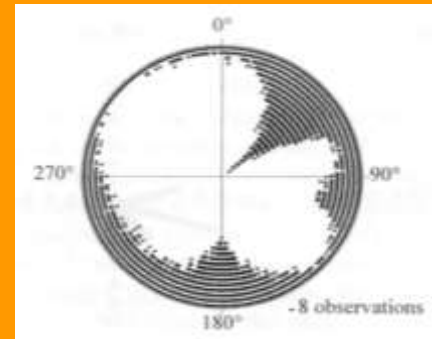


# Circular statistical analysis of birch colonization and the directional growth response of birch and black cottonwood in south Iceland

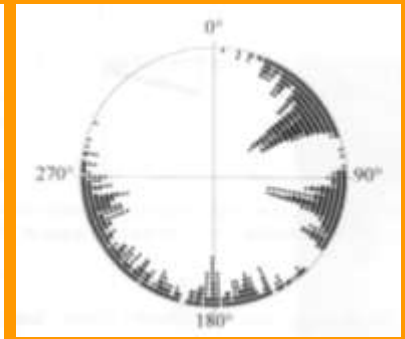
Ása L. Aradóttir<sup>1</sup>, Alexander Robertson<sup>2</sup> and Edward Moore<sup>3</sup>



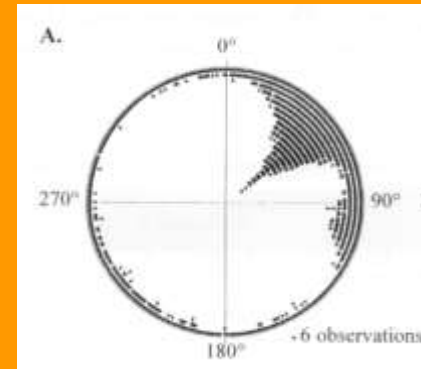
Directionality of Seedlings



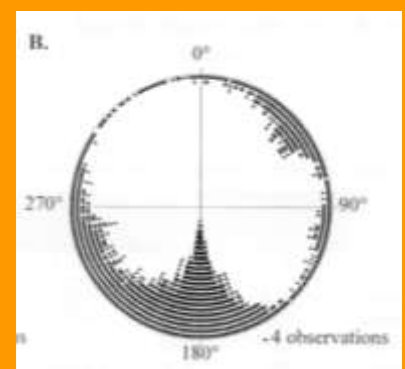
$> 2 \text{ m s}^{-1}$



$> 10 \text{ m s}^{-1}$



‘dry’ winds  
( $R_h < 75\%$ )



‘wet’ winds  
( $R_h > 85\%$ )

Alexander Robertson



Crossing the lava plain to the lush grasslands of the abandoned village of Reynifell á Rangárvöllum below Þrihyrningur. Near here two burial grounds, dating to a period with a *warmer medieval climate and when Iceland was 25% forested* including this area, were discovered beside the River Rangá, which supports the authenticity of Njál's Saga; i.e., how Gunnar of Hildarendi and his brother Kolskeggur were attacked beside the river and killed many of their attackers at the cost of Kolskeggur's life. With the *waning the little ice age* and better control on grazing the natural forest is gradually returning.



Bone rings like this one in the Iceland National Museum were commonly used by medieval archers to protect their thumb. There is speculation that this one, found at the gravesite belonged to Hjörtur, the brother of Gunnar of Hilderandi



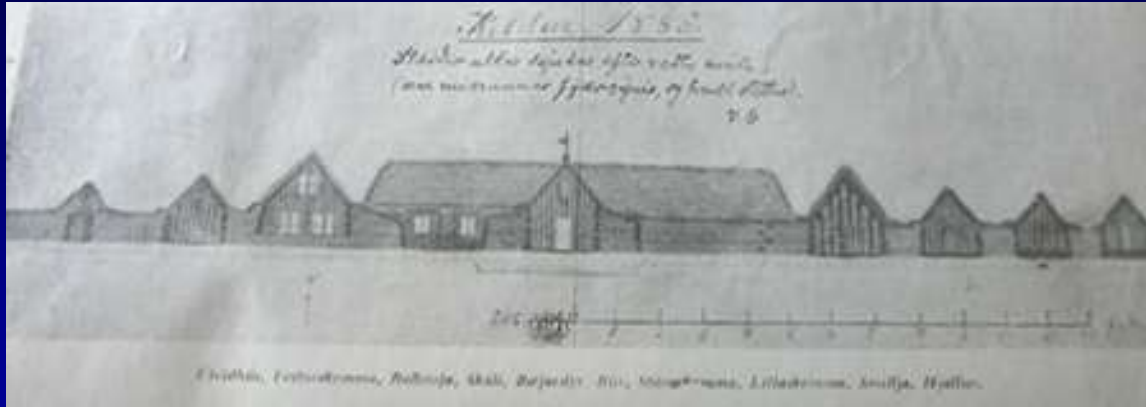


**In 1776**, the Danish King decreed that walls be built to protect hay fields from grazing. In most cases the walls would be built of turf, like this one at Reynifelli á Rangárvöllum. By 1778 the *Annals of Rangárvallahreppur* record that, of 52 farms, 32 had turf walls varying in length from 1 – 146 fathoms (1.83 m – 263 m) and in many cases only 3-5 fathoms (5.4 m – 9 m). The short ones presumably were ‘works in progress’ to oblige the decree. Most of the sand farmers ignored the decree partly because digging for turf would expose the sand and lead to serious erosion by wind and water – which does in fact happen today.





