

# FROST UPHEAVAL IN AVALON PENINSULA PLANTATIONS

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## Frost Upheaval in Avalon Peninsula Plantations

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### Introduction

In 1966 a number of areas of barren heathland on the Avalon Peninsula in Newfoundland were plowed with a Parkgate tine plow under the supervision of the Department of Forestry and Rural Development. The following spring most of these areas were planted with a variety of species, chiefly spruces. Plantations were inspected periodically and at the end of the winter of 1967-68 it was found that a high proportion of the trees had been lifted or washed partially or completely out of the ground, apparently as a result of frost action.

This situation warranted further investigation so a careful examination of one of the worst affected areas, at Come-by-Chance, was made in July 1968. Several other areas were also examined but less intensively. Most of the frost-lifted trees, except those on the Come-by-Chance examination area, were replanted in a salvage operation before July.

### The Area

The plowed and planted areas at Come-by-Chance lie on small rounded hills on either side of the Trans Canada Highway about two miles south of the Come-by-Chance junction, on the barren windswept isthmus of Avalon. On the east side of the highway lies area 66-4-1 which was examined intensively.

This area occupies 7.1 acres on three sides of a small knoll completely exposed in all directions except possibly east and southeast. The soil is a

stony sandy loam underlying about six inches of organic matter. The natural vegetation is dominated by ericaceous dwarf shrubs with a few small stunted black spruce and birch trees.

Plowing was carried out in an east-west direction and in most places parallel to the slope. Furrows are spaced five to six feet apart. Almost all of the area was planted with black spruce 2-1 stock of central Newfoundland origin.

#### Method of Examination

In seven rows selected systematically, every tree was examined, making a total of about 750 trees. For each tree the following items were noted: length of shoot, length of exposed root, planting location, planting site condition, plant condition. For consecutive groups of ten trees, general notes were made of slope, aspect, soil texture, organic matter depth (before plowing) and condition of furrows. This was done to obtain a general picture of site conditions. Only items referring to individual plants were subjected to detailed analysis.

The term, planting location, refers to the position of the tree relative to the furrow cross-section. This was variously identified as bottom, bottom corner, side, upturned slice, edge or slice, or 'bottom hole' (see Diagram 1). The last term was applied when the tree was planted in a position where the furrow was much narrower than usual, thus creating a very sheltered situation.

Planting site condition refers to the nature of the planting medium. Numerous categories were identified in the field but these may be grouped under the following headings: mineral soil, mineral soil with a thin wash of organic material, mineral soil with a thin unwashed organic top, thin

