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Pinus contorta in Ireland—a forester's guide to provenance identification.

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Natural Range :

In its natural habitat *Pinus contorta* extends from 64° N in the Yukon to 31°N in Baja California. Its northern limit lies on the Yukon river and its range stretches south through Alaska, Yukon, British Columbia, Alberta, Washington, Montana, Oregon, Idaho, Wyoming, South Dakota, Nevada, Utah, Colorado and New Mexico. Its altitudinal range extends from sea level up to the timber line at 11,000 feet in Colorado. This immense natural range demonstrates its ability to grow under diverse climatic conditions. Rainfall varies from 11 inches in north western British Columbia to 160 inches off the Alaskan coast. Snowfall is negligible throughout the coastal range but can reach a depth of 38 feet high in the Sierra Nevada mountains. Inland the temperature ranges from minus 55° to plus 100°F., but these extremes occur for only short periods of time. Frost can be recorded in any month of the year throughout the inland range. The climate of the coastal range is typically cool and moist with a narrow range of temperatures. Soil types on which the species grows are very diversified. Along the northern part of its coastal range it is found mainly on peat bogs and muskegs. Further south it occurs on dry, sandy and gravelly sites close to the Pacific Ocean. Inland, good stands are found on soils of granitic, shale or sandstone origin. On well drained calcareous tills having a silty loam or clay loam texture in Alberta stands are of medium to good productivity. Along the Cascade Mountains it is found mainly on wet, flat, poorly drained soils while further east it is found on soils derived from volcanic ash or alluvial deposits.

Throughout its natural range it grows in association with a number of different species. It is found in predominantly pure stands at middle elevations along the Cascade, Sierra and Rocky Mountain ranges. At high elevations it is found in association with *Picea engelmannia* and *Abies magnifica*. It is a minor component

at middle elevations of the Douglas fir — larch association while at lower elevation it is found in association with *Pinus jeffreyi*. Where repeated burning occurs *Pinus contorta* tends to be the first species to colonise the burned sites leading in many instances to formation of pure stands in regions where it was formerly in mixture. Throughout its coastal range it generally exists as a pure stand. In places it may be associated with Sitka spruce. In Alberta it is associated with *Pinus banksiana* with which it has been known to hybridise.

History : Because of the wide variation in habitat the interaction of genotype and environment gave rise to very different phenotypes. Many 19th century botanists assumed that the species, as it is now known, was in fact a number of separate and distinct species. The first known record of *Pinus contorta* was that of David Douglas, a Scottish botanist, in 1825. He recognised it as a distinct species when he recorded its presence near Cape Disappointment at the mouth of the Columbia river, Washington. This was the shore or coastal provenance as it is now recognised. Other botanists recorded its presence along the coast of western north America but due to its great variability it was often identified incorrectly. Critchfield holds that Douglas made a similar mistake when he identified a pine on the slopes of the Rocky Mountains as *Pinus banksiana*. What he most probably saw was the Rocky Mountain sub-species of *Pinus contorta*. *Pinus banksiana* is not known to occur within this region. The next major step was when John Jeffrey in 1852 discovered the relatively inaccessible Sierra Nevada form and called it *Pinus Murrayana*. This sub-species, like that discovered by Douglas, was found at different locations by other botanists and given a variety of names. The fourth sub-species under modern classification was not recognised until 1866 when Bolander described the dwarf pine found on the Mandocino White Plains, California. However he referred to it as *Pinus muricata*. Parlatore using Bolander's material described the same pine as *Pinus Bolanderi* in 1868. Engelmann was the first to regard the species as dimorphic, grouping all the inland populations under *P. contorta* var. *latifolia* in 1871. He was to change his nomenclature to *P. contorta* var. *Murrayana* in 1880. In 1908 Sudworth stated that *Pinus contorta* was a single "polymorphous" species with no subdivisions. Critchfield in his study "The Geographic variation in *Pinus contorta*" in 1957 states that *Pinus contorta* has undergone evolutionary differentiation into a series of geographical aggregates of populations which differ from one another in manifold ways. For this reason he proposed to express the regional variation in terms of four sub-species, these being 1. Coastal 2. Mendocino White Plains 3. Sierra Nevada and 4. Rocky Mountain.