The story of Keldur is as much about the battles with weather and encroaching desert (the sand demons) as it is about its famous ecclesiastical history



*Top: Keldur in 1886*



*Bottom left:* Keldur kirk and ancient farm houses in 2005 the main hall is the oldest in Iceland.

*Bottom right:* an abandoned farm with it's entrance on the west side - which is less likely to be blocked by sand drifting from the northeast and southeast.



An aerial photograph of a vast, green, grassy field. In the center-left, there is a cluster of small, dark, rectangular structures, possibly tents or small buildings, surrounded by a low, dark, irregular line. To the right of this cluster, there are several small, white, rectangular objects scattered across the grass. The overall scene appears to be a temporary camp or a small settlement in a rural area.



Despite the onslaught of the sand demons, this famous farm and former monastery of Keldur has survived a thousand years and has the oldest building in Iceland. The dark area at the bottom is the exit from a tunnel. Some contend it is a secret tunnel. In truth, it may have been part of watermill mentioned on an ancient map.



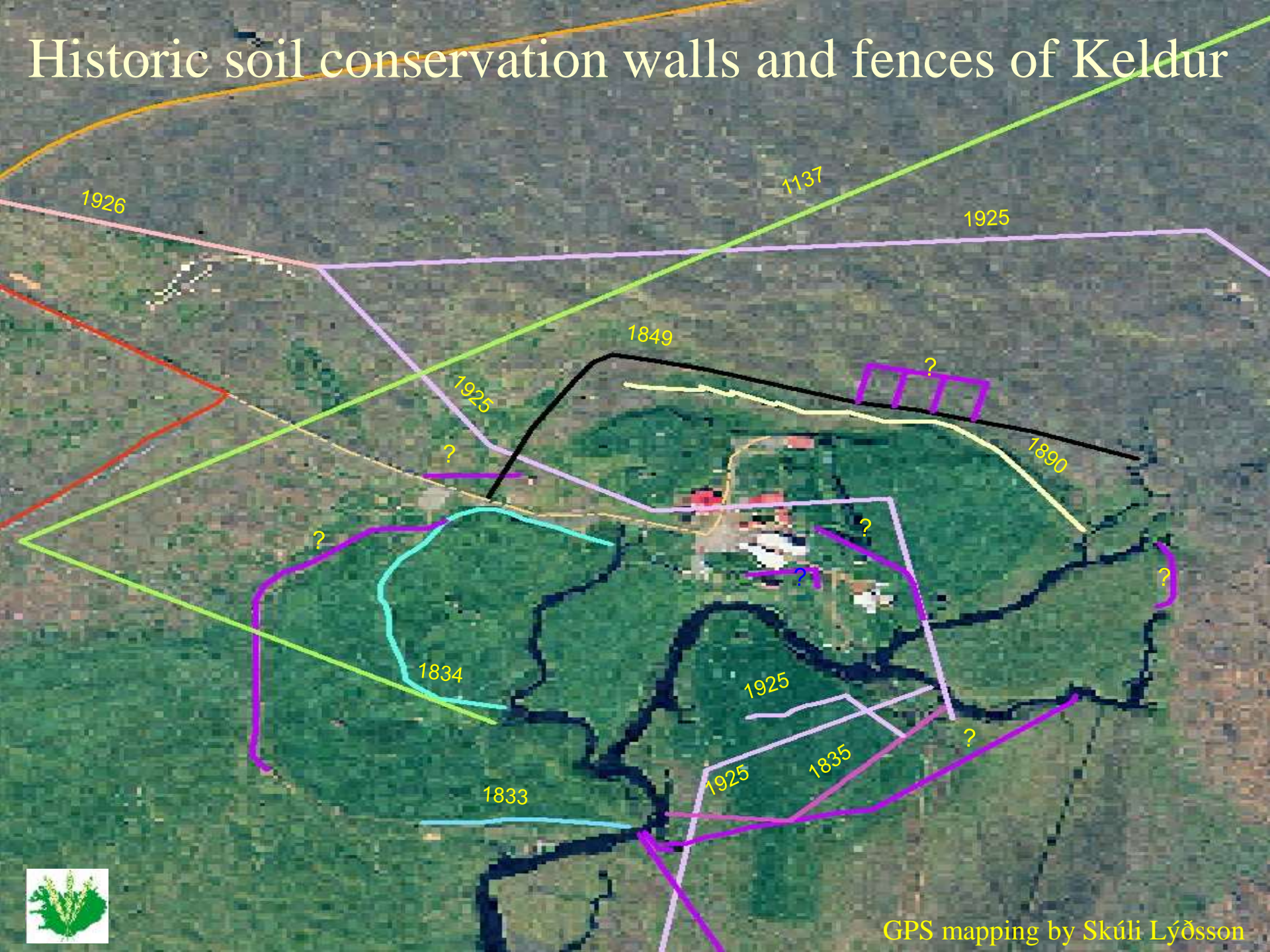


Keldur and Mt Hekla in 2002. Less than a century ago, the black desert near Hekla extended past Keldur towards the south coast. In recent years the climate and weather have been favourable enough to allow for considerable restoration of vegetation





# Historic soil conservation walls and fences of Keldur



GPS mapping by Skúli Lýðsson

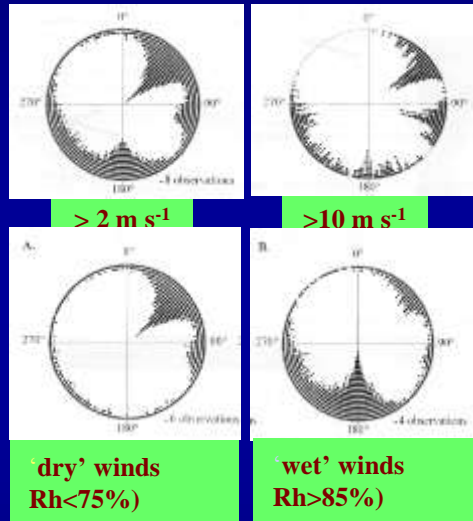


**The offset (dog-leg) gateway on the wall built by Skúli Guðmundsson in 1890 partly to make it easier to open the gate while controlling livestock and also to keep drifting sand out on windy days.**





The historic Keldur farm's long battle with the encroaching desert, particularly in the 18-20<sup>th</sup> centuries is well documented. Skúli Guðmundsson (1862-1946), the farmer of Keldur considered 1882 as the worst year of them all for sand drifting, when the farm houses and some of the livestock houses filled up. The hayfields were almost covered entirely by the sand.