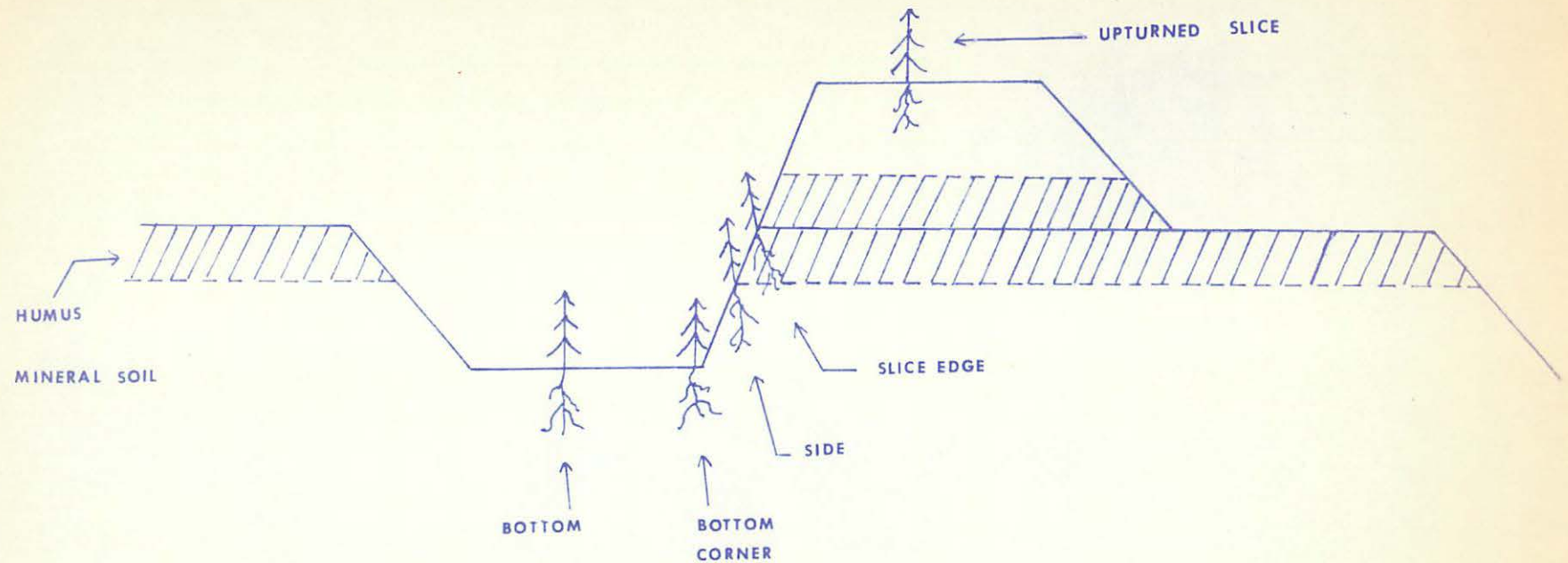


DIAGRAM - 1

PLANTING LOCATION IN PLOUGH FURROW

VERTICAL SECTION



mineral soil over organic matter, washed organic matter, and relatively undisturbed organic matter. The terms 'wash of organic material' and 'washed organic matter' were applied to a layer of very finely divided organic particles which appeared to have been washed out of the original organic matter layer. The latter term, 'washed organic matter, without reference to mineral soil was used when the organic layer was more than one inch deep.

Under plant condition a number of stages were recognized between live normal trees and completely dead trees. These may be grouped as: live, likely to survive, unlikely to survive, and dead.

#### Results

The relationships between planting location and planting site condition, between plant condition and planting location, and between plant condition and planting site condition, are shown in Tables 1 to 3, respectively.

Mineral soil overlain by small amounts of organic matter is found almost exclusively in the furrow bottom and to a lesser extent in the bottom corner position (Table 1). The situation where mineral soil overlies organic matter is associated with the overturned slice. Relatively undisturbed organic matter is found in all positions, though more often on the overturned slice. It is in the furrow bottom that organic matter is most subject to washing.

Table 2 indicates a survival gradient from the furrow bottom planting position, where very few trees survive, to the top of the overturned slice which seems the best situation for survival. Bottom corner, side and

'bottom hole' positions present intermediate conditions in which approximately the same number of trees survive as perish.

Table 3 makes it very clear that unless a tree was planted where there was a reasonable amount of organic matter over the mineral soil, or in mineral soil over organic matter, its chances of survival are very low. A thin organic layer is better than bare mineral soil but best of all is a thick, relatively undisturbed organic matter layer. The superiority of the overturned slice as a planting location is again reflected in the high survival rates on mineral soil over organic matter.

Figure 1 shows the average length of exposed roots and shoots in different planting locations. Obviously frost-heaving was greatest in the bottom and bottom corner positions while trees on the top of the slice or in the sheltered 'bottom hole' position were heaved very little or not at all. It is perhaps noteworthy that average shoot length is longer in sheltered 'bottom hole' and bottom corner positions than in the fully exposed slice-top positions.

Figure 2 shows the average lengths of exposed roots and shoots under different planting site conditions. Frost heaving occurred to almost the same degree on mineral soil overlain by a thin organic layer as it did on bare mineral soil. Previous examinations suggested that heaving was not severe where thin organic matter was present, but this study shows that the organic layer must be relatively thick and preferably undisturbed by washing action in order to help prevent frost-heaving. Once again the most favourable condition appears to be a mineral soil layer over organic matter as found on the overturned slice.



TABLE I

PERCENTAGES OF DIFFERENT PLANTING LOCATIONS ASSOCIATED WITH PARTICULAR  
PLANTING SITE CONDITIONS

Planting site condition	Planting location						Total	No. of Observations
	Bottom	Bottom Corner	Side	Upturned Slice	Slice Edge	'Bottom Hole'		
Mineral soil	90	8	2	0	0	0	100	322
Mineral soil with organic wash	85	13	1	0	0	1	100	137
Mineral soil with thin organic layer	80	14	2	0	0	4	100	190
Mineral soil over organic matter	0	3	16	69	12	0	100	32
Washed organic matter	69	21	10	0	0	0	100	29
'Undisturbed' organic matter	25	19	11	33	3	9	100	36
Average	79	11	3	5	1	1	100	