Introduction : Elwes and Henry state that the first introduction of the coastal provenance to these islands was not until 1855 when it appeared in Lawson's Catalogue under the name *P. Macintoshiana*. The inland provenance, though discovered 30 years later, was introduced a year earlier in 1854 when seed and specimens reached

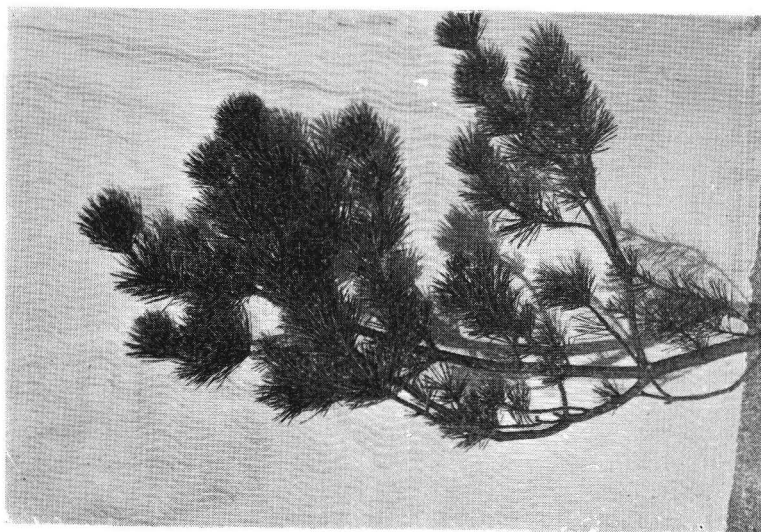
Edinburgh. In 1909 two trees of an inland provenance at Westonbirt had reached heights of 59 ft. and 50 ft. Elwes and Henry state that a tree of typical *contorta* planted in 1886 at Grayswood, Haslemere, as *P. Bolanderi* measured 28 ft. in 1906. The first record of *Pinus contorta* planted in Ireland was in 1928 when Forbes stated that on limestone soil at Cong, County Galway, specimens planted in 1884 reached a height of 70 ft. in 1923. They were planted as *Pinus Bolanderi*.

The importance of provenance was realised by Forbes. He stated that the result of planting *Pinus Murrayana* in the place of *Pinus contorta* may not be serious from an aboricultural point of view but in his experience, the growth of the former is much slower than that of the latter and consequently gives rise to quite different results. In 1918 Forbes had trees of *Pinus contorta* and *Pinus Murrayana* planted side by side at Avondale, Co. Wicklow. At the end of 10 years growth they clearly depicted the relative rates of growth of the two types. He found that the coastal provenance was superior to the inland one. It is said that it was on the performance of these trees that Forbes ultimately selected the type best suited for this country. All plantings of this species in the early twenties were of a heavily branched type with dark green foliage.

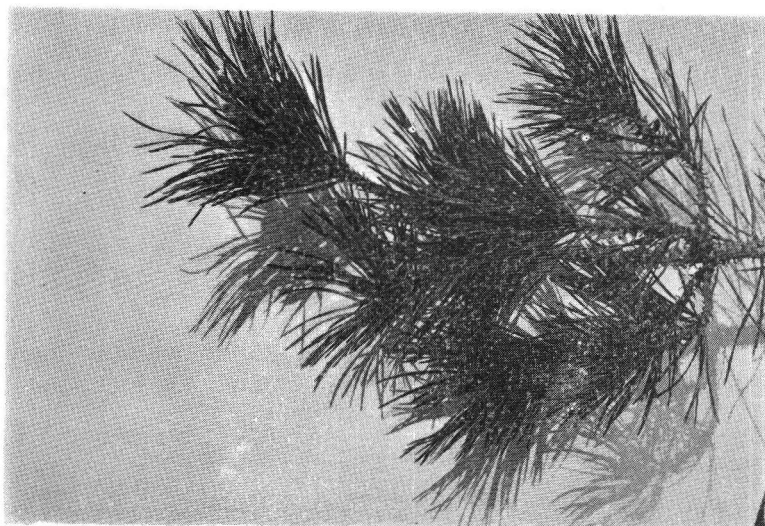
Classification : *Pinus contorta* was first introduced on a commercial basis to Ireland in 1923 when 7 lbs. was purchased from Manning and Co., Seattle. Unfortunately no record of origin was given. In subsequent years the importance of this species increased and further quantities of seed were purchased from a wide variety of origins. In some instances origins were given but these proved on the whole to be rather vague and they could never be authenticated. It could be said that the seed came from two broad regions, coastal and inland. Over the years from the variety of provenances planted, a pattern emerged which permitted the species to be sub-divided into three broad categories based on their growth performance under Irish conditions. The three groupings were 1 Coastal — covering that region of Washington and Oregon along the Pacific Ocean, 2 Lulu island — covering a small area in the Frazer River delta and 3 Inland — covering that region of the species range well removed from the coast. No attempt has been made to further sub-divide any of these broad groups as was carried out by Critchfield. In drawing up these headings only the macrophenotypic characters were used, no recourse being made to microscopic features. These macroscopic features were used to draw up a table by which the forester in the field would be in a position to identify the three main groups as found in Irish forestry. In using this table it is essential that it be applied to a stand of trees rather than to a particular individual. Due to the heterogenous nature of the species it is possible to get representatives in a stand showing some of the features of one of the other groups.

