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Report Title: Effects of PCT and Plantation Management on Ground Vegetation

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Fundy Model Forest

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FINAL REPORT
for fiscal year: 2006 - 2007

Title of Project Effects of PCT and plantation management on ground vegetation			
Name of Project Proponent Drs. Kate Frego and Mark Roberts			**Date** March 1, 2007
Organization Univ. of New Brunswick – Saint John and Fredericton		**Position** Professors	
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Research by **Individual** ( ) **Team** (X)		**Length of Study (years)** 1st of 2	
Working Group ETM		**Start** April 2005 **End** March 2006	
Research Partners Sustainable Forest Management Network (Dr. David MacLean) JD Irving Ltd. (Greg Adams)			
10 Key Words biodiversity, bryophytes, disturbance, harvesting, herbaceous species, pre-commercial thinning, stand structure, plantations, understory, vascular plants			

EXECUTIVE SUMMARY

In the 2006-2007 project year, work progressed as planned. Work began with field checks of new potential sites identified from the J.D. Irving GIS database. Additional PCT and comparable control sites were sampled in each age class (5,10 and 20 years after PCT), increasing the total sample size to 40 stands for the vascular component and 25 for the bryophyte component.

In each stand, fifty $1m^2$ quadrats were divided among four 300m transects within a 6 ha sampling area. Percent cover of vascular plants < 1 meter in height and environmental variable, including substrates such as mineral soil and humus, were sampled in each of the fifty quadrats. For the bryophyte component, measurements also included species diversity and abundance (percent cover of each species) according to substrate, percent cover of any unoccupied substrates, and microtopography (height and depth of pits and mounds). Canopy density of deciduous and coniferous trees, residual tree density, average tree height and diameter were recorded along with the density and diameter of coarse wood debris (CWD), snags and stumps.

Preliminary analyses are presented for the vascular plants and observational analyses are noted for bryophyte data as the bryophyte identification is incomplete and analyses of partial data would be unreliable. Results indicate that PCT increases fine slash cover, but does not seem to have an impact on vascular plant substrates. PCT did not seem to have an impact on vascular plant diversity (which is based on richness and evenness); however, further analysis is required

to determine if the treatment has any effect on the growth of individual species. Future work will also include a more detailed analysis of possible correlations between vascular species groups and environmental features using multivariate techniques.

PERSONNEL:

Kerienne La France and Amy Witkowski, team-leaders
Aiden Cwynar (field assistant, SCP)
Caitlin Porter (field assistant, SCP)
Faith Penny (field assistant, SCP)
Occasional P/T help:

Megan de Graaf	Takamitsu Mamashita
Allison Scovil	Krystal Mathieson
Peter Crowley	Zheng Fang
Joe Mudge	Leah Dalrymple
Ryan Power	

WORKPLAN OBJECTIVES FOR 2006-7 AND THEIR STATUS:

1. Assess plant community characteristics (species present and their abundances) at various ages since management treatments (pre-commercial thinning – PCT) and controls.
   - Vegetation sampling completed in 25 PCT (7-9 within each age class) stands and 15 controls (5 within each age class).
   - Vascular plant data entered and compiled.
   - Bryophyte sampling completed in 15 PCT stands (5 within each age class) and 10 control stands (5 within the 10 and 20 year stands).
   - Bryophyte identification underway.

2. Document environmental features (substrates and stand structure) in the same sample stands.
   - Substrate data collection complete; data entered and compiled.
   - Stand structure (slash, canopy cover, residual tree density, CWD, snags and stumps) data entered, data manipulation for some variables is still underway.

Data analysis and writing:

- Environmental features, vascular plants – underway.
- Bryophytes - await completion of bryophyte identification.

RESULTS & DISCUSSION

Environmental features:

Analysis of Variance (ANOVA) was used to compare percent cover of environmental features and species diversity between treatments and age classes. Results indicate that several environmental features are influenced by PCT and age class (Table 1, Figure 1) The percent

Table 1: ANOVA comparisons of percent cover of environmental features among treatments and age classes (p<0.05 are significant).

