LOSSES OF

FORESTED LANDBASE

IN THE

PRINCE ALBERT MODEL FOREST

GOLDER ASSOCIATES

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A Report Submitted to:

THE PRINCE ALBERT MODEL FOREST ASSOCIATION

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1.0 INTRODUCTION

Current forestry, and other industry practices may be impacting the forested land base, through inefficient siting of certain forestry activities. The activities in question include roads, landings and other storage sites. Further, the duration and degree of impact to the land's capability to regenerate merchantable timber species is also of interest.

The present study was sponsored by the Prince Albert Model Forest Association (PAMF) and completed by Golder Associates Ltd. of Saskatoon. The study attempted to quantify the areal extent of forestry activities that impact the forest landbase, and evaluate the impact (e.g. reduced growth, semi-permanent removal from the forest harvest land base, permanent removal from the forest harvest land base).

It is recognized that productive forest is being lost to seismic lines and other non-forestry related rights-of-way (ROW) (transmission lines and pipelines), blowdowns, buffer strips and fires, however, these are beyond the scope of this study.

2.0 STUDY AREA

The Study Area was centred within the PAMF Study Area, within the Weyerhaeuser forestry lease area, north of Prince Albert. The general study area is located within the Mixedwood Ecodistrict of the Southern Boreal Ecoregion of central Saskatchewan.

Several candidate Study Sites within the Prince Albert Model Forest were considered for inclusion into the project. In consultation with Weyerhaeuser, Prince Albert Model Forest and Saskatchewan Environment and Resource Management personnel, three sites were chosen that were representative of the soils in the PAMF and provided easy access. Two study areas were situated on heavy soil, and one on sandy soil. The locations of the Study Sites are as follows:

Sandy Soil 1 Study Site

The Sandy Soil 1 Study Site is located along both sides of Highway #2, approximately 6.5 km north of the Highway #169 turn-off. The UTM coordinates of the Study Site boundary corners: 437930, 5990220; 437930, 5985200; 442020, 5990220; and, 442020, 5985200.

The last forest harvesting operations at the Sandy Soil 1 Study Site were completed in 1981-1982 (Roman Orynik, pers. comm. 1994).

Heavy Soil 3 Study Site

This site is located on the east side of Highway #2, bordering the west side of the Bittern Lake I.R. 218, extending from a point 7 km north of the Waskesiu turn-off, to the junction of Highways #2 and 169. The UTM coordinates for the Study Site boundary corners are: 440760, 5980260; 440760, 5972150; 443020, 5972150; and, 443020, 5980260.

The Heavy Soil 3 Study Site was first harvested in 1969-1970. and reharvested in 1984-85 (Roman Orynik, pers. comm. 1994).

Heavy Soil 4 Study Site

This site is located immediately north of the junction of Highway #926 (Snowfield Highway) and the Meeyomoot Trail. The UTM coordinates of the Study Site boundary corners are: 468500, 5990220; 468500, 5986100; 473040, 5986100; and, 473040, 5990220.

The most recent forestry harvesting operations on the Heavy Soil 4 Study Site were completed in 1978-1982 (Roman Orynik, pers. comm. 1994).

3.0 METHODOLOGY

3.1 GIS Mapping Component

The GIS component of the study was undertaken in phases. The digitized Forest Cover Map data for the relevant areas were obtained from the Saskatchewan Forestry Branch and Prince Albert Model Forest GIS personnel. Digitized data for existing road/trail systems and forest cover were selected and incorporated into maps for each of the three Study Sites, which were later plotted.

The GIS system was used to generate the total area for each of the Study Sites. In addition, harvested areas were delineated from 1984 aerial photography, and the corresponding area of harvested land base extracted with the GIS system.

Using the Road Construction Specifications provided by Weyerhaeuser, and in association with the previously completed field work, the roads within each of the three Study Areas were classified into one of the following categories: Class 1 - Main Haul Road (permanent), Class 4 - Main Access Bush Road, or Class 5 - Bush road. Weyerhaeuser personnel familiar with the road construction in the area were consulted to identify the different road classes present in the three Study Sites. The road classes were then assigned to the digitized road data..

To generate areas of land base originally disturbed during road construction, the right-of-way widths for Road Construction Specifications (Weyerhaeuser) were used: Class 1 - 61.0 m, Class 4 - 7.9 m and Class 5 - 6.1 m. The Class 1 roads (Hwy. #2, Hwy. #926 and the Meeyomoot Trail) in the Heavy Soil Sites, were considered to be half of the 61.0 m right-of-way width, as they formed portions of the boundaries of the Study Sites. All roads in the three Study Sites were buffered to the appropriate original disturbance right-of-way width with the GIS program and the areas for each road class right-of-way generated.

Width measurements of the travelled portion of the road rights-of-way (e.g. disturbed road area with decreased production of merchantable timber) were taken during the fall 1993 field program. Mean widths of disturbed area for each road class in the three Study Sites were used to establish the corresponding buffer width. The GIS program was then used to generate the land base area presently exhibiting a decreased production of merchantable timber species.

The difference in area between the original right-of-way disturbance during road construction and the existing amount of disturbance (areas not presently vegetated in the right-of-way) was generated with the GIS system. This difference represents the amount of the right-of-way that has successfully regenerated to merchantable timber species.

