FOREST PLANTINGS ON A WET SITE IN MICHIGAN

W. A. Lemmien, V. J. Rudolph, and J. F. Marzec

ABSTRACT.—Seven species—black spruce, white spruce, Norway spruce, Scotch pine, European larch, tamarack, and cottonwood—were planted on a wet site in southern Michigan on: (1) furrow slices made in the fall and planted the following spring, and (2) furrow slices made in the fall and planted the second spring after plowing. Eight-year survival was greatest on the newer furrows for all species, as was height growth except for tamarack, which grew equally well on both site conditions. For the best 150 trees per acre, total height growth for eight growing seasons averaged 13 feet for Scotch pine, European larch, and tamarack, and 6 feet for black spruce, white spruce, and Norway spruce.

IN the Lake States region, when the original forest cover is removed on poorly drained areas, a heavy vegetative cover usually becomes established rather quickly and competes severely with both planted and natural tree seedlings. Hence such sites are difficult to reforest.

Nevertheless, a desirable land use for many of these areas is timber production. This report presents results of a fairly successful plantation establishment effort on a wet site in the W. K. Kellogg Forest near Battle Creek, Mich.

Previous Work

There has been little study of reforesting wet sites in Michigan. Previous attempts at establishing forest trees on a poorly drained site in the W. K. Kellogg Forest were unsuccessful. In New Hampshire, white pine (*Pinus strobus* L.), white spruce (*Picea glauca* [Moench] Voss), red spruce (*P. rubens* Sarg.), and red pine (*P. resinosa* Ait.) planted in plowed furrows showed better survival and height growth than in unbroken sod (*1*). In northern Wisconsin, Stoeckeler (*3*) found that survival and height growth of white spruce, Norway spruce (*P. abies* [L.] Karst.), black spruce (*P. mariana* [Mill.] B.S.P.), white pine, and white ash (*Fraxinus americana* L.) were increased when plantings were made on the plow lay rather than the bottom of the furrow or on scalped areas. Wilde and Voigt (*4*) obtained similar results with 3-0 white pine planted on Superior clay soils in northern Wisconsin. Scholz and Hovind (*2*) found that black spruce in northeastern Wisconsin also demonstrated superior survival and height growth when planted on furrow slices instead of in the furrows. In all of these studies, furrow slices were either freshly plowed, or had been plowed in the fall before planting in the spring.

THE AUTHORS are, respectively, resident forester, W. K. Kellogg Forest; professor of forestry; and former graduate research assistant, Dept. of Forestry, Michigan State University, E. Lansing. Published with the approval of the director of the Michigan Agric. Expt. Sta. as Jour. Art. No. 3988.

Methods

In the present study, the age of furrow slices is examined as a factor in the survival and growth of planted trees on a wet site. The following treatments were used: (1) furrow slices made in the fall and planted the following spring; and (2) furrow slices made in the fall and planted the second spring. Spring-plowed furrow slices were not considered, since these areas are usually too wet in the spring to permit plowing. A four-replicate split-plot design was used, with individual plots containing 80 trees.

The planting area is a level to gently sloping lowland of flood plain origin. The vegetation consisted mainly of sedges, grasses, some sweet clover, and scattered woody shrubs and hardwoods. All woody vegetation was sprayed with a foliar application of 2,4,5-T in August 1955, a year before the first furrowing. The soils consist of Sebewa loam, which has a sandy silt loam surface, and Houghton muck, a relatively shallow muck; both have a poorly drained, mottled gravelly clay subsoil. Soil moisture content is usually high, and fairly constant throughout the growing season.

Table 1.—Soil Moisture Content for Two Growing Seasons

	1958						
Location	May 7	May 14	May 28	July 9	Aug. 4	Aug. 27	Sept. 22
				percent			
Undisturbed sod	81	85	75	99	68	94	93
Bottom of furrow	86	94	90	100	86	96	95
Within the slice	84	82	44	92	19	84	90
Under the slice	84	96	75	98	49	64	71
	1959						
	April 14	May 1	May 15	June 5	June 19	July 13	Aug. 25
				percent			
Undisturbed sod	93	98	98	99	59	39	95
Bottom of furrow	97	100	99	100	75	66	99
Within the slice	91	98	93	91	27	4	70
Under the slice	94	98	98	100	49	12	80

Furrows were made 6 to 8 inches deep on half the area in October 1956, and on the other half in October 1957.