Feature	Source	df	MS	F-ratio	*P*
Slash	TREATMENT	1	1110.749	10.666	0.002
	AGE	2	12.959	0.124	0.883
	AGE*TREATMENT	2	291.459	2.799	0.075
	STAND(AGE (TREATMENT)	34	104.143	9.268	0.000
	Error	1960	11.237		
Slash height	TREATMENT	1	0.209	0.012	0.915
	AGE	2	73.402	4.106	0.025
	AGE*TREATMENT	2	38.825	2.172	0.130
	STAND(AGE (TREATMENT)	34	17.876	4.992	0.000
	Error	1960	3.581		
CWD	TREATMENT	1	13.961	0.426	0.518
	AGE	2	86.979	2.653	0.085
	AGE*TREATMENT	2	169.632	5.173	0.011
	STAND(AGE (TREATMENT)	34	32.791	1.987	0.001
	Error	1960	16.502		
Moss	TREATMENT	1	4113.079	0.365	0.550
	AGE	2	20921.458	1.855	0.172
	AGE*TREATMENT	2	80397.531	7.128	0.003
	STAND(AGE (TREATMENT)	34	11279.034	13.481	0.000
	Error	1960	836.649		
Hardwood litter	TREATMENT	1	1663.41	0.145	0.706
	AGE	2	43785.131	3.822	0.032
	AGE*TREATMENT	2	78697.155	6.870	0.003
	STAND(AGE (TREATMENT)	34	11455.822	13.809	0.000
	Error	1960	829.572		
Softwood litter	TREATMENT	1	1625.61	0.408	0.527
	AGE	2	57985.026	14.549	0.000
	AGE*TREATMENT	2	552.373	0.139	0.871
	STAND(AGE (TREATMENT)	34	3985.636	5.959	0.000
	Error	1960	668.793		