Sand is initially transported by dry, moderate northeast winds across the plain and later shifted by stronger, and very turbulent east winds from the mountains & glaciers, which explains the cross-braiding pattern seen at a larger scale.



**In spring 1882 this field was covered by drifting sand. To restore it to grass, Skúli and his workers spent 175 working days to remove the sand by hand. In the process they removed 453 horse trailer loads and 80 sledges of sand pulled by horses, plus all the sand they pushed into the river by hand. From another hayfield they removed 155 cart loads. The yield of hay after all that work was only 150 kg of hay from about 3000 square meters (equivalent to a days work with the scythe).**





By 1905 the field was completely covered with sand. On the opposite side of the river is the the end of a 412 m and 1-2 m deep ditch that Skúli Guðmundsson and his workers dug from 11<sup>th</sup> November, 1905 to 14<sup>th</sup> March, 1906. At the top end of the ditch was a dam so that, when the workers had filled the ditch with sand taken off the fields, the dam was opened to flush the sand down river. Across the river can be seen two ancient stone walls of uncertain age – one extending to the river, the other barely visible crossing the ditch.





The orientation of dunes, that virtually inundated a turf barn indicates a history of massive sand drifting from the southeast, and also a first-class example of reclamation from desert to extremely productive and well-maintained pastures.





It is hard to imagine this lush pasture with a thick layer of grass was black sand dunes a century ago. The rolling topography provides localized shelter for livestock regardless of wind direction, but in winter it is also prone to deep snow drifts in the hollows which can trap sheep sheltering from a blizzard.



Alexander Robertson



**Great weather for harvesting the bountiful hay crop on a restored desert. In winter, a few farmers stack the bales in strategic locations to provide shelter and manipulate snow drifting around farms buildings and residences.**