Species and class of stock that were shovel-planted on the furrow slices in April 1958, at a spacing of 6 by 7 feet, were: 1-0 cottonwood (*Populus deltoides* Bartr.); 2-0 tamarack (*Larix laricina* [Du Roi] K. Koch); 2-1 white spruce; 2-1 black spruce; 2-1 Norway spruce; 2-0 European larch (*Larix decidua* Mill.); and 2-0 Scotch pine (*Pinus sylvestris* L.). At the time of planting, the vegetation on top of the older furrow slices was of moderate density, while the newer slices were bare (Fig. 1).

To follow the seasonal trend of soil moisture in the study area, eight soil moisture measuring stations were established in May 1958, with four Bouyoucos soil moisture blocks at each location. One block was placed about 5 inches below the surface in the undisturbed sod midway between two furrows, the second about 4 inches below the surface in the bottom of the furrow, the third in the center of the furrow slice, and the fourth about 5 inches below the bottom of the slice. Soil moisture readings were taken approximately weekly during the first two growing seasons after planting. Because of consistently high moisture readings during both growing seasons, readings were discontinued after 1959.

Fig. 1—The area at the time of planting in April 1958; (top), furrowed in October 1956; (bottom), furrowed in October 1957.

Table 2.—Survival After 1, 5, and 8 Growing Seasons

Species	1 growing season		5 growing seasons		8 growing seasons	
	Newer furrows	Older furrows	Newer furrows	Older furrows	Newer furrows	Older furrows
	percent					
Black spruce	95.8	95.0	88.2	91.0	84.5	86.2
White spruce	99.0*	85.8	90.5**	75.2	88.2**	72.8
Norway spruce	98.8	98.0	94.5	94.8	91.8	91.0
Scotch pine	98.5	96.0	94.8	89.8	93.2	89.0
European larch	90.0*	75.0	82.5**	58.0	80.2**	52.8
Tamarack	95.5**	86.8	81.2	73.0	72.0	65.0

* Significantly higher at the 5 percent level.
** Significantly higher at the 1 percent level.

First-, fifth-, and eighth-year survival data are included in this report. Height growth data after 5 and 8 growing seasons are for the tallest 150 trees on a per-acre basis. Almost all the cottonwood died the first year, apparently because of the very small planting stock used—the 1-0 seedlings were less than 6 inches tall. Thus, cottonwood was eliminated from the study.

Results and Discussion

Soil moisture.—Soil moisture content was high for all treatments during most two growing seasons (Table 1). Only in the center of the furrow slice may there have been a temporary moisture deficiency.

Survival.—There were relatively small differences between survival for the two furrow slice conditions for all species combined. The average survival for the newer furrow slices (plowing in the fall and planting the next spring) was greater at each inventory than for the older furrow slices (plowing in the fall and planting two springs later), but only at the end of the first growing season was the difference significant (at 5 percent).

Among the six species, there were important differences between average tree survival for each year (Table 2). On the newer furrows, survival of white spruce, Norway spruce, and Scotch pine ranked high, with European larch and tamarack significantly lower. On the older furrows, Norway spruce and black spruce had high survival, while that of white spruce, European larch, and tamarack was significantly lower. For individual species, important differences between survival on the newer and older furrows occurred with white spruce, European larch, and tamarack.

Table 3.—Height Growth of the Best 150 Trees Per Acre, After 5 and 8 Growing Seasons

Species	5 growing seasons		8 growing seasons	
	Newer furrows	Older furrows	Newer furrows	Older furrows
	feet			
Black spruce	4.6	4.1	6.5	5.9
White spruce	3.8**	3.3	5.3	4.5
Norway spruce	4.5*	3.4	6.9*	4.8
Scotch pine	7.6	7.2	12.9	12.0
European larch	7.4	6.1	13.7	11.3
Tamarack	8.3	8.3	12.8	12.8

* Significantly taller at the 5 percent level.
** Significantly taller at the 1 percent level.

