Forest Site Management Section
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SILVICULTURE NOTE 22

SETTLING OF MECHANICALLY PREPARED MOUNDS IN NORTHERN BC: 10-YEAR SUMMARY

Introduction

Mechanical mounding is a common site preparation technique in BC, particularly in northern areas of the province where low soil temperature, excess soil moisture, and the shading and snowpress associated with competing vegetation can severely limit seedling performance. The benefits of mounding on harsh sites are now well documented, largely as a result of site preparation trials initiated in the mid-1980s. One such study was established at four sites in northern BC to measure the effectiveness of various mounding implements (Hedin 1987, 1989). As part of that project, dimensions of mounds created by Ministry and Bräcke mounders were measured at the time of installation, after one winter, and after planting had taken place. In order to provide more information about the settling process for mechanically prepared mounds, dimensions were remeasured five and 10 years after installation. This memo summarizes relevant information about mound dimensions from the original study and discusses changes to the height, width and length of mounds over a 10 year period.

Mounding Implements

The Ministry mounder employed in this trial had digging buckets mounted on a Cat D7E crawler equipped with floatation tracks and a V-blade, and was a prototype for later versions of the machine. As the Cat moved forward, the digging buckets were driven into the ground by hydraulic pressure, raised, and then flipped over to deposit an inverted mound of soil material. At the Mackenzie and Vanderhoof sites, where slash was heavier than at the other sites, the V-blade on the Cat was used to remove debris prior to mounding. Mounds created with the Ministry mounder are similar to those created by an excavator, which is currently the mounding implement of choice in BC.

The Bräcke mounder was an adaptation of the Bräcke cultivator used in Scandinavia and Canada for patch scarifying. It was equipped with a mattock wheel that turned as the machine moved forward, creating scarified patches and collecting inverted accumulations of surface material. A shovel mechanism then dug additional mineral soil out of the scalp and deposited it on top of the mound of organic material. The Bräcke mounder was not equipped with a blade, so at the Mackenzie site, mounds were often deposited over a considerable amount of slash.

Measurements

Height, length and width of mounds were measured in 1986, 1991 and 1996. Height was also measured in 1987, following settling over the first winter (Hedin 1987), and in 1988, following planting (Hedin 1989). The 1991 and 1996 measurements included the entire population of mounds installed for the experiment, whereas Hedin measured a randomly selected subset of mounds, classifying them as 'acceptable' or 'unacceptable.' To

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Table 1. Characteristics of the study sites

	Stewart Lake	Iron Creek	Mackenzie	Vanderhoof
Site characteristics				
Latitude	55°54'N	56°37'N	55°13'N	53°34'N
Longitude	120°59'W	122°18'W	123°01'W	124°38'W
Elevation	850 m	820 m	760 m	1036 m
BGC subzone	BWBSmw1	BWBSmw1	SBSwk2	SBSmc3
Moisture regime	mesic/subhygric	subhygric	mesic/subhygric	mesic/subhygric
Forest floor	5–20 cm moder	5–20 cm moder (mor)[a]	2–20 cm mor	2–17 cm mor (moder)
Soil texture	SL–CL	CL–SiCL	SiL–SL	SiL
Soil class	Gray luvisol	Gray luvisol	Dystric brunisol	Dystric brunisol
Coarse fragments	<2%	<5%	<2%	10% (20–35%)
Subzone climate[b]				
Mn. annual temp.	1.1°C	1.1°C	1.0°C	0.6°C
Frost-free days	150	150	80	not avail.
Mn. annual ppt.	485 mm	485 mm	905 mm	506 mm
Mn. annual snowfall	190 cm	190 cm	1075 cm	197 cm

[a] Parentheses indicate minor site components.
[b] Reynolds, G. 1989. Climatic data summaries for the biogeoclimatic zones of British Columbia. B.C. Min. For., Research Branch, Victoria, BC (unpublished).

ensure legitimate comparison between the 1986, 1991 and 1996 data sets, means and standard errors were re-calculated for the 1986 data set, to include both 'acceptable' and 'unacceptable' mounds. For this reason, means presented in this memo may differ slightly from those presented by Hedin (1987).

Results and Discussion

The settling process for Ministry and Bräcke mounds in this study can be divided into three phases: over-winter settling following installation, settling as a result of planting disturbance, and long-term settling. Changes to height are discussed for all three phases, but changes to length and width, which were measured only at five-year intervals, can be discussed only in relation to long-term settling.