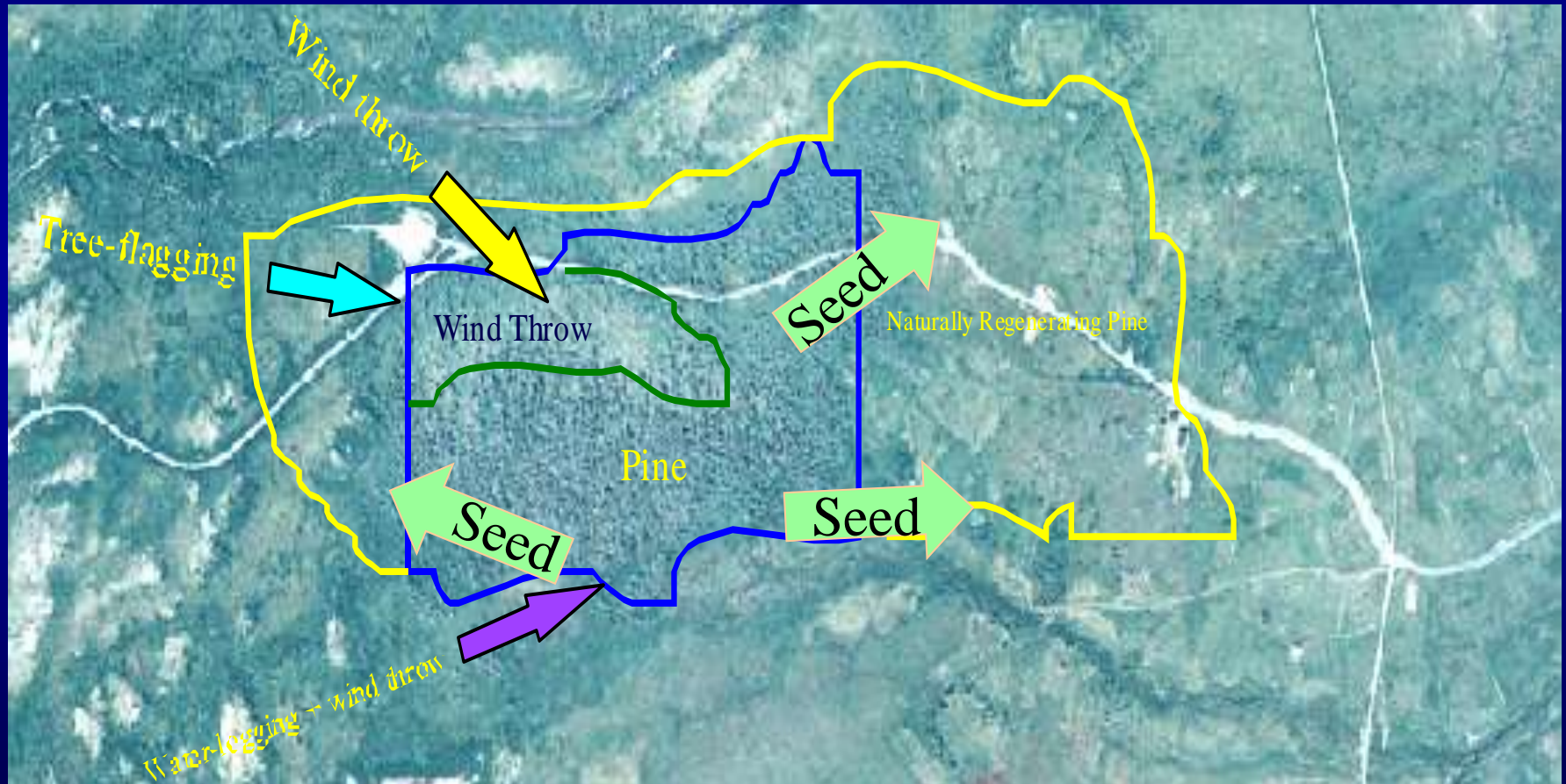


**A beautiful example of the vast expanse of lush grasslands in south Iceland with a moderately high rainfall and relatively mild winters. Despite occasional strong winds, the area has a high percentage of relative calm.**