Height growth.—For all species except tamarack, height growth was greater on the newer furrows than the older ones, although the differences were significant only for white spruce and Norway spruce five growing seasons after planting, and for Norway spruce after eight growing seasons (Table 3). Tamarack grew equally well on both furrow conditions.

Height growth of the six species can be placed into two classes—the three spruces in a slow growth class, and Scotch pine, European larch, and tamarack in a rapid growth class. The large differences between these growth groups were highly significant at both height measurements.

White spruce and Norway spruce suffered severe damage from late spring frosts in 1961 and 1963. Although survival was not affected, their height growth was seriously retarded. There was light frost damage on European larch. Since many wetland sites are natural "frost pockets," susceptibility to frost damage may be an important consideration in selecting species for planting on similar sites.

Conclusions

The year's delay in planting the older furrows, intended to permit the herbaceous material between the furrow slice and the soil beneath to decay and for the slice and the soil beneath to unite, apparently was not necessary. Both survival and height growth were higher on the newer slices. The rapid resurgence of grass and herbaceous vegetation on the older furrows,

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Thomas W. Beers

Slope Correction in

ABSTRACT.—Ignoring the correction for sloping terrain in horizontal point sampling leads to biased estimates of forest parameters. Slope, if present, must be corrected for in all careful timber inventories. The two general types of slope correction, the constant and the variable gauge angle techniques, are discussed and certain aspects are explored in depth.

THE ARTICLE by Del Hodge (*4*) fills a void in the theory of slope correction for horizontal point sampling. But there appears to be a more direct way of describing his method of slope correction and refining its application. The present article attempts such refinement. An additional purpose is to place the Del Hodge concept in the existing framework of point-sampling slope correction and to compare it with other methods commonly used.

Correction for slope in horizontal point sampling can be made in two general ways as discussed by Grosenbaugh (*5*). These can be referred to as the *constant gauge angle technique* and the *variable gauge angle technique.*

The constant gauge angle technique in the usual application does not require prism rotation but relies on the use of a constant correction factor at any given sample point, depending upon one slope measurement (made perpendicular to the contour through the point). In theory this amounts to establishing concentric circles on the slope which project to the horizontal as slightly undersize ellipses, necessitating a multiplicative correction greater than 1.0 to subsequent estimates of the various forest parameters.

THE AUTHOR is associate professor of forestry, Dept. of Forestry and Conservation, Purdue University, Lafayette, Ind. Paper published with the approval of the Director, Purdue Agric. Expt. Sta. as Journal Paper No. 2844.

The variable gauge angle technique (*1*), on the other hand, might require adjustment of the gauge angle itself for a number of trees at each point. This is accomplished by using a self-correcting gauge such as a relascope, or by prism rotation in an amount equal to the slope of the line of sight to each questionable (nearly borderline) tree. In theory, this implies the establishment at each point of slightly enlarged concentric ellipses (with the long axis perpendicular to the contour) which project to the horizontal as proper-area circles.

With the appearance of the Del Hodge article it became apparent that the correction for slope can be achieved through yet another approach. It is probably best described as an "adjusted constant gauge angle technique," since only one slope measurement at a point is needed, leading to one prism rotation, resulting in an adjusted (reduced) gauge angle which remains constant *at that point.* The analogous type of correction for fixed-radius plots was proposed by Bryan (*3*) whose reasoning apparently was—instead of laying out concentric ellipses on the slope which project as proper-area horizontal circles, why not lay out concentric circles on the slope which project as proper-area ellipses? Such phrasing is adequate for fixed-radius plots but the theory of horizontal point sampling demands thinking in terms of horizontal circles. Therefore the Del Hodge approach must be thought of as establishing enlarged circles on the slope which project to horizontal ellipses having the same area as proper horizontal circles.