To simplify examination, the trees under review are divided into two broad areas, the stem and the crown. Within each of these areas

the main features are described. The description takes the form of a comparison of the features of each of the three groups into which the species has been divided. The general performance of the trees under review also assists in arriving at a conclusion as to the group to which the trees can be assigned but this can be strongly influenced by site conditions.



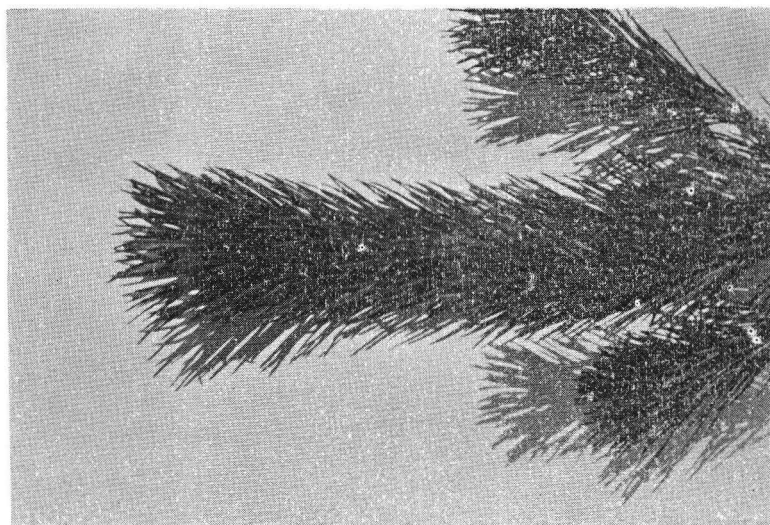
Lulu Provenance — needle in tufts caused by regular yearly male flowering.



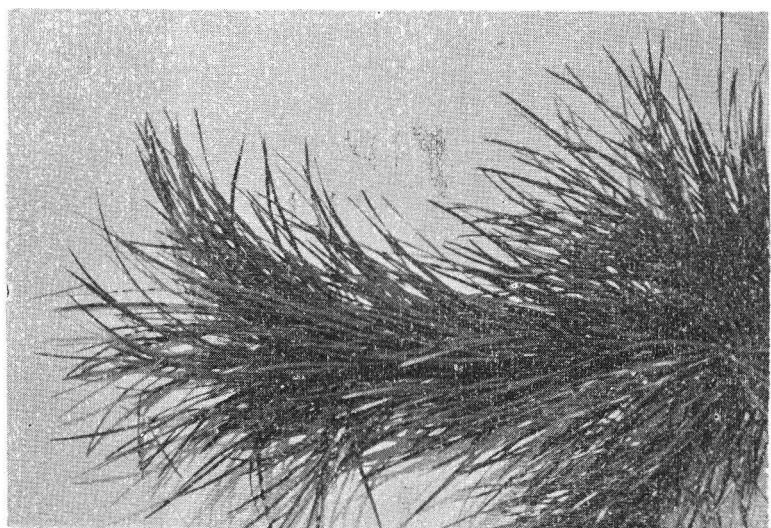
Lulu Provenance — short needles more loosely appressed to stem.

STEM : GENERAL :

Coastal : Continuous, usually devoid of forks which can be attributable to genetic control. Shows rapid diameter growth, heavy. May include flaws attributable to loss of leader bud due to storm damage during earlier years.



Coastal Provenance — short needles closely appressed to stem.



Inland Provenance — long needles standing out from stem.

Lulu : Continuous, straight, usually devoid of forks. Light, does not show rapid diameter growth.

Inland : Continuous, straight more likely to contain forked individuals, more so in some provenances than in others. Does not show rapid diameter growth.

BASAL SWEEP :

Coastal : Very prevalent particularly on exposed sites.

Lulu : Absent due to lack of vigorous growth.

Inland : Absent though showing good height growth on many sites.

BARK :

Coastal : Generally rough and thick, well fissured giving rise to blocks. In some instances, moderately smooth and fairly thin. Colour is generally very dark brown. In some of the thick-barked phenotypes bark tends to have a corky consistency.