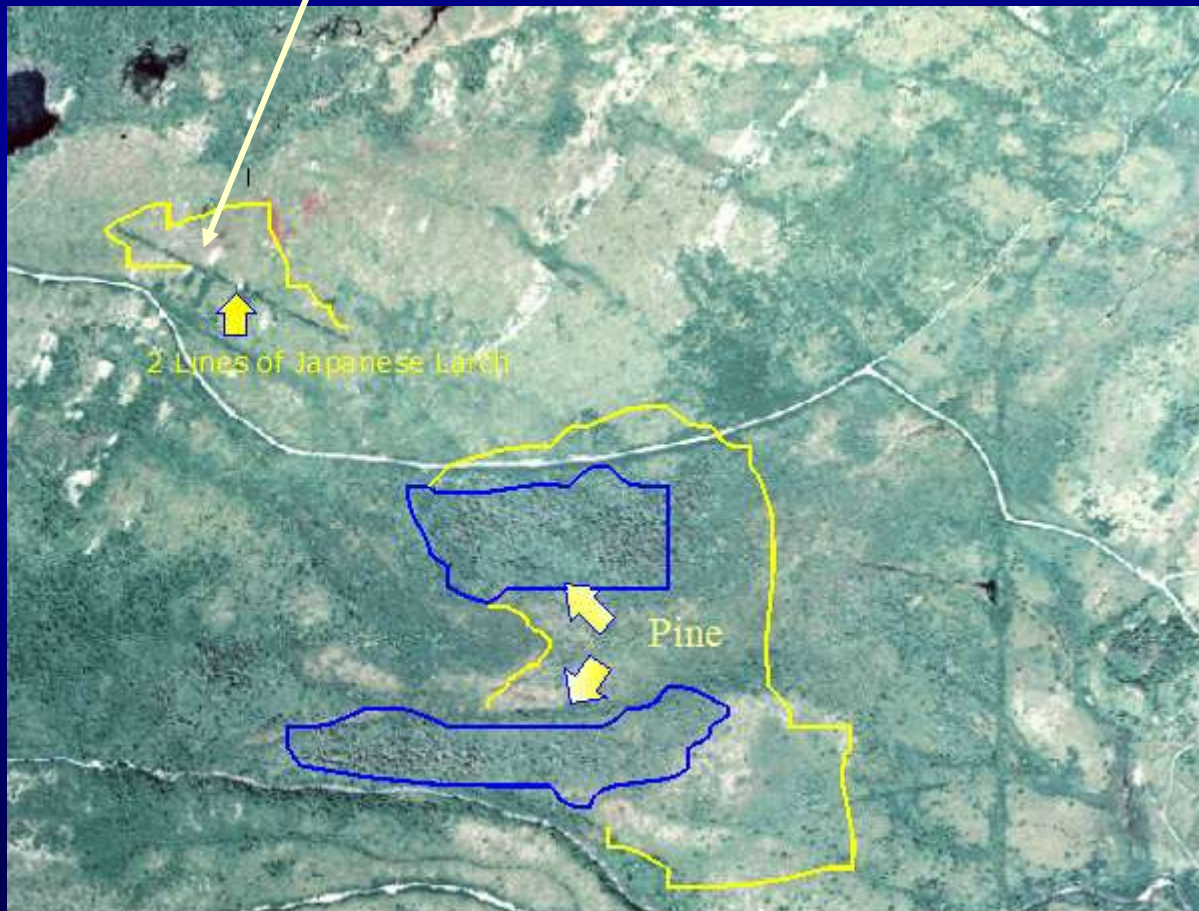
Woodlands provide an indication of both the troublesome and beneficial aspects of wind. In this pine plantation (*about 60 years old*) in eastern Newfoundland wind throw of stands and deformation of trees by ice and wind have become a serious problem as the plantation matures. On the beneficial side, the wind from various directions is dispersing viable seed.







The effect of persistent, brisk west winds on a row of larches in eastern Newfoundland is obvious in the severe flagging of trees and an open, rough profile of the double-row of the Japanese larch shelterbelt (top); and also in the distinctive distribution of seeds and natural regeneration of both the larch shelterbelt and two nearby pine plantations.





Compared to most of the boreal, Iceland has a mild winter such that poorly drained pastures used for winter grazing by horses are prone to frequent episodes of soil frost heaving.





**Frost mounds are very common in damp climates and, on pastures, are mostly created by horses and cattle. Frost-mound infested sites like these will require heavy-duty soil drainage and tilling to make them suitable for hayfields and tree plantations**





A spruce plantation on the exposed lava near Keflavik that didn't make it past the tuckamore stage due to a combination of hummocks arising from severe frost heaving, poor soils, and persistent, often brisk winds and occasional loading by freezing rain, wet snow, sea salt and surfactants, and blasting by airborne ice crystals plus sheep browsing.





In hollows where cold air settles and/or receives little solar radiation, trees such as larch are prone to damage by frosts and breakage by deep snow drifts





**Frost pocket.** “Engelmann spruce was planted there in 1996 or so, down on the flat part as well as on the slope. You can still see a couple of hangers-on that haven’t been killed yet. But mortality on the flat part is about 90 % and only about 20% on the slope (mostly due to grass competition)”