TABLE 2

PERCENTAGES OF TREES IN DIFFERENT CONDITION CLASSES ASSOCIATED WITH  
PARTICULAR PLANTING LOCATIONS

Planting location	Plant condition				Total	No. of Observations
	Live	Likely to survive	Unlikely to survive	Dead		
Bottom	9	6	46	39	100	611
Bottom Corner	20	19	49	13	100	89
Side	36	9	41	14	100	22
Upturned slice	86	0	6	8	100	35
Slice edge	80	0	0	20	100	5
'Bottom Hole'	58	0	42	0	100	12
Average	16	7	44	33	100	

TABLE 3

PERCENTAGE OF TREES IN DIFFERENT CONDITION CLASSES ASSOCIATED WITH  
PARTICULAR PLANTING SITE CONDITIONS

Planting site condition	Plant condition				Total	No. of Observations
	Live	Likely to survive	Unlikely to survive	Dead		
Mineral soil	6	4	44	47	100	331
Mineral soil with organic wash	7	5	61	27	100	146
Mineral soil with thin organic layer	15	14	45	26	100	191
Mineral soil over organic matter	65	3	12	20	100	40
Washed organic matter	30	11	52	7	100	27
'Undisturbed' organic matter	70	5	17	8	100	37
Average	16	7	44	33	100	