Lulu : Generally smooth, though in older stems low down it is sometimes rough. It never however approaches that of coastal, plates are usually small and very thin. Colour is variable but usually dark brown at lower end of stem and somewhat greyer higher up.

Inland : Smooth, very thin with very pronounced small swellings similar to lenticels over the entire stem. Where rough plates occur they are usually very thin. Grey in colour.

NODAL SWELLING :

Coastal : This is a very pronounced feature particularly on the more vigorous trees. The swollen area around each branch tends to amalgamate with its neighbours in the whorl until a very definite ring of swelling occurs. The degree of swelling varies from tree to tree.

Lulu : Nodal swelling is not seen in this provenance. This can in all probability be attributed to its general lack of vigour.

Inland : Swelling does occur in this group but it is confined to where the branch enters the stem. Characteristically following pruning the stem is covered with small nodules. This feature is more pronounced in the older stages of development.

CROWN :

Branch : Number, length and form

Coastal : Very vigorous strong and long, giving rise to large knots in the timber. Characteristically there are from 5 to 8 per whorl. Of this number 3 to 5 respectively are usually dominant branches, the others being less vigorous. In some instances there is a minor whorl of branches, due to lammas growth. Branches are usually straight and devoid of twists.

Lulu : Light and not very vigorous. Tend to be of moderate length. Characteristically there are 4 to 6 per whorl. They are usually straight and devoid of twists.

Inland : Light and generally not very vigorous. Tend to be variable in length. Characteristically there are 2 to 4 per whorl. They are normally rather wavy.

NUMBER OF GROWING POINTS PER BRANCH

Coastal : In keeping with the vigorous nature of the tree, there is a high number of growing points per branch. This gives the tree its rather characteristic dense crown.

Lulu : The number is moderately high but due to the needle arrangement and lack of vigour, crown is not very dense.

Inland : Number is very low and it appears to correspond with the number of branches per whorl. Due to this feature and the waviness of the branches the crowns are very open.

BRANCH ANGLE :

Coastal : Is described as from flat to ascending. Their position in the crown will have an influence on the exact angle.

Lulu : Very definitely ascending entering the stem at an acute angle. This makes for a narrow crowned tree.

Inland : Generally flat. There is a tendency for the branch ends to turn upwards.

INTERNODAL BRANCHES :

Coastal : As a rule internodal branching is absent but not always. There is a suggestion of internodal branching in the form of minor branches at the whorl. This is in fact lammas growth.

Lulu : Seldom occurs in this group.

Inland : It is quite prevalent and gives the tree an impression of being extremely branchy. As with the normal branches, internodal branches are very light, short and wavy. It does not appear in regular whorls.

NEEDLES : Colour

Coastal : Normally rich dark green. It must however be borne in mind that site factors will control colour to a greater or less degree.

Lulu : Predominantly they are a metallic grey—dark green colour. Application of fertiliser may alter it but they normally revert to the grey-dark green colour.

Inland : Characteristically they are a light green or yellow green colour. When compared with the other two groups it is many shades lighter.

NEEDLE LENGTH :

Coastal : On average they are 2 inches in length but can range from $\frac{1}{2}$ to $2\frac{1}{2}$ inches. Site conditions will have an influence on their length.

Lulu : Short $\frac{1}{2}$ to 2 inches long.

Inland : Long in comparison to the other two groups. Range is from 2 to 4 inches with an average length of 3 inches.

RETENTION AND APPEARANCE

Coastal : On each branch needles are retained from 2 to 6 years, the higher figure being the most usual. In their first year needles are appressed to the branch giving it a well clothed appearance. On young trees needles are retained on the stem for a few years. Needles are straight.

Lulu : Needles are retained from two to six years in the coastal group. On average they are retained for 4 years. Needle arrangement is such that they stand out from the branch giving it a prickly appearance. Added to this is the fact that the needles appear in small groups separated by bare stem (see flowering). Needles are straight.

Inland : Needle retention is from 1 to 4 years with the most common length of period being 2 years. Needles stand out in no regular pattern from the stem of the branch. This gives the branch a loose hairy appearance when viewed from a distance. Needles themselves are twisted and hang very loosely.

FLOWERING :

Coastal : Flowering is confined to definite regions for the sexes. Female flowers are predominantly in the upper one third of the crown and male flowers in the lower two thirds of the crown. Though flowering can occur at an early age, when plants have been two years in the field, it is most prevalent when the tree reaches the age of 10 years. This period of prolific coning would appear to continue for about 5-10 years. Thereafter coning appears to be confined to seed years.