Phase 1: Over-winter settling following mound installation (1986 to 1987)

Immediately following installation, Ministry mounds were 35 to 36 cm high at Stewart Lake, Iron Creek and Mackenzie, but only 27 cm high at Vanderhoof (Table 2). Mounds were probably smaller at Vanderhoof because the mounder had difficulty gathering adequate mineral material. The relatively shallow surface soil overlay dense basal till, and had a high coarse-fragment content. Height of Ministry mounds did not decrease over the first winter at Iron Creek and decreased by only 2 cm (6%) at Stewart Lake. Over-winter settling is thought to have been minimal at these sites for two reasons; first, there was little slash to prevent full contact between mound materials and the ground surface, and second, once dry, the clayey soil in the mineral cap was extremely resistant to sloughing. At Mackenzie, by comparison, the height of Ministry mounds decreased by 6 cm (17%) over the first winter, likely because the loose silt-loam to sandy-loam textured soil in the mineral cap sloughed and settled under the heavy snowpack. Ministry mounds at Vanderhoof decreased in height by 4 cm (15%) during the first winter, also probably because of settling and sloughing of the mineral cap. Soil at Vanderhoof was silt-loam in texture, with a higher coarse-fragment content than at other sites, and was loose following mound preparation. Across all locations, Ministry mounds in this study decreased in height by a maximum of 17% over the first winter. However, in a similar study in the Cariboo Forest Region, mounds settled by 67% over the first winter. This was due to the combined effects of fine-textured soil clumps disintegrating in the mineral cap and organic material settling within the mounds (Sutherland 1990).

Table 2. Mound height at installation, after over-wintering, and after planting (from Hedin (1987, 1989)

	Ministry mound height (cm)			Bräcke mound height (cm)		
	1986 Installation	1987 Over-winter	1988 Post-planting	1986 Installation	1987 Over-winter	1988 Post-planting
Stewart Lake	36	34	26	22	21	12
Iron Creek	36	36	24	20	20	14
Mackenzie	35	29	23	23	19	12
Vanderhoof	27	23	19	*no Bräcke mounds at Vanderhoof*		

Bräcke mounds generally consisted of several disconnected deposits of material, and were smaller than Ministry mounds throughout the trial. Immediately following installation in 1986, Bräcke mounds were 20 to 23 cm tall at Stewart Lake, Iron Creek and Mackenzie. No Bräcke mounds were installed at Vanderhoof because of the compact, stony soil conditions. Bräcke mounds also settled over the first winter; they did not change in height at Iron Creek, settled by 1 cm (5%) at Stewart Lake, and decreased in height by 4 cm (17%) at Mackenzie. Because the Bräcke mounder was not equipped to clear slash prior to mound preparation, initial contact between mound materials and the ground surface was poor. The relatively large decrease in height at Mackenzie was likely due to the settling of slash materials under and within the mounds, as well as to settling and sloughing of mineral material.

Phase 2: Settling as a result of the planting process (1987–1988)

Mounds were planted in spring 1987 and their height was assessed one year later, in 1988. Planting had a more profound effect on mound height than any other single factor during the 10 year monitoring period (Figures 1, 2). Planters were instructed to break up the mineral cap with shovels and boots in order to place the root plug in contact with the inverted organic layers, which involved substantial alteration of the mineral cap. This was especially true of the blocky, high clay-content mounds at Stewart Lake and Iron Creek. Whereas settling over the first winter had little effect on the height of mounds at those sites, planting reduced height of Ministry mounds by 8 to 12 cm (24 to 33%) and height of Bräcke mounds by 6 to 9 cm (30 to 43%). Over-winter settling had been more