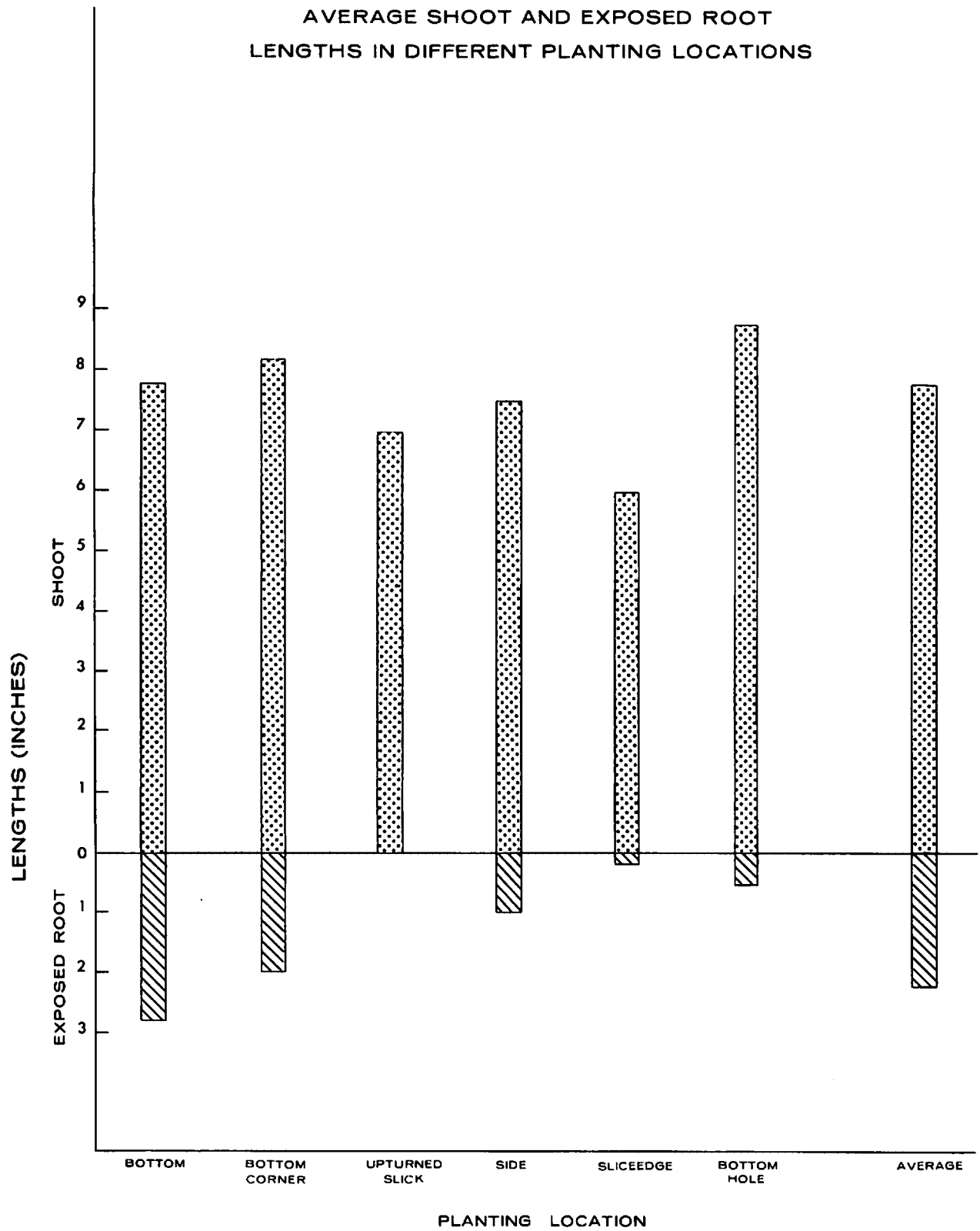


Figure 1

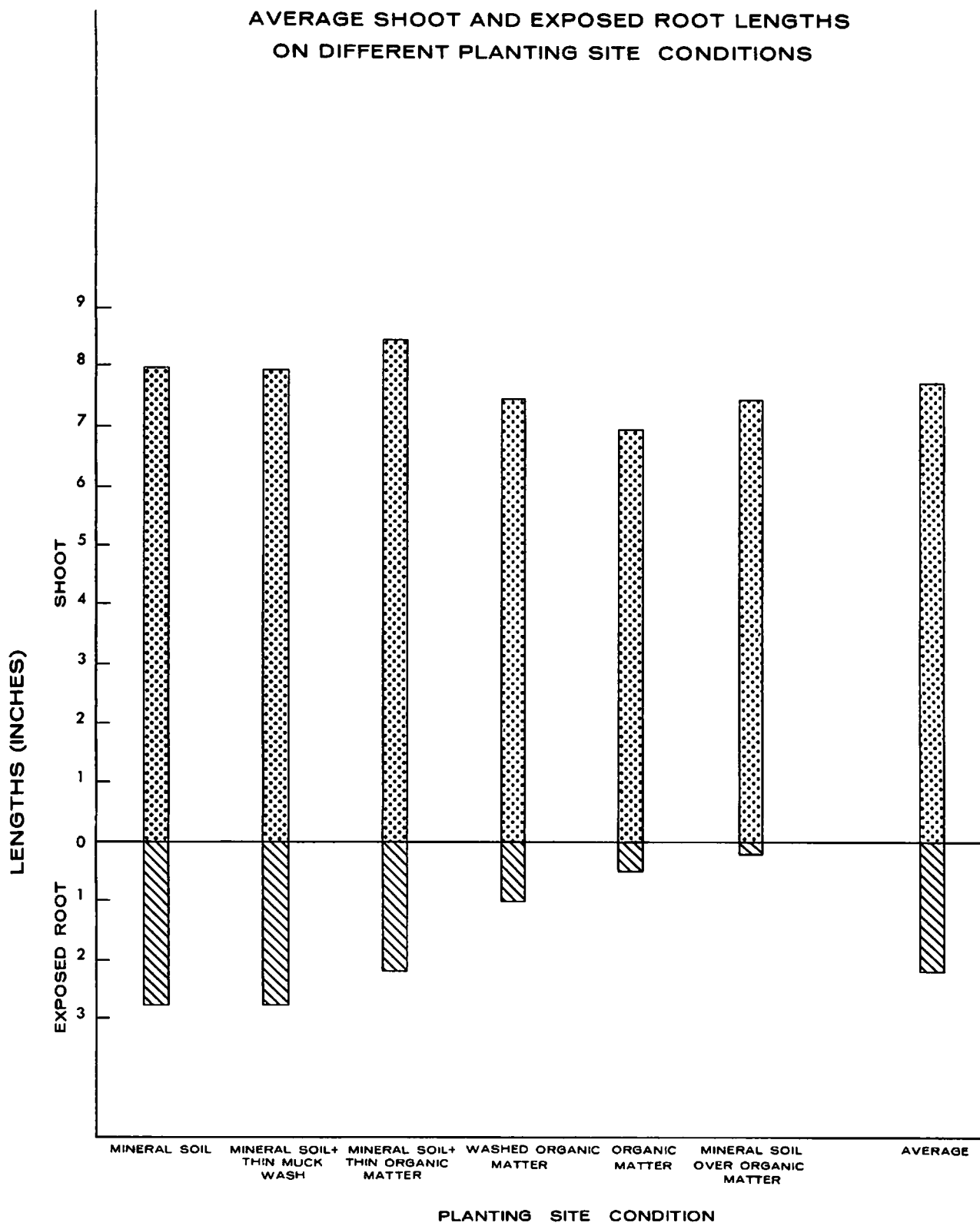


Figure 2

### Discussion

It seems clear that unless trees are planted in a situation where there is a reasonably thick organic layer, either under or over a mineral layer, they will be frost-heaved to such an extent that they are unlikely to survive. One inch of organic material appears to offer good protection but it must be compact (not loose or amorphous which makes it more subject to washing action).