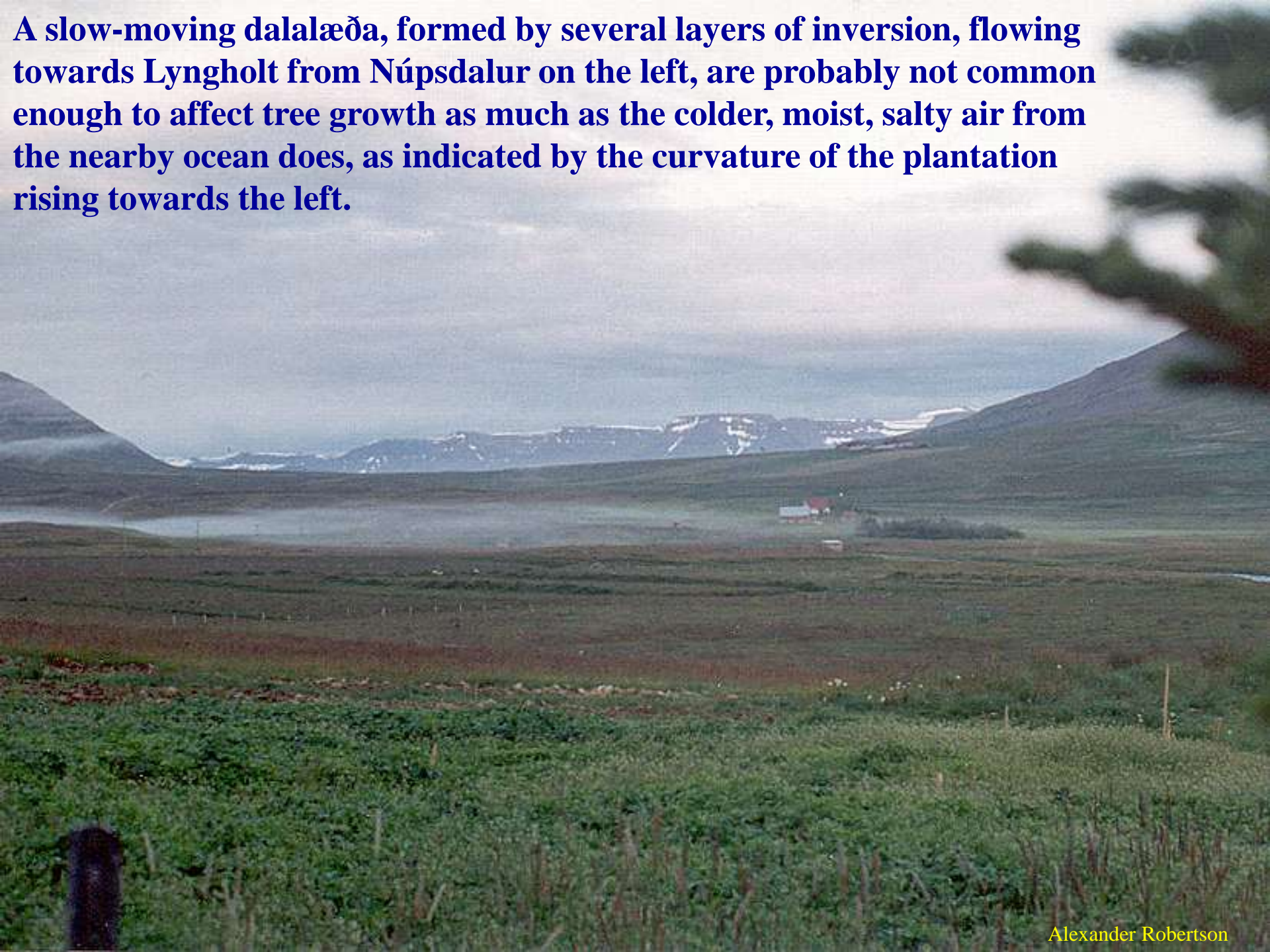


Dalalæða (ground fog) depresses growth until the trees grow above it (top). When there are enough trees and shrubs, there is enough heat storage that dalalæða will not develop (middle). Dalalæða is common in Iceland as shown below and develops into several layers of inversion such as at Lynholt, Núpsdalur. Onshore fogs (dalalæða) such as this example at Trinity, Newfoundland (*bottom right*), depresses tree growth, but increases the biodiversity of coastal heathlands





**A slow-moving dalalæða, formed by several layers of inversion, flowing towards Lyngholt from Núpsdalur on the left, are probably not common enough to affect tree growth as much as the colder, moist, salty air from the nearby ocean does, as indicated by the curvature of the plantation rising towards the left.**





Another weather beaten Sitka spruce ‘tuckamore’ and a hard-living birch in northeast Iceland. Here we see that growth has been shifted downwards into thickend trunks, branches, bark and foliage. Despite it’s low stature it makes a very effect shelterbelt and tends to re-radiate heat better than a taller, more porous canopy.





The root plate of yellow birch, like rowan, tends to be extruded when tipped over by ice loading or blown over in a storm. This is a positive attribute in tree species selected for windy climates. The flagging and dead branches in the upper parts of the crowns of balsam fir in the background are indicative of a persistent wind combined with severe winter weather





Lightning strikes are the most common cause of forest fires in Newfoundland – but rarely in urban areas as in the case of this tree roasted by lightning (medium to well-done) in a garden in Conception Bay South, Newfoundland.





A fire reveals the structure of typical coastal balsam fir tuckamore in Newfoundland shaped by wind, ice and snow loading. In the lee of the tuckamore exceptionally fine crops of vegetables are grown as a result of a 10-fold increase in growing degree days due to the shelter.





Strong 'free-stream' wind flow can entrain snow and deposit it on the inside edge of the plantation, while the tops of the trees are swept clean of snow exposing them to damage by wind-blown ice crystals while the lower parts in the more turbulent zone on the outside edge are laden down with heavy snow but protected from abrasion by ice crystal.