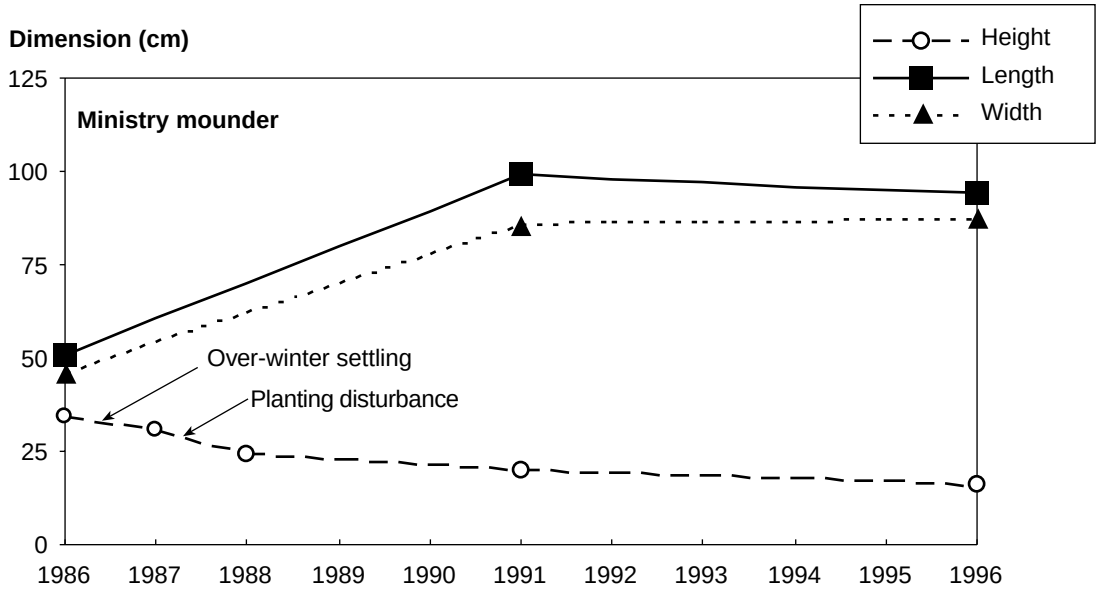

Figure 1. Dimensions of mounds created by the Ministry mounder, across all locations, from 1986 to 1996.

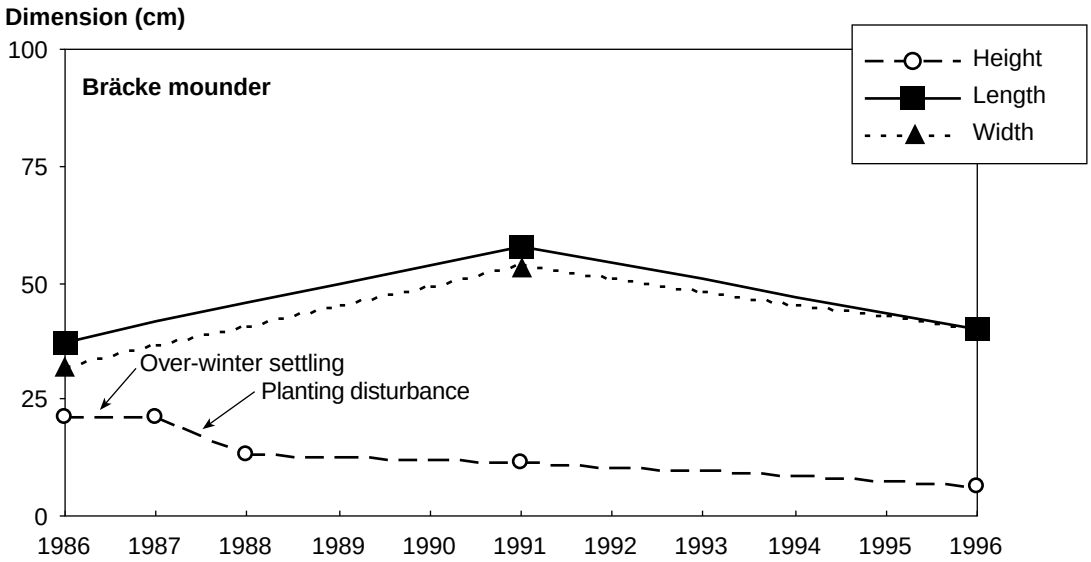

Figure 2. Dimensions of mounds created by the Bräcke mounder, across all locations, from 1986 to 1996.

substantial at Mackenzie and Vanderhoof, and less alteration of the mineral cap was required for planters to correctly place the seedling root plug. At Mackenzie, planting reduced the height of Ministry mounds by a further 6 cm (21%) and the height of Bräcke mounds by a further 7 cm (37%). At that site, planter activity probably contributed to breaking down slash materials incorporated into Bräcke mounds. At Vanderhoof, planting reduced the height of Ministry mounds by a further 4 cm (17%) from the over-winter height.

Phase 3: Long-term settling (1988–1996)

Mounds continued to settle between 1988 and 1996, assisted by frost action, rain and the weight of snow. Between years two and five after mound preparation (1988–1991), the height of Ministry mounds decreased by 0 to 5 cm across all locations and the height of Bräcke mounds decreased by 1 to 2 cm (Table 3). Between years five and 10 (1991–1996), Ministry mound height decreased by a further 2 to 7 cm, and Bräcke mound height by a further 4 to 6 cm. By 1996, Ministry mounds at Stewart Lake, Iron Creek and Mackenzie, which had originally been 36 cm tall, were 16 to 19 cm tall. Mounds at Vanderhoof, which had originally been 27 cm tall, were 12 cm tall. Bräcke mounds settled proportionally more than Ministry mounds during the 10 year monitoring period; at all sites, mounds that had initially been 20 to 23 cm tall were 6 to 7 cm tall by 1996.