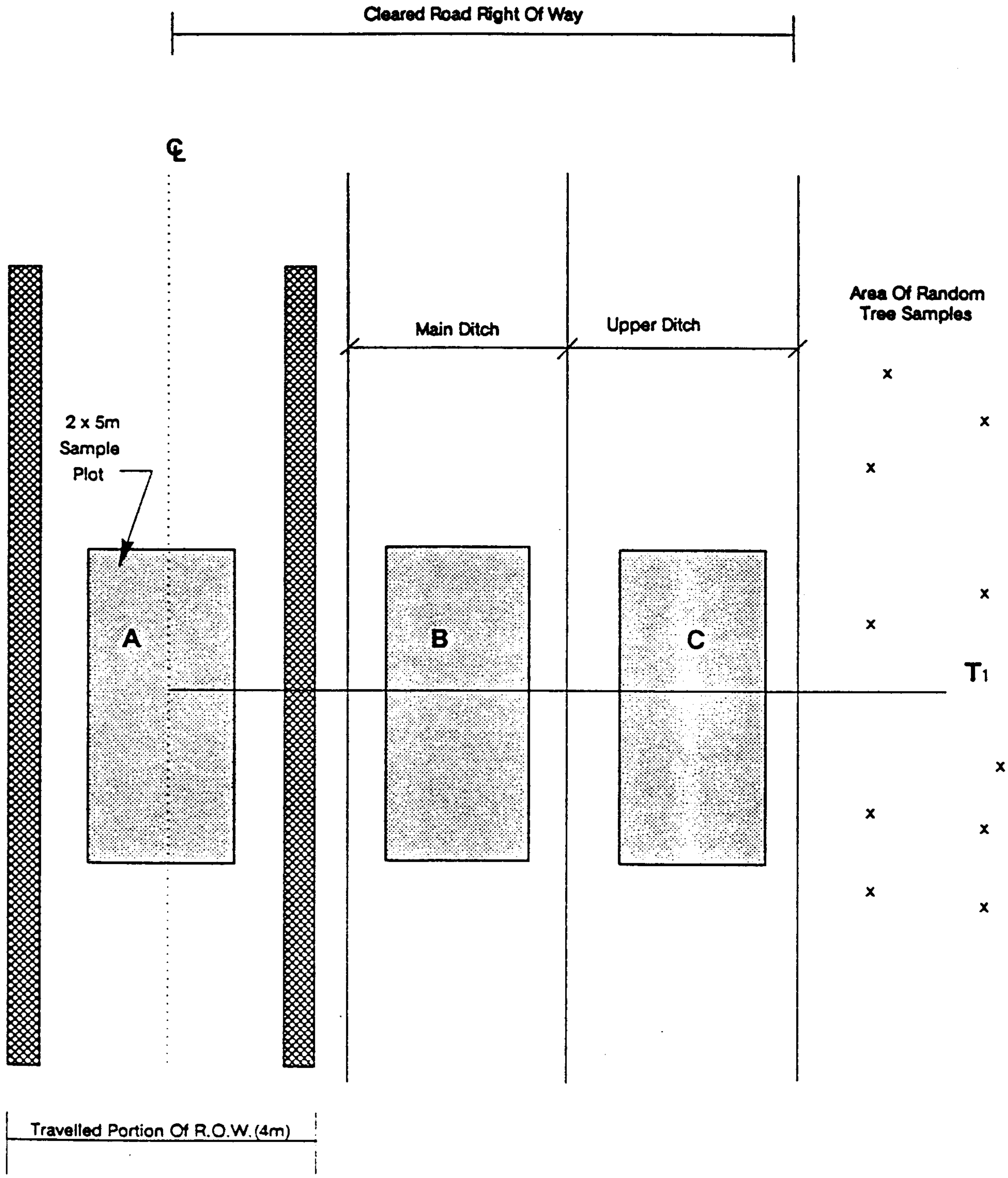
3.2 Field Measurements

A field program was implemented to obtain accurate measurements for tree heights and right-of-way widths. Field surveys were conducted on the three study sites during the period of October 28 - 29, 1993. For the purpose of this document, merchantable timber was assumed to be one of the following species: jack pine, black spruce, white spruce, balsam fir, trembling aspen, black poplar and tamarack. No distinction was made between naturally regenerating trees and planted trees.

Each of the Study Sites was visited and random sampling sites established on the different road classes found. As the trails and roads had not been classified on the forest inventory maps, the criteria outlined in Appendix I for road classes (supplied by Weyerhaeuser) was used in the field to determine the class of each road sampled. All road classes located within each Study Site were sampled. The field road classifications were later verified by Weyerhaeuser personnel in Prince Albert, familiar with the Study Sites and the road classes. Roads classified wrongly during the field trip were corrected as required.

At each random sample site within the Study Sites, 2 m by 5 m plots were established along a line perpendicular to the road trail. As shown in Figure 1, plots were established on the centreline of the road, the "main-ditch" (lowest concave portion of the ditch), and the "upper ditch" (typically contained the soil push-up and brush piles) of the cleared right-of-way. The height of all merchantable tree species within each of these plots were measured, and the information

Figure 1.
ROAD CLASS SAMPLING SITES



recorded on an information sheet. In addition, 10 trees of each merchantable species present in adjacent regenerating clear-cut or uncut areas of the end of the transect, were measured for height.

For the road classes in the Study Sites that did not have ditches associated with them, tree heights of merchantable timber species were taken on the road centre-line plot, as well as the trees selected at random in the regenerating or undisturbed tree cover adjacent to the road plot. Where determination of the extent of the original right-of-way disturbance could be made, measurements were taken of the width of the travelled portion of the road right-of-way, as well as the total disturbed width of the road right-of-way. In most instances, particularly for the class 5 roads, post-harvesting land manipulations and subsequent revegetation made it impossible to determine the extent of the original land disturbance during road construction, and only the existing road right-of-way width was measured.

In addition to the road system, landing sites were also investigated for regeneration of merchantable timber. On representative landings in each of the Study Sites, a maximum of ten trees for each merchantable species present were measured for height.

3.3 Statistical Analysis

For each of the merchantable tree species measured on the different road classes and Study Sites, the mean tree height was calculated and the standard error generated.

The mean tree heights of merchantable species on the roads, ditches and landings were compared statistically to the mean tree heights of merchantable timber species on the adjacent regenerating cut-over or undisturbed areas, using the Student's distribution test (Snedecor and Cochran (1980).

4.0 RESULTS AND DISCUSSION

The total area of each of the three Study Sites, and the harvested area within each site was generated with the GIS system, and the results presented in Table 4.1. Comprehensive data from each of the Study Sites is provided in following sections.

4.1 Impacted Forested Land Base Areas

Table 4.2 shows the right-of-way widths of the various road classes within the three Study Sites as measured during the field program. This measurement corresponds to the driveable portion of the right-of-way, often exhibiting sparse merchantable tree cover.

The existing road classes and land base area impacted (as compared to total Study Site area and harvested area within each Study Site), are presented for: the Sandy Soil 1 Study Site (Table 4.3); the Heavy Soil 3 Study Site (Table 4.4); and, the Heavy Soil 4 Study Site (Table 4.5). As no landing sites were delineated on the forest cover maps, no areas were generated for this component of the forested land base loss.