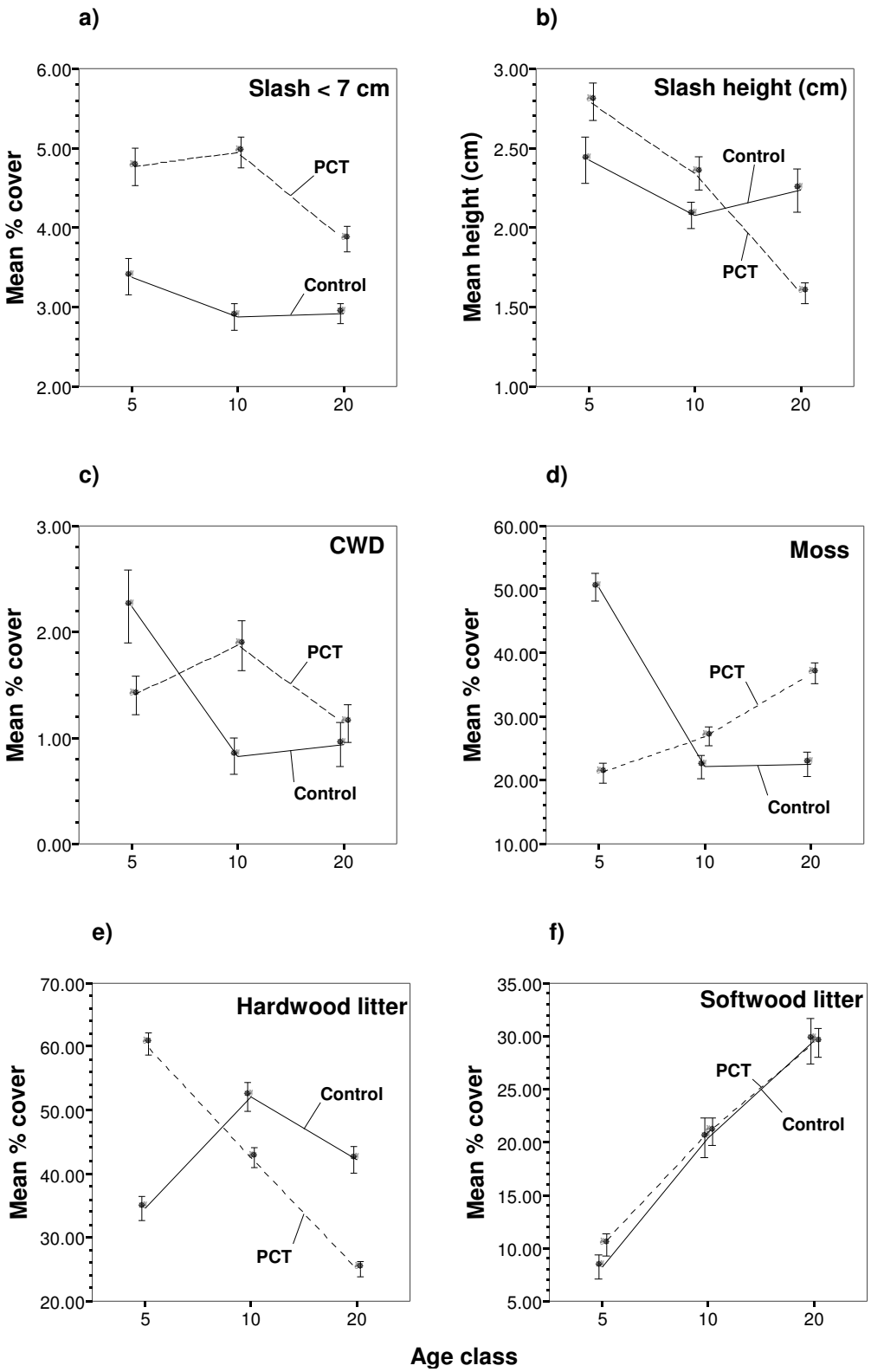

Figure 1: General trends of environmental features by age class and treatment: mean percent cover of slash (a); mean slash height (cm) (b); mean percent cover of CWD (c); moss cover (d); hardwood litter (e); and softwood litter (f). Error bars represent ± 1.0 SE.

cover of slash (< 7cm in diameter and mostly composed of softwood) was significantly higher in PCT stands than in unthinned controls (Figure 1a). While there was no significant change in slash cover over time in either treatment, slash height decreased over time in the PCT stands (Figure 1b). An increase in slash height in PCT stands was expected because debris is left on site after treatment. The decrease in slash height in PCT stands over time may be due to a combination of settling and decomposition.

There was a significant age x treatment interaction effect on the cover of CWD (slash > 7 cm measured at the quadrat level). Mean cover of CWD was higher in PCT stands 5 years after treatment, but then decreased 10 years after treatment (Figure 1c). The same pattern was observed for moss cover (Figure 1d) which suggests that CWD and moss are positively correlated, and CWD (a substrate) may be one of the critical environmental features which influences total moss cover in unthinned stands.

There was a significant age x treatment interaction effect on the cover of hardwood leaves, percent cover was higher in young PCT stands and lower in older PCT stands compared to controls of the same age (Figure 1e). This pattern may be due to a temporary increase in available light 5 years after treatment (from canopy removal), followed by a decrease in available light as the residual softwoods dominate the canopy. This is supported by the increase in cover of softwood litter, which seems to be influenced by time, but not by treatment (Figure 1f). There were no significant effects ($p>0.05$) of treatment or age on other substrates (mineral soil and humus) or track cover or depth.

While the patterns of these environmental variables indicate changes in slash cover and tree species composition, it has not yet been determined if these are driving factors which influence the abundance of bryophytes or herbaceous species.

Herbaceous species:

Individual species data were used to calculate several measures of species diversity including species richness, evenness, Shannon-Wiener index and Simpson's Index. There was no significant effect of treatment ($p> 0.05$) on any of the diversity measures (Table 2); however, diversity measures were significantly different ($p < 0.001$) between age classes. Shannon-Wiener diversity ($F_{2,34}$, $p<0.001$) (Figure 2) and Simpson's diversity ($F_{2,34}$, $p<0.001$) were high in both PCT and control stands in the 5-year class and decrease at 10 years, which may be due to canopy closure. Similar patterns and significance values were obtained for richness and evenness because these measures are used to calculate these diversity indices. There was a significant effect of stand ($p<0.001$) for almost all environmental variables and diversity measures, which reflects the natural heterogeneity of mixed-wood forests.

Bryophytes:

Based on observations, there is substantial overlap of species between thinned and unthinned stands, especially of species associated with open wet patches, but marked dissimilarities in the bryophyte species present, especially in the earlier age classes. Diversity is relatively low in the early age stands, with patches of highest diversity under remnant trees or on stumps from original harvest. Communities in these stands mainly consisted of *Sphagnum magellanicum*, *Sphagnum angustifolium, Polytrichum* spp. and *Pleurozium schreberi.* At 10 yrs, the high stem density and canopy cover in unthinned stands appear to shade out many of the earlier stage bryophyte species, however the abundant trunk substrate and cooler microclimate support a variety of liverwort and other shade-loving species. The PCT stands in the 10 yr age class have a lower stem density, but also an abundance of fine woody debris (from felled trees) at an advanced stage of decay which seems to be exploited by more bryophyte species at this stage

than in the younger stands. Lower bryophyte growth seems to be associated with the abundance of heavy needle litter in older PCT stands and hardwood leaf litter in unthinned stands.