In the first five years after mounds were installed (1986–1991), decreases in height were accompanied by increases in length and width among both Ministry and Bräcke mounds. Length and width increased by 60 to 120% among Ministry mounds, and by 28 to 90% among Bräcke mounds (Table 3, Figures 1, 2). It is assumed that the sloughing of mineral material from the mound cap and its displacement during planting were responsible for increases in length and width between 1986 and 1991, but since these dimensions were not measured in 1987 or 1988, it is impossible to be certain.

In the second five years (1991–1996), length and width of both Ministry and Bräcke mounds decreased (except at Stewart Lake), probably as a result of material at the mound perimeter settling into the surrounding terrain. During this period, the length and width of Ministry mounds decreased by 4 to 13%, and the length and width of Bräcke mounds decreased by 12 to 41%.

Sloughing of mineral soil from the mound cap likely played an important role in early mound settling, but by 1991, mounds on all sites except Vanderhoof were covered with dense vegetation that would have restricted the movement of soil (Figures 4, 5). Once mounds were vegetated, it is likely that decomposition of organic material within the mounds become the main factor governing settling. This is especially true of Bräcke mounds, which had less mineral capping than Ministry mounds and a higher proportion of organic material within the mound. Bräcke mounds were less consolidated than Ministry mounds at the time of installation, and after 10 years, they were small and poorly defined. By 1996, it was difficult to define the edges of Bräcke mounds, and 39% of those measured in 1991 were no longer discernible from the surrounding terrain. By comparison, only 11% of Ministry mounds measured in 1991 were no longer discernible from surrounding terrain in 1996.

Table 3. Mound dimensions from 1986[a] to 1996

	Ministry mounder						Bräcke mounder					
	1986		1991		1996		1986		1991		1996	
	Mean	s.e.	Mean	s.e.	Mean	s.e.	Mean	s.e.	Mean	s.e.	Mean	s.e.
Stewart Lake												
Height (cm)	36	0.7	22	0.4	19	0.4	22	0.6	11	0.3	7	0.3
Length (cm)	70	1.8	113	3.9	116	1.6	46	1.8	59	0.8	47	1.9
Width (cm)	53	1.1	93	1.0	105	1.4	36	0.9	52	0.8	46	1.8
Iron Creek												
Height (cm)	36	0.8	21	0.4	17	0.4	20	0.6	12	0.3	6	0.4
Length (cm)	35	1.0	77	0.8	74	1.6	29	0.9	51	0.7	34	1.8
Width (cm)	36	0.7	71	0.7	75	2.4	29	0.7	50	0.7	36	1.9
Mackenzie												
Height (cm)	36	0.7	23	0.4	16	0.4	23	0.7	12	0.3	6	0.4
Length (cm)	54	1.5	113	3.2	99	2.0	37	1.5	64	0.9	38	2.2
Width (cm)	42	0.8	92	0.9	87	1.8	31	0.9	59	0.7	37	2.1
Vanderhoof												
Height (cm)	27	0.5	15	0.4	13	0.4	*no Bräcke mounds at Vanderhoof*					
Length (cm)	44	1.1	96	0.9	87	2.3						
Width (cm)	46	0.8	88	0.7	83	2.2						

[a] Means and standard errors for 1986 were recalculated from original data to include both 'acceptable' and 'unacceptable' mounds described by Hedin (1987).

Figure 3. Newly installed Ministry mound at Iron Creek (1986).

Figure 4. Five-year-old Ministry mound at Iron Creek (1991).

Figure 5. Ten-year-old Ministry mound at Iron Creek (1996).

Conclusions

This study suggests that, within 10 years of preparation, Ministry mounds will settle by 49 to 56%, and Bräcke mounds by 68 to 75%. Although the long-term process of mound settling was similar on all four sites, height decreases in the first two years varied as a result of local differences in soil texture, soil density, coarse-fragment content, amount of debris incorporated into the mound, climatic conditions, and compaction of the mineral cap during planting. The least amount of early settling can be anticipated where soils have a high clay content, and where there is relatively little slash on site when mounds are prepared.

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