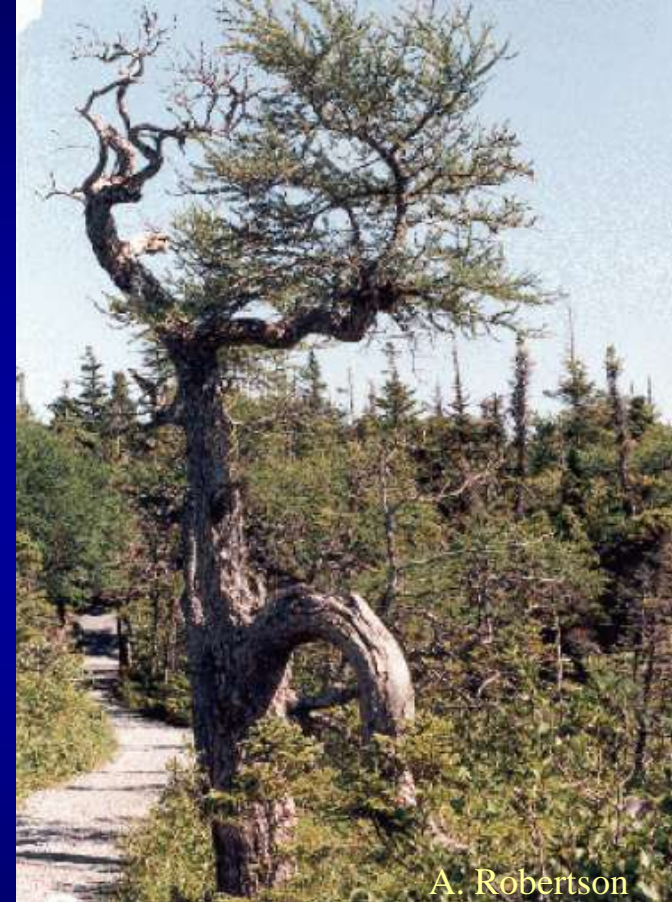
# Effects of severe winter weather on trees



Ice-blasting



Wet Snow



Everything - and then some!



The consequence of severe snow drifting is that, on the inside edges of a young spruce plantations, severe crown breakage and some mortality can occur; whereas, the lack of snow during warm days in winter can lead to winter burn. The positive side is that the 'snow-loading' gap makes an excellent sheltered ski trail and picnic area.





The trees in this stand have good form, except those in a narrow band that were buckled at a young age by the deposition of snow a few meters inside the top edge of the forest. As can be seen from one of the logs and a standing tree above it, the episodes of the snow damage only occurred early in the life of the plantation.





Another case of inside the edge effect of snow loading. This one in a Siberian larch stand where snow is brought in by onshore winds coming off Lagarfljót near Hallormsstaðir. In this case, a faint white line indicates a gap where Þór Þórfinnsson, the Regional Forester, had the deformed trees removed. The gap is used as a convenient trail.



Sigurður Blöndal



Þór Þórfinnsson



Snow packs, including street bergs like this, may persist for several months, thus virtually eliminating soil frost,. However, they do little damage to plants, as shown by the healthy leaves & buds on this partially uncovered rhododendron. On the positive side, street bergs are often laden with nutrients and de-acidifiers such as salt, surfactants, detritis and grit which dispenses with the need for fertilizing



Alexander Robertson





Sea-ice, such as in Torbay, doesn't arrive till late spring (if at all) and usually only stays in the bay for a week or two at most. Moderate surface wind speeds of  $7\text{-}10\text{ m s}^{-1}$  from the west and southwest associated with cyclones can draw the pack ice out of the bay northwards in a matter of hours; while the Labrador Current will draw the bergs southwards. Note the streamlines on ice created by longitudinal rollers





The influence of onshore winds on trees, which have passed over pack-ice and icebergs and generates coastal fog, usually does not extend very far inland as indicated by the size of the 160 yr-old beech trees growing less than a kilometer from the sea. In fact, the strong flagging of the beech (eastward) is caused by brisk west winds in summer. The colonization of white spruce on abandoned pastures on the outskirts of St. John's is likewise not particularly affected by onshore winds.





Many gardeners have a tendency to prune the lower branches of feathered trees. While this looks great in summer, it destroys the shelter value and erodes the humus layer and can cause severe snow drifting in winter and slower growth in summer. Planting a fast-growing willow on the downwind side corrects the problem





Trees in the horizontally aligned shelterbelts (*top*) are declining due to stress; while those in the vertically aligned are much better.

The long 'fetch' of these widely spaced, linear shelterbelts suggests that strong 'free stream' winds aloft will readily entrained moisture and snow close to the shelterbelt but, being too far apart, allows the free-stream 'fetch' to re-established over most of the distance between shelterbelts.

The much shorter 'fetch' of narrow shelterbelts (*below*) are able to trap much more snow and conserve moisture which are less likely to be entrained by the free stream wind flow.





Freezing rain is a common problem in Iceland and Newfoundland and, to a lesser extent, Scotland. Birch is particularly susceptible to freezing rain.





One reason to create a 'safe zone' around buildings & utilities is to avoid planting species of tall trees prone to damage by excessive ice and snow loading



Alexander  
Robertson





# Skin temperature differences of foliage, soils and rock measured by an infrared thermometer

Type of Surface	T sunny	T shade	T difference
Dry soil with no humus in a sheltered area	35.5	18.3	17.2
Moist soil with no humus in a sheltered area	27.9	15.8	12.1
Moist soil in a ploughed and and tilled field on a windy slope	19.7	-	-
Moist soil in a gap vs. under the canopy of balsam fir forest	26.6	8.5	18.1
Moist garden soil with high organic content	32.0	16.7	15.6
Peat mulch	30.7	18.0	12.7
Boulder – roughly 1 m diameter, sunny side vs shade	35.6	15.6	20.0
Humus layer under a leafless willow coppice	27.2	-	-
Humus layer under a leafless larch stand	15.3	-	-
Sunny vs. shady sides of the crown of a Norway spruce	22.5	17.7	4.8
Sunny vs. shady sides of the crown of an eastern hemlock	24.4	14.3	9.9
Leaf of a rhododendron in the sun vs. in the shade	34.1	17.9	16.2
Foliage of golden variety of eastern white cedar	20.3	16.1	4.2
Foliage of Ajuga repens	32.1	16.0	16.1
Cut and rolled sections of a sheltered lawn	29.3	15.5	13.8
Uncut section of sheltered lawn (5-8 cm high)	22.7	14.3	8.4
Small sunfleck on a sheltered lawn	18.3	-	-
Trunk of an Austrian pine	23.1	16.8	6.3
Moss carpet in a gap vs. under dense balsam fir forest	25.5	11.8	13.7
Moist humus layer around a tree stump in the open	30.7	16.3	14.4



Snow melt by long-wave re-radiation by the trees and is often mistaken for a wind effect





This photo demonstrates the differences in wind, solar radiation and moisture. There is not a great deal of difference in the ambient air temperature. Woods and a path are on both sides of the stream. Both banks were planted with white spruce on the same day about 3 years before this photo was taken. There is no survival on the left bank due to it being exposed to greater solar heat and windiness and early loss of snow cover - which adds up to a chronic drought unfavorable to white spruce





An example of why soil classification systems which do not factor in the effects of weather are not good indicators of potential growth



According to the soil classification, climate and general appearance of the barren landscape with scrub woods, the area is considered too harsh for good tree growth. The small plantations established 50 years ago are now 16-18 m tall and have DBH in the range of 25-55 cm making them the fastest-growing and tallest stands in Newfoundland.



This new shelterwood planting is located in City of Mount Pearl. It is an upland site that is extremely exposed to persistent wind, prone to periods of freezing rain and severe snow drifting. The soil is typical urban land-fill gravel which was made productive by adding a small amounts of fertilized peat in the planting holes





Obviously, weather takes a toll of single species hedge rows, such as willow (*top left*). Mixed plantings with sparse 'standard' conifers (*top right*) are more resilient to moderate weather extremes, but exert limited snow control. Deciduous-dominant plantings are resilient to moderate weather extremes and function well in summer but much less so in winter (*bottom left*). An even balance of 'feathered' conifers and deciduous species are resilient to severe weather extremes and are effective in all seasons





Despite its location in persistent and often strong, dry winds in a typically cool, boreal climate, the Robertson garden in St. John's produces a fine annual crop of Bartlett pears on a single tree. According to the Canadian Plant Hardiness Zone map, this should not be possible in this area.





While this plantation in south Iceland is a good idea for trapping cold downslope winds, rock creep, and minor avalanches, it is actually a potato patch with good growing conditions .





Avoiding another avalanche disaster at Flateyri required a massive control dam.





Many parts of Iceland, such as the Westfjords, have a lengthy drought period in spring and early summer when no tree planting can be done. Therefore, on sites like this, drought is often serious enough to warrant replanting. The photo shows even the normally tolerant lupine has difficulty colonizing parts of the berm. Without the vegetation planted by Skjóluskógar and associates, this magnificent avalanche defense would quickly erode.





A volcanic dust storm near Vik, south Iceland from the Eyjafallajökull eruption in 2010 caused a lot of anxiety for people and livestock





Thorvaldseyri was among those hardest hit by the volcanic ash and floods from the Eyjafallajokull eruption in the glacier. More importantly the volcanic ash was high in nutrients which yielded an exceptionally good crop of barley. The farmers Ólafur Eggertsson and Gudný A. Valberg have opened a small memorial house on the eruption.



Thorvaldseyri was among those hardest hit by the volcanic ash blown in from the Eyjafallajokull eruption plus its flood waters in early spring actually produced exceptionally good grazing land and a bumper crop of high quality hay. A fine example of the positive side of wind-blown volcanic dust.