Table 2: ANOVA comparisons for vascular plant diversity measures among treatments and age classes (p<0.05 are significant).

Diversity Measure	Source	df	MS	F-ratio	*P*
Richness	TREATMENT	1	96.501	1.337	0.256
	AGE	2	969.945	13.442	0.000
	TREATMENT*AGE	2	166.828	2.312	0.114
	STAND(TREATMENT (AGE)	34	72.159	12.875	0.000
	Error	1960	5.604		
Evenness	TREATMENT	1	0.397	1.764	0.193
	AGE	2	2.425	10.778	0.000
	TREATMENT*AGE	2	0.705	3.133	0.056
	STAND(TREATMENT (AGE)	34	0.225	5.025	0.000
	Error	1960	0.045		
Shannon-Wiener Diversity	TREATMENT	1	2.063	1.358	0.252
	AGE	2	29.934	19.706	0.000
	TREATMENT*AGE	2	4.5	2.962	0.065
	STAND(TREATMENT (AGE)	34	1.519	7.344	0.000
	Error	1960	0.207		
Simpson's Diversity Index	TREATMENT	1	0.425	1.687	0.203
	AGE	2	4.434	17.595	0.000
	TREATMENT*AGE	2	0.82	3.254	0.051
	STAND(TREATMENT (AGE)	34	0.252	6.372	0.000
	Error	1960	0.04		

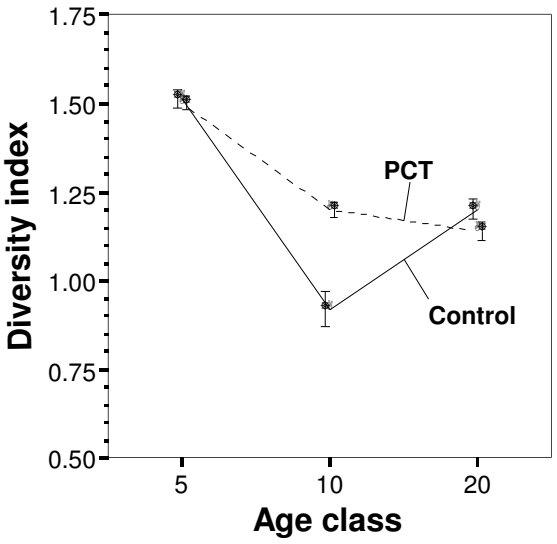

Figure 2: Mean Shannon-Wiener diversity for herbaceous species for each treatment over time. Error bars represent ± 1.0 SE.

CONCLUSIONS:

- PCT increases slash cover; however, it has not yet been determined if slash cover affects species composition or individual species abundance.
- The combined effects of PCT and time seem to influence the cover of other environmental variables such as CWD, moss and tree litter; however the PCT treatment does not seem to have any significant effect on vascular plant substrates.
- PCT does not seem to influence vascular species diversity; rather, changes in diversity measures are influenced by stand age, which may be related to tree canopy cover.
- The combined effects of PCT and time which potentially influence CWD and tree litter may also be linked to patterns in species composition and abundance of bryophytes.

FUTURE WORK:

- Complete analysis of remaining stand-level environmental variables including canopy cover, tree density, stumps and CWD.
- Investigate response patterns of individual herbaceous species to determine the effects of PCT and time on composition and species replacements.
- Investigate correlations between herbaceous species groups and environmental features in greater detail using multivariate techniques such as multivariate regression trees (MRT) and canonical correspondence analysis (CCA).
- Complete identification of bryophyte field samples.
- Investigate response patterns in bryophyte species composition and abundance

- Investigate correlations between response patterns in bryophytes and environmental variables (CCA & PCCA).
- Investigate correlations between response patterns in bryophytes and bryophyte functional characteristics (DCA).

FUNDING

AGENCY	LEVERAGED CASH	IN-KIND EQUIVALENT
UNB Research Fund (MRR)	$ 3,000	
SFMN student support	$ 15,000	
UNB graduate student support	$8,000	
Summer Career Placement (2 field assts, partial)	$2,500	
Student Works (PT field asst)	$1,800	
UNB Lab and equipment		$28,000
UNB PI salaries (~ $17,000 x 2)		$34,000
Total	**$30,300.00**	**$67,000**

Signed: Kate Frego, Mark Roberts