

2.7. Forest Renewal

Forest renewal and stand management were an integral part of responsible forest stewardship and forest management. Louisiana-Pacific Canada Ltd. was assigned all forest renewal and stand management obligations and responsibilities within the area