Lulu : The outstanding definitive feature of this group is its prolific coming and flowering from an early age. Regardless of year it produces vast quantities of male flowers at every growing point except that of the terminal shoot. When the empty pollen sacks are shed they leave gaps between each successive year's growth. This gives each branch a tufted appearance. There is no definite zoning of sexes as in the coastal group. Female flowers are produced in equal profusion throughout the entire area of the crown. If not picked they tend to remain for a number of years on the stem. This can also occur on Coastal but is less noticeable due to crown density.

Inland : Production of flowers is not very prolific. It tends to follow the same distribution pattern as that of the coastal group, female flowers being mainly confined to the upper one third of the crown and male to the lower two thirds. Some provenances within this group have the habit of retaining cones for many years on both stems and branches though the branch may be long since dead.

GROWTH FORM :

Coastal : Provenances within this group show very good vigorous growth both in height and diameter. Due to the very dense crown there is almost complete suppression of ground vegetation once the canopy has closed.

Lulu : Within this group both height and diameter growth are poor. Early development is vigorous both in the nursery and for a short period following planting in the field. A stand is characterised by the almost complete lack of suppression of ground vegetation and no apparent closure of canopy.

Inland : Though height growth in some provenances is moderately good, diameter growth is generally poor. This allied to the very light crown, results in only moderate suppression of ground vegetation even though there is in some provenances on good sites a closure of canopy.

STABILITY :

Coastal : Due to its vigour it is liable to windblow from an early age. On exposed sites where not blown it develops a characteristic basal sweep.

Lulu : No wind blow of any consequence has occurred in this group a fact attributable to its general lack of vigour.

Inland : This group is not prone to wind blow on the majority of sites. Where it occurs it is generally only odd trees which are blown.

Two minor groupings within the coastal sub-group occur but are of no great significance since they are not widely planted. The first of these is the "Rainer" provenance characterised by its very ascending branch form. In all other respects it is similar to the normal coastal provenances. The second minor grouping is the Mendocino provenance. Macroscopically this cannot be differentiated from the normal coastal provenances.

Examples of the three main groups are to be found in close proximity in

Rathdrum forest	Ballintombay property, C.11, C.10, C.12.
Forth forest	Forth Commons, C.15.
Ballyhoura forest	Skahanagh, C.175, 19, 159.
Cloosh forest	Cloosh Valley, C.66, C.10, C.119.
Ballinaboy forest	Croughonagh, C.19, C.20, C.3.

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SUMMARY OF MAIN DISTINCTIVE FEATURES

Feature	Coastal	Lulu	Inland
<u>A. Stem</u>			
General	Straight, heavy	Straight, light.	Straight but sometimes forked, light.
Basal Sweep :	Very prevalent	Absent.	Absent.
Bark :	Rough, well fissured blocks, thick, dark brown.	Smooth, thin grey-brown.	Smooth, "lenticels present.
Nodal Swelling	Very pronounced, particularly on vigorous trees.	Absent.	Swelling does occur but confined to branch base.
<u>B. Crown</u>			
Branch	Very vigorous, 5 to 8 per whorl, straight.	Not vigorous, 4 to 6 per whorl, straight.	Not vigorous, 2 to 4 per whorl, wavy.
No. of Growing Points per Branch	Large number giving branch well clothed appearance.	Moderate number.	Few.
Branch Angle	Flat to ascending.	Ascending.	Flat.

Feature	Coastal	Lulu	Inland
Internodal Branches	Generally absent.	Absent.	Prevalent.
<u>C. Needles</u>			
Colour	Rich, dark green.	Metallic grey-green.	Light green—yellow green.
Length	Short, $\frac{1}{2}$ to $2\frac{1}{2}$ inches.	Short, $\frac{1}{2}$ to 2 inches.	Long, 2 to 4 inches.
Retention and Appearance	2 to 6 years. Appressed to stem in first year, straight.	2 to 6 years. Stand out from stem, straight.	1 to 4 years. Loosely standing out from stem, wavy.
<u>D. Flowering</u>	Female confined to upper $\frac{1}{3}$ male to lower $\frac{2}{3}$ of crown, flowers 5-15 years.	Profuse, regular male and female flowering all over crown.	Not very prolific, cones retained on stem and branches for many years.
<u>E. Growth Form</u>	Very vigorous growth both in height and diameter, complete suppression of ground vegetation except on poor sites.	Height and diameter growth poor, no suppression of ground vegetation.	Height growth moderately good, diameter growth poor, moderate suppression of ground vegetation on good sites.
<u>F. Stability</u>	Prone to wind blow.	Not very prone to wind blow.	Not very prone, only odd trees.