The winter of 1967-68 on the Avalon Peninsula was characterized by unusually mild conditions and an almost complete absence of snow. The exposed mineral soil, without the protection of snow, vegetation or organic cover had no insulation against the alternate freezing and thawing and as a result trees were gradually lifted out of the ground. At the same time it appears that the soil in the furrow bottom was waterlogged which likely increased the degree of expansion on freezing and caused a considerable flow of water along the furrows on thawing. This had the effect of laying the lifted trees flat on the furrow bottom and in some cases completely covering them with washed mineral soil and organic muck. Some trees may also have been laid flat by washing along without prior lifting and in some situations the roots of trees exposed by frost-heaving may have been covered subsequently by material washed down the furrow. Surprisingly few of the frost-lifted trees were actually dead when examined. Many lying flat on the furrow bottom partly covered with debris still had green healthy foliage.

The majority of the trees planted on the overturned slice escaped lifting and washing since their roots were mainly in a well-structured, well-drained organic layer. Some roots were exposed in this position but this happened

chiefly where some mineral soil which was on top of the slice was washed down into the furrow. The length of root exposed in this way was rarely more than half an inch.

Although trees on the overturned slice largely escaped frost-lifting they have suffered badly from exposure. At the time of examination old needles on many trees were either blasted or fallen and new growth was limited compared with that on trees in the bottom of the furrows.

An examination of the plowed areas at Come-by-Chance where the frost-lifted trees had been replanted revealed that most of the trees were alive and producing new growth if somewhat slowly. Time will show whether the replanted trees will continue to grow and develop satisfactorily.

Finally, and by way of contrast, some mention should be made of another plantation on plowed ground at Avondale on the Avalon Peninsula. This plantation lies on a long ridge which is open to southwest and west, but is probably slightly less exposed than the Come-by-Chance area. The soil is a relatively well-drained stony sandy loam with about 50 percent stones in the furrows. The organic layer is relatively thin, not more than three or four inches deep. The vegetation is typified by ericaceous dwarf shrubs, particularly Vaccinium angustifolium Ait., but there is also a high proportion of fine grass coming up all over the plowed and unplowed soil, its development may have been stimulated by the plowing.

Plowing and planting were carried out at the same time as at Come-by-Chance. A variety of spruces and pines, and some larch were planted. Frost heaving was apparently quite severe here also but all trees had been replanted by the time this examination was made and most of the trees were healthy and



growing vigorously. The larger pine and larch were doing particularly well.

Perhaps the most interesting observation at Avondale was that the mineral soil exposed by plowing is rapidly becoming stabilized by the invading grass and other herbaceous species. This is a promising sign and perhaps frost-heaving will not be as severe at Avondale in future years.

### Conclusions

A number of reasons were responsible for the serious frost upheaval situation in 1967-68 on the Avalon. These are mentioned below as well as procedures which should reduce the risk from such phenomena in the future.

The immediate and direct cause of the frost-heaving was the meteorological conditions experienced during the winter of 1967-68. The relatively mild winter with little or no snow was unusual for the Avalon but certainly not uncommon. Such a winter might be experienced once in every ten years, and therefore cannot be dismissed as a freak. Attendant site conditions also increased the chances and severity of damage. The soil at Come-by-Chance was waterlogged and unless protected by a coherent organic structure must have expanded considerably on freezing. Moreover because of the abundance of water much washing action took place along the furrow bottom after thawing. These problems could be minimized by a careful choice of planting location and by improving drainage in the furrows. The latter could be accomplished by use of a longer tine on the plow and the amount of washing could be decreased by lessening the furrow slope. Trees planted in the furrow bottom on such areas should suffer less risk of damage.

A simple solution is suggested by the present appearance of the Avondale area. Planting might be delayed until natural vegetation was established in the furrows; the soil would then be stabilized and protected to some extent from alternate freezing and thawing. On the other hand this vegetation might present serious competition to the young trees which could be more serious than the frost-heave problem.

Still another solution might be to use larger planting stock. Such trees might be planted with their roots below the layer of alternately freezing and thawing ground. There is some possibility that species such as pines and larches which become established rapidly and have deep root systems might give better results. Perhaps such species could be planted in strips as shelterbelts some five or six years before planting the rest of the area with the more valuable spruces.

In all this work, the economic aspect must be remembered. If replanting the frost-lifted trees results in a satisfactory plantation, as appears likely, it is possible that this may be more feasible than elaborate and possibly costly plowing and planting modifications.