In this enlarged slope-circle technique two basic derivation problems exist. Assuming one slope measurement is made perpendicular to the contour through the sample point they are:

which was well underway by the time the trees were planted, very likely offset any advantage of greater union between the slice and the soil beneath.

All six species have shown high survival. Scotch pine, European larch, and tamarack have shown the best height growth, but even the slower growing spruces have achieved dominance over the surrounding vegetation.

Eight growing seasons after planting, the tallest 150 trees per acre of each species have emerged above the competing herbaceous vegetation, and increasing height growth has taken place for the past two growing seasons. The majority of these stems should become components of the final crop-tree stand.

Because wet sites usually cannot be plowed in the spring, they should be furrowed in the fall, which is generally the driest season of the year. Planting on the furrow slice should follow the next spring as early as possible.

Literature Cited

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-Iorizontal Point Sampling

1. What is the radius (R_S) of the enlarged slope circle for given tree diameter (D), basal area factor (F), and degree of slope (S)?

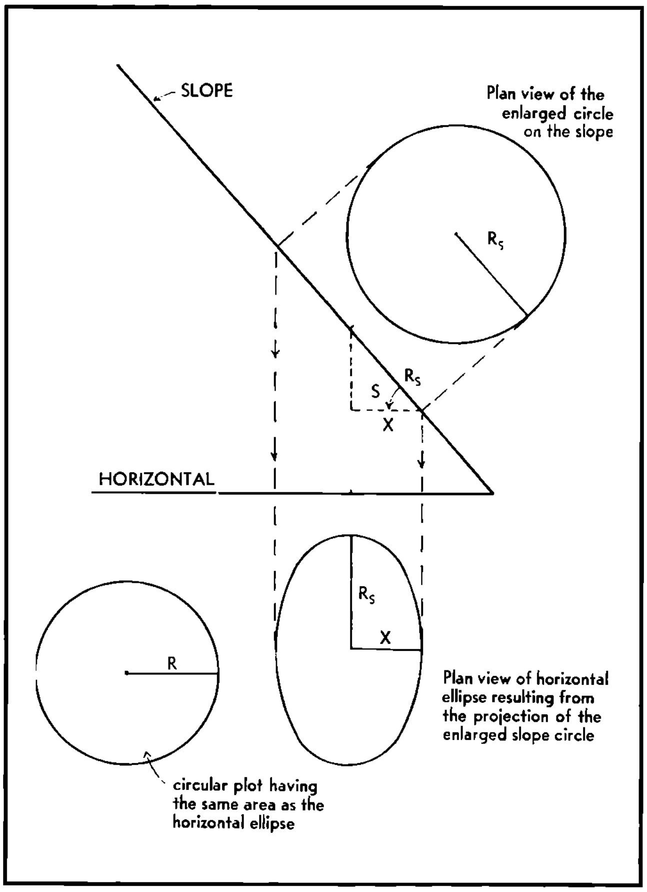

Fig. 1.—The geometry of the Del Hodge enlarged slope-circle slope correction technique.

2. Through what angle (β) must a prism be rotated to obtain the simulated horizontal picture—that is, to insure the proper angular relation between R_S and the radius (R) of the pertinent proper-area horizontal *circle?*

To develop a formula for R_S, consider Figure 1, where the enlarged slope circle is projected to a horizontal ellipse having the same area as the "associated circular plot."

Now,

slope circle area $= \pi R_s^2$,

and ellipse area $= \pi R_s X$,

$= \pi R_s (R_s \cos S)$

since R_s = major half axis

and X = minor half axis $= R_s \cos S$.

Equating the proper circular associated plot area with this ellipse area we have

$$\pi R^2 = \pi R_s (R_s \cos S)$$

$$R^2 = R_s^2 \cos S$$

therefore

$$R_s = \frac{R}{\sqrt{\cos S}} \qquad (1)$$

Substituting for $R = (PRF)(D) = \dfrac{33\sqrt{10}\,D}{12\sqrt{F}}$ leads to

$$R_s = \frac{(33\sqrt{10}\,D) \,/\, (12\sqrt{F})}{\sqrt{\cos S}}, \qquad (2)$$