Sandy Soil 1 Study Site

The GIS map showing the Study Site and existing road class system is illustrated in Figure 2a.

In the Sandy Soil Site 1 Study Site, the Main Haul Road Highway #2 represented the greatest area lost at 26.65 ha or 1.47% of the total Study Site area. This impact to the forested land base rises to 11.41% of the harvested area within the Study Site.

This represents a permanent loss to the forested land base, not just due to road construction itself, but ongoing mowing of the ditches and maintenance required to keep Highway #2 operating to Saskatchewan Highways and Transportation standards.

Table 4.1
Total Areas for the Loss of Forested Land Base Study Sites

Study Site	Total Site Area (ha)	Harvested Area (ha)
Sandy Soil 1 Site	1808.91	393.35
Heavy Soil 3 Site	1531.78	846.21
Heavy Soil 4 Site	1023.68	233.60

Table 4.2
Measured Road Right-of-way Widths for the Road Classes within the Three Study Sites

Study Sites	Road Class Right-of-way Width (m)		
	Class 1	Class 4	Class 5
Sandy Soil l Site	61	0 *	4.11
Heavy Soil 3 Site	61	4.33	4.0
Heavy Soil 4 Site	61	4.15	5.25

* The value of 0 was used because the entire Class 4 right-of-way had been trenched and replanted. The assumption was that 100% of the right-of-way would support merchantable timber growth.

Table 4.3
Land Base Loss and Regenerated Merchantable Timber Areas on the Sandy Soil 1 Study Site Road System

	Main Haul Road	Class 4 Road	Class 5 Road	Totals
		Area (ha)		
Original ROW Disturbed in Study Site	26.65 (1.47%)* (11.41%)**	0.38 (0.02%)* (0.16%) **	14.63 (0.81%)* (6.26%)**	41.66 (2.3%)* (17.83%)**
Current Revegetation of ROW to Merchantable Timber	0.0	0.38	4.69	5.06
Area of Lost MerchantableTimber Production	26.65 (1.47%)* (11.41%)**	0.0 (0.0%)* 0.0%)**	9.95 (0.55%)* (4.26%)**	36.60 (2.02%)* (15.67%) **

* Based on disturbed road area divided by entire Study Site area.
** Based on disturbed road area divided by harvested area within the Study Site.

Table 4.4
Land Base Loss and Regenerated Merchantable Timber Areas for the Heavy Soil 3 Study Site Road Svstem

	Main Haul Road	Class 4 Road	Class 5 Road	Totals
		Area (ha)		
Original ROW Disturbed in Study Site	24.97 (1.63%)* (2.95%)**	20.58 (1.34%)* (2.43%)**	11.09 (0.72%)* (1.31%)**	56.64 (3.70%)* (6.69%)**
Current Revegetation of ROW to Merchantable Timber	0.0	9.62	3.82	13.44
Area of Lost Merchantable Timber Production	24.97 (1.63%)* (2.95%)**	10.96 (0.72%)* (1.30%)**	7.27 (0.47%)* (0.86%)**	43.28 (2.82%)* (5.11%)**

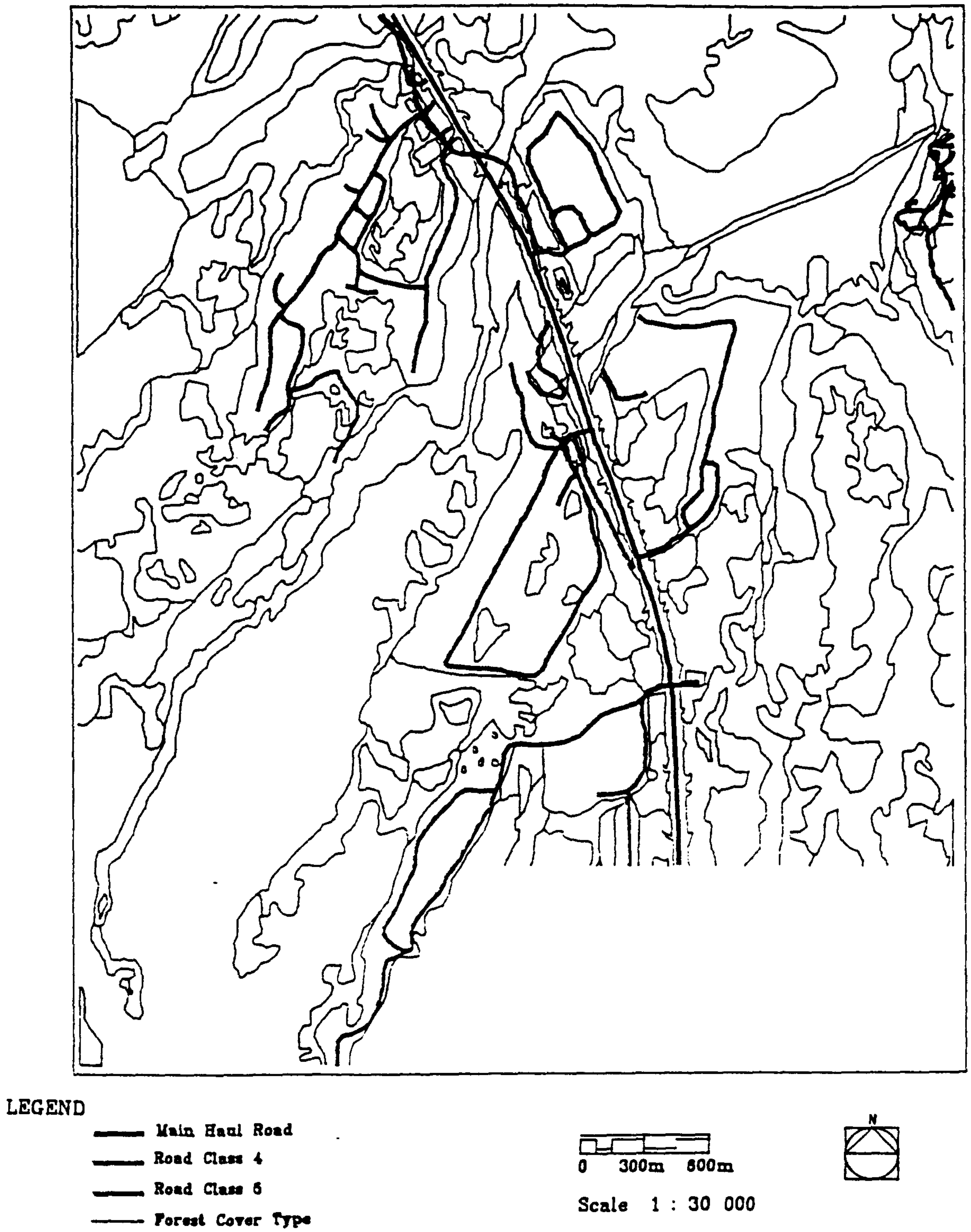
* Based on disturbed road area divided by total Study Site area.
** Based on disturbed road area divided by harvested area within the Study Site.

Table 4.5
Land Base Loss and Regenerated Merchantable Timber Areas
for the Heavy Soil 4 Study Site Road System

	Main Haul Road	Class 4 Road	Class 5 Road	Totals
		Area (ha)		
Original ROW Disturbed in Study Site	29.90 (2.9%)* (7.60%)**	3.62 (0.4%)* (0.92%)**	13.55 (1.32%)* (3.44%)**	47.07 (4.60%)* (11.97%)**
Current Revegetation of ROW to Merchantable Timber	0.0	1.72	1.87	3.59
Area of Lost Merchantable Timber Production	29.90 (2.90%)* (7.60%)**	1.90 (0.19%)* (0.48%)**	11.68 (1.14%)* (2.97%)**	43.48 (4.23%)* (11.05%)**

* Based on disturbed area divided by total Study Site area.
** Based on disturbed area divided by harvested area within the Study Site.

Figure 2a.
PRINCE ALBERT MODEL FOREST, SANDY SOIL 1 STUDY SITE.
LOSSES OF FORESTED LANDBASE STUDY



The data generated for the class 4 roads is inconclusive due to the small sample size and the short length of this road class (460.45 m) in the Sandy Soil 1 Study Site. The impacts of this road class would have been better represented if the Study Site had not been so close to the main haul road.

Further, the entire class 4 road right-of-way had been scarified and replanted to jack pine. Due to the soil work and replanting effort that had been initiated on the class 4 roads sampled, it is likely that the entire class 4 right-of-way in this Study Site would return to merchantable timber cover over time, if left undisturbed (e.g. the right-of-way was not re-cleared for a second harvest).

Road class 5 rights-of-way exhibited a regeneration to merchantable timber, of 32.0% of the originally disturbed area over the 11 year period since the last harvesting activity. This translated into an area land base loss to merchantable timber production of 9.95 ha in the Sandy Soil Study Site. In terms of land base area available to produce merchantable timber, this represents a 0.55% loss to the entire Study Site, and a 4.26% loss to the harvested area within the Study Site.

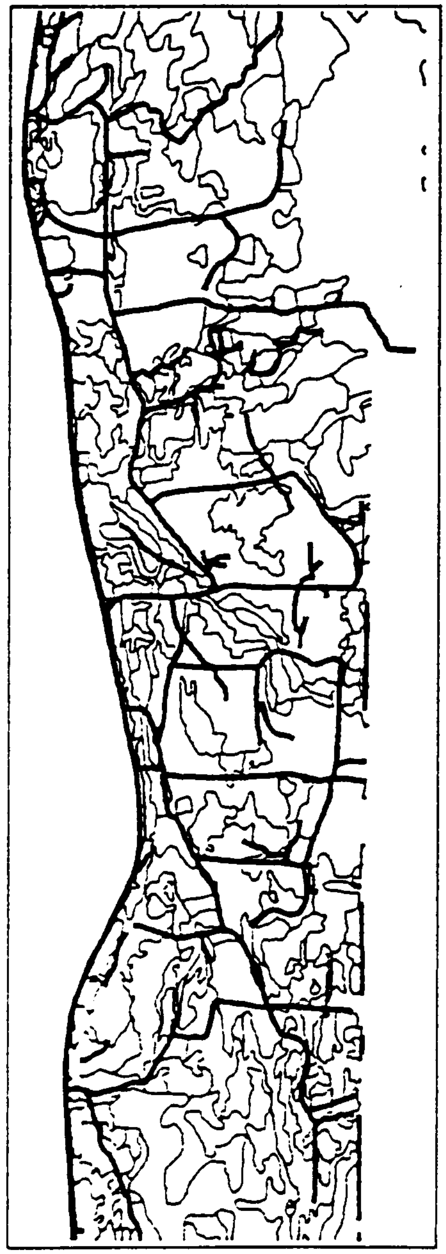
Access to the Sandy Soil 1 Study Site has been restricted with a soil push-up blockade at the entrance. This will limit additional compaction and disturbance (e.g. vehicle traffic from hunters, berry pickers and other forest user groups), which if continued, would negatively affect regeneration of the disturbed road rights-of-way.

Heavy Soil 3 Study Site

The GIS map illustrating the road class system in the Heavy Soil 3 Study Site is shown in Figure 2b.

As in the Sandy Soil 1 Study Site, the Main Haul Road in the Heavy Soil 3 Study Site represented the greatest loss to the forested land base, at 24.97 ha or 1.63% of the Study Site

Figure 2b.
PRINCE ALBERT MODEL FOREST, HEAVY SOIL 3 STUDY SITE.
LOSSES OF FORESTED LANDBASE STUDY



(2.95% of the harvested area within the Study Site). Again, this was considered to be a permanent loss, due to the ongoing maintenance of the highway and the mowing of the ditches.

Class 4 road rights-of-way were calculated to have impacted 20.58 ha (1.34% of the total Study Site and 2.43% of the harvested area within the Study Site), with 46.74% or 9.62 ha exhibiting regeneration to merchantable timber species. This represents a loss of merchantable timber production area of 0.72% of the entire Study Site and 1.30% of the harvested area within the Study Site.

Class 5 road rights-of-way comprised 0.72% of the Heavy Soil 3 Study Site and 1.31% of the harvested area, exhibiting a 34.44% (3.82 ha) regeneration to merchantable timber species. The regenerating merchantable timber species in all of the above measurements occurred over an 8-9 year period since the last harvesting activities.

The higher percentage of the class 4 road rights-of-way regenerating to merchantable timber species, as compared to class 5 road rights-of-way, may be related to increased land restoration and replanting efforts along class 4 roads in the Study Site. It may also be related to the limits of the soil to be compacted beyond a certain amount. In the present study, the class 4 and class 5 roads have in effect been impacted the same on the travelled portion, but the class 4 roads have more non-travelled areas that can regenerate to merchantable timber (e.g. a wider original right-of-way).

The Heavy Soil 3 Study Site did not have road closures on the access points. This provides year-around access to the area. and therefore potentially additional compaction by wheeled vehicles and recreational vehicle traffic (e.g. skidoos).

Heavy Soil 4 Study Site

Figure 2c illustrates the GIS map of the road classes found within the Heavy Soil 4 Study Site.

As exhibited in the other Study Sites, the Main Haul Roads had the greatest impact to the forested land base loss in the Heavy Soil 4 Study Site, with 2.9% (29.9 ha) of the entire Study Site and 7.60% of the harvested area within the Study Site, permanently lost to the production of merchantable timber. Again, the assumption was made that class 1 road rights-of-way would be maintained to highway standards (including mowing of the ditches), which would prohibit the trees on the right-of-way from reaching sizes adequate for harvesting.

The low percentage of class 5 road rights-of-way (13.94%) in the Heavy Soil 4 Study Site returning to merchantable timber production in the 11-12 year regeneration period, is at least partially related to the wider rights-of-way measured on the Heavy Soil 4 Study Site class 5 road transects during the 1993 field program (see Table 4.2). This illustrates the potential for increased disturbance to the land base during the original construction of the road when right-of-way clearing is wider than specified).

4.2 Merchantable Timber Revegetation Measurements

4.2.1 Sandy Soil 1 Study Site

Table 4.6 illustrates the species composition and mean tree height measurements of the merchantable timber encountered on the Sandy Soil 1 Study Site transects. Sampling effort consisted of 5 transects on class 4 road rights-of-way, 23 transects on class 5 road rights-ofway, and 3 plots on landings.

Figure 2c.
PRINCE ALBERT MODEL FOREST, HEAVY SOIL 4 STUDY SITE.
LOSSES OF FORESTED LANDBASE STUDY

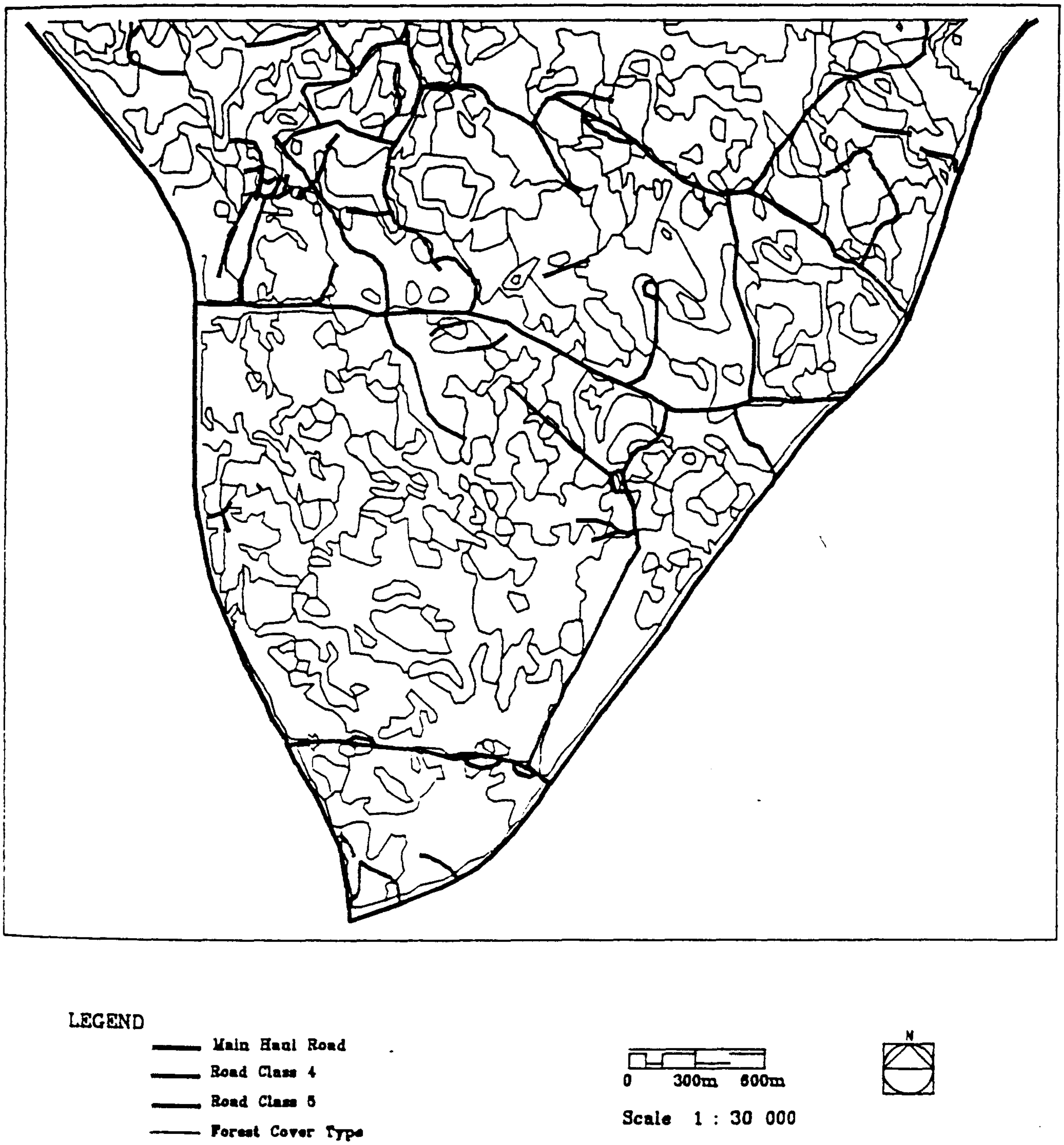


Table 4.6
Sandy Soil 1 Study Site 1993 Regenerating Merchantable Timber Species Composition, Mean Tree Heights (m) and Stand Error (in Brackets)

Tree Species						
	Black Spruce	**White Spruce**	**Jack Pine**	**Tamarack**	**Trembling Aspen**	**Balsam Poplar**
Road Class 4						
Road Plot Tree Height	0.39 (0.04)	-	2.19 (0.54)	-	-	-
Random Regenerating Tree Height	0.91* (0.04)	-	3.21* (0.07)			
Significance Level	P<0.01	-	NS	-	-	-
Road Class 5						
Road Plot Tree Height	0.35 (0.02)	0.34 (0.05)	1.76 (0.12)	1.30 (-)	1.14 (0.19)	0.63 (0.09)
Random Regenerating Tree Height	0.91 (0.04)	0.71 (0.06)	3.21 (0.07)	-	2.98 (0.11)	2.02 (0.21)
Significance Level	P<0.01	P<0.01	P<0.01	-	P<0.01	P<0.01
Landing Area						
Plot Tree Height	0.40 (0.09)	-	1.33 (0.28)	1.90 (-)	1.46 (0.27)	0.85 (0.08)
Random Regenerating Tree Height	0.91* (0.04)	-	3.21* (0.07)	-	2.98* (0.11)	2.02* (0.21)
Significance Level	P<0.01	-	P<0.01	-	P<0.01	P<0.01

* Random regenerating tree heights for landing area comparison were taken from the lowest value for Class 4 or Class 5 random heights for that species.

On class 4 road rights-of-way, black spruce trees were the most abundant species recorded within the sample plots (n=29). The mean tree heights were highly significantly different (P<0.01) for black spruce between the road plot trees and regenerating trees located in the cutover areas, suggesting an impact to seedling growth related to soil conditions (e.g. comparison). Jack pine mean tree heights were not significantly different.

On class 5 roads, jack pine was the most common species recorded (n=107) with black spruce the second most common (n=91). Where data was sufficient for comparison, all species on class 5 road rights-of-way exhibited highly significant lower mean heights (P<0.01) for the trees growing on the road plots as compared to the trees growing in the adjacent regenerating cutover areas.

Balsam poplar (n=24) was the most common species regenerating on the landings, while jack pine (n=21) and black spruce (n=21) were the second most common regenerating merchantable species. As noted on the class 5 roads plots, all merchantable species measured on the landings showed significantly lower mean heights (P<0.01) than trees growing in adjacent regenerating cut-over areas.

4.2.2 Heavy Soil 3 Study Site

The merchantable timber species diversity and mean tree height for the Heavy Soil 3 Study Site, are shown in Table 4.7. Field sampling effort consisted of 9 transacts on class 4 road rights-of-way, 4 transacts on class 5 road rights-of-way, and 5 plots on landings.

Balsam poplar was the most abundant merchantable tree species found regenerating within the plots on class 4 road (n=45) and class 5 road (n=17) rights-of-way.

On class 4 road rights-of-way, black spruce, white spruce and balsam poplar all showed highly significant (P<0.01) lower mean tree heights, as compared to tree heights from the adjoining regenerating cut-over areas. Balsam fir and trembling aspen mean tree heights did not differ significantly (P=0.05) between the road plots and regenerating cut-over areas.

Table 4.7
Heavy Soil 3 Study Site 1993 Regenerating Merchantable Timber Species Composition, Mean Tree Heights (m) and Stand Error (in Brackets)

	Tree Species				
	Black Spruce	**White Spruce**	**Balsam Fir**	**Trembling Aspen**	**Balsam Poplar**
Road Class 4					
Road Plot Tree Height	0.06 (0.14)	0.77 (0.12)	4.5 (0.87)	2.74 (0.26)	0.89 (0.10)
Random Regenerating Tree Height	4.09 (0.82)	2.14 (0.27)	2.37(0.34)	3.71 (0.27)	1.95 (0.35)
Significance Level	P<0.01	P<0.01	NS	NS	P<0.01
Road Class 5					
Road Plot Tree Height	-	0.30(-)	-	3.41 (0.56)	2.21 (0.39)
Random Regenerating Tree Height	3.00(-)	2.77 (0.24)	5.57 (1.03)	3.54 (0.17)	1.95* (0.35)
Significance Level	-	-	-	NS	NS
Landing Area					
Plot Tree Height	-	1.46 (0.19)	-	1.67 (0.33)	0.49 (0.05)
Random Regenerating Tree Heights	-	2.14* (0.27)	-	3.54* (0.17)	1.95* (0.35)
Significance Level	-	P<0.05	-	P<0.01	P<0.01

* Random regenerating tree heights for landing area comparisons were taken from the lowest value for Class 4 or Class 5 random heights for that species.

The trembling aspen (n=7) and balsam poplar (n=17) found on the class 5 road plots in the Heavy Soil 3 Study Site did not differ in mean tree height from the same species trees in the regenerating cut-over areas (P=0.05). This may be indicative of decreased negative impacts to seedling growth on class 5 roads, due to less vehicular traffic and less compaction, as compared to class 4 roads.

As in the Sandy Soil 1 Study Site, balsam poplar (n=30) was the most abundant tree species growing on the landings in the Heavy Soil 3 Study Site. White spruce (n=10) mean tree height was significantly lower (P<0.05), while trembling aspen (n=10) and balsam poplar mean heights were highly significantly lower (P<0.01), as compared to adjacent cut-over area tree heights.

4.2.3 Heavy Soil 4 Study Site

Table 4.8 shows the merchantable timber species located on the transects established in the Heavy Soil 4 Study Site, the corresponding mean heights and statistical analysis results. Within the Heavy Soil 4 Study Site the sampling effort consisted of: 4 transects on class 4 road rights-of-way, 4 transects on class 5 road rights-of-way, and one landing plot. In addition, six transects were measured on the main haul road (Snowfield Lake and Meeyomoot Roads).

Balsam poplar (n=27) was the most abundant tree species located on class 4 road rights-of-way, followed by jack pine (n=10). A single white spruce was located within the transect plots established on the roads. The mean tree height for jack pine was highly significantly different (P<0.01), while balsam poplar heights were not significantly different (P>0.05), compared to tree heights measured in adjacent cut-over areas. Statistical information could not be generated from the single white spruce measurement.

On class 5 road rights-of-way, balsam poplar (n=33) was the most abundant tree species growing in the plots, followed by white spruce (n=10) and trembling aspen (n=10). Both white spruce and trembling aspen showed highly significant (P<0.01) lower, mean tree heights as

Table 4.8
Heavy Soil 4 Study Site 1993 Regenerating Merchantable Timber Species Composition, Mean Tree Heights (m) and Stand Error (in Brackets)

	Tree Species				
	Black Spruce	**White Spruce**	**Jack Pine**	**Trembling Aspen**	**Balsam Poplar**
Road Class 4					
Road Plot Tree Height	-	0.45(-)	0.53 (0.07)	-	0.49 (0.05)
Random Regenerating Tree Height	-	1.68 (0.16)	4.93 (0.13)	3.42 (0.20)	1.60 (0.39)
Significance Level		NA	P<0.01	-	NS
Road Class 5					
Road Plot Tree Height	-	0.30 (0.05)	-	5.70 (0.35)	0.87 (0.15)
Random Regenerating Tree Height	9.80 (0.26)	1.54 (0.33)	-	10.61 (0.73)	1.60* (0.39)
Significance Level	-	P<0.01	-	P<0.01	NS
Landing Area					
Plot Tree Height	-	0.76 (0.06)	-	0.93 (0.18)	-
Random Regenerating Tree Height	-	0.86 (0.06)	-	2.22 (0.10)	0.40 (-)
Significance Level	-	NS	-	P<0.01	-

* Random regenerating tree heights for landing area comparison were taken from the lowest value for Class 4 road random heights for that species.

compared to trees measured in adjacent cut-over areas. Balsam poplar tree mean heights were not significantly different (P>0.05) between the road rights-of-way plots and the regenerating cut-over areas.

Trembling aspen (n=10) and white spruce (n=10) were the two most common species regenerating on the landing sampled in the Heavy Soil 4 Study Site. Trembling aspen showed highly significantly different (P<0.01) mean tree heights as compared to adjacent cut-over areas, while the white spruce mean heights were not significantly different (P>0.05).

4.2.4 Main Haul Road

Road rights-of-way in this class are represented by the Meeyomoot Road, the Snowfield Lake Road, and Highway #2. These roads, due to the degree of development and constant use and maintenance, represent a permanent loss (100%) of forested land base for the production of merchantable timber.

Table 4.9 shows the tree species and mean heights, as measured for the plots along a transect starting in the middle of the road, crossing the ditch and terminating in the undisturbed forest adjacent to the road right-of-way.

Balsam poplar (n=61) was the most common merchantable tree species recorded along the main ditch of the haul road, while trembling aspen (n=34) was the most common merchantable species growing along the upper ditch.

Statistical comparison of the mean tree heights for the species located in both the upper and lower ditches indicated that white spruce was significantly different (P<0.05); jack pine and trembling aspen were highly significantly different (P<0.01); and, balsam poplar showed no significant difference. This trend for trees growing in the lower ditch to be shorter, may be related to numerous factors including, but not necessarily limited to: increased exposure to the elements, negative growth effects of dust, more intensive mowing of lower ditches, increased erosion, higher soil comparson and decreased soil quality.

Table 4.9
Main Haul Road Transect 1993 Regenerating Merchantable Timber Species Composition
Mean Tree Heights (m) and Standard Error (in Brackets)

Tree Species					
	Black Spruce	**White Spruce**	**Jack Pine**	**Trembling Aspen**	**Balsam Poplar**
Main Haul Road					
Road Plot Tree Height	-	-	-	-	-
Lower Ditch Plot Tree Height	-	0.55 (0.08)	1.07 (0.35)	1.21 (0.16)	0.83 (0.05)
Upper Ditch Plot Tree Height	-	0.96 (0.90)	4.61 (0.90)	3.85 (0.35)	0.76 (0.15)
Un-disturbed Random Tree Height	6.8 (0.43)	5.10 (1.18)	-	10.42 (1.26)	-
Lower vs Upper Ditch Plot Tree Height Comparison - Significant Difference Probability	-	P<0.05	P<0.01	P<0.01	NS
Upper Ditch vs Undisturbed Random Tree Height Comparison - Significant Difference Probability	-	P<0.01	-	P<0.01	-

The higher developed road classes, particularly the improved bush roads (class 3) and the main haul roads, are typically turned-over to the department of highways and operated as Provincial grid roads or highways (e.g. Meeyomoot Road and the Snowfield Lake Road). Due to safety factors related to vehicular traffic, these roads are often maintained in such a way as to be prohibitive to the production of trees to a merchantable size. An example would be that the ditches are regularly mowed to allow increased visibility, decrease snow build-up and decrease dust. Therefore, even though there are merchantable trees regenerated within the rights-of-way of these roads, the trees are mowed and are never allowed to reach merchantable size.

5.0 CONCLUSION

This study showed that the construction of a road system within a forested land base, and the subsequent heavy truck traffic required to haul out the wood, affects the soil's capability to support tree growth, as well as having a significant negative impact on the land base area that can accommodate regeneration of merchantable timber species. Compared to the total area of the Study Sites, the road system (all road classes included) represented a loss of land base area for the production of merchantable timber species amounting to 2.02% of the Sandy Soil 1 Study Site, 2.82% of the Heavy Soil 3 Study Site and, 4.23% of the Heavy Soil 4 Study Site. When compared to the harvested area in each of the Study Sites, the road system (all road classes included) represented a loss to future merchantable timber production of 15.67% of the Sandy Soil 1 Study Site, 5.11% of the Heavy Soil 3 Study Site and, 11.06% of the Heavy Soil 4 Study Site.

Class 1 roads (main haul roads) represented the largest loss, both in terms of area disturbed and decreased regeneration potential for merchantable timber species in all three of the Study Sites. The high percentage of the class 4 rights-of-way regenerating to merchantable timber in all Study Sites was likely due to replanting efforts on this road class. Regeneration of merchantable timber species on the class 5 roads was less pronounced than expected in all Study Sites, and may have been affected by competition from grasses and shrubs, as well as impacts from disturbance and compaction.

This negative impact of heavy forestry equipment on soil properties, and the subsequent effects on tree growth has been documented from several parts of the world (Hatchell *et al*. 1970; Greacen and Sands 1980; Corns 1988). Generally, it appears that soil compaction from vehicular traffic increases the bulk density of the soil, decreases the aeration of the soil and is detrimental to the establishment and growth of seedlings (op. cit.). Further, soil compaction in the boreal forest of Alberta appears to persist for several decades. despite the annual freeze-thaw cycles (Corn 1988).

Valentine (1988) notes that ground conditions, ground contact pressures and the frequency of passes of vehicles are all important in the final determination of the impacts of the road system on the soils ability to support regenerating vegetation. In addition, it is likely that there would be a seasonal component also; as bush roads utilized only during the winter months would exhibit less soil compaction due to frozen soil conditions.

The negative impacts to merchantable timber species growth on the road rights-of-way within the Study Sites of the present study may be related to several factors, including but not necessarily limited to: increased exposure to the elements, compacted soils, poorer quality of soil due to mechanical manipulation and mixing, different moisture regimes and periodic compaction by vehicles. In addition, the magnitude of the productivity loss is related to the permanency of the road, vehicle weights, and volume and duration of traffic it was subjected to. For example, main haul roads exhibit a permanent loss to the forested land base, while class 5 roads would exhibit a long-term decrease in the forested land base until regeneration of merchantable timber species occurs.

Further, this negative impact to merchantable timber regeneration occurs on roads in both sandy and heavy soil sites in north-central Saskatchewan. The small sample size of the present study (1 sandy soil site and 2 heavy soil sites) did not allow statistical inferences to be made about impact differences of the road classes between the soil types. The amount of the right-of-way that will revegetate to merchantable timber species is likely dependent upon soil quality, reclamation techniques, tree planting effort and road maintenance.

Landing areas, particularly in the Heavy Soil Study Sites, supported fewer species and numbers of merchantable tree species. as well as exhibiting significantly lower mean tree heights as compared to adjacent regenerating cut-over areas. This is likely related to, but not necessarily limited to soil compaction and the large amount of slash/wood chips covering the ground in these areas.

It should be noted that not all uses of the road systems, and the subsequent long-term impacts discussed above are related to forestry operations. Other activities which promote vehicular use on the road system within the forest include: berry picking, mushroom picking, trapping, hunting, and other recreational activities such as snowmobiling. The significance of the impacts by these users on any given forested area is likely related to ease of access and distance to a community and/or recreational area (e.g. park).

Another important consideration is the time period between the original harvest and the second harvest, when replanted trees can be cut (or another species such as aspen). Even if trees on the various road class rights-of-way do regenerate, they will not likely reach the merchantable value of the trees growing in the less disturbed cut-over areas. Further, the roads will be impacted once again, leading to further compaction and disturbance to the soil.

Although the present study only measured the regeneration heights of merchantable timber species on the road system, landings and clear-cut areas, it should be noted that other plant species, notably grasses and shrubs (e.g. alder and willow) were often quite prolific on the class 4 and 5 road rights-of-way. Although not important from a commercial perspective, these species provide valuable erosion protection, wildlife food and habitat, as well as a developed substrate for additional natural revegetation.

6.0 RECOMMENDATIONS

The present road class system was difficult to apply in the field, particularly after several years of revegetation. Extrapolating the road classes throughout the PAMF, along with the associated impacts may be difficult. Information related to road classifications in the commercial forest may be available from the Wildlife Branch and/or Weyerhaeuser, but the classification system is not available in digital format.

The present study obtained information on merchantable tree species regeneration success related to tree height only, as an indication of growth vigor. During the field program, a subjective investigation indicated that not only were the regenerating tree heights lower on the road rights-of-way and landings, but the density of the regenerating trees was also lower. Therefore, the overall scenario for merchantable timber regenerating on the road rights-of-way and landings will be the production of fewer numbers of trees of poorer quality, as compared to trees regenerating in the adjacent cut-over areas. This relationship could better be investigated, if plant species information was gathered on known plot sizes located along a transect that incorporated the road, the ditch and the cut-over areas. This information would provide additional data on competition factors (e.g. grass and alder on the roads), and could potentially provide more definitive data on the regeneration potential of the road rights-of-way within the forest on different soil types.

As discussed earlier, it was noted during the field program that the road rights-of-way located in the Heavy Soil Study Sites, supported a more developed and diverse community of nonmerchantable species, particular shrubs and grasses, than the road rights-of-way in the Sandy Soil Study Site. This association may be causing increased competition for the merchantable species seedlings, an effect that should be investigated.

Compaction of a given soil type. is only one factor influencing the successful regeneration of a road right-of-way back to merchantable timber species. Other factors such as soil moisture, exposure, road aspect, type of harvesting and hauling equipment and season of harvesting activities also influence an areas potential for regeneration of merchantable timber.

Forest operations have to accept certain losses of the forested land base that can produce merchantable timber, due to the construction of access roads. This loss can be minimized over time, by having detailed harvest plans that can incorporate existing road and landing systems for future new or second cuts.

Again where feasible, road rights-of-way widths on the lower road classes (e.g. class 4 - 5) could be decreased during road construction to minimize the soil manipulation and compaction within the rights-of-way. Related to this would be strict adherence to the construction specifications by the contractors during the road construction, with frequent spot-checks by Weyerhaeuser or Forestry Branch personnel to ensure compliance.

Planned roads into cut-block areas that have soil types that are highly prone to compaction and subsequent decrease in regeneration potential for merchantable timber species on the rights-of-way, could be identified and alternate harvesting and hauling methods, or timing (e.g. winter) of cutting employed on these areas.

Related to all of the above concerns, and presently employed by the forest harvesting companies is the planning of the access system to achieve the least length of road feasible, particularly main haul roads, required to harvest any given area.

7.0 LITERATURE CITED

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APPENDIX I
Road Construction Specifications

Road Construction Specifications

Feature	Main Haul Road	Improved Bush Road	Class 4 (1st Class Bush Road)	Class 5 (1st Class Bush Road)
Life Expectancy	Permanent	5 yrs or less	1-2 yrs	< 1 year
Right-of-way Width	61.0	8.5 m	7.9 m	6.1 m
Travel Surface	Gravel	Gravel	Sand or Gravel	Earth
Side Slope	3:1 Slope on fills up to 4 m; 2:1 for fills greater than 4 m	2:1 slope	2:1 slope	no grade
Stumping Distance beyond edge of road		Side dozed to not within 4.6 m of standing timber to a max. of 1.2 m	Max. 4.8 m beyond ditch bottom	Nil

Source: Weyerhaeuser Road Construction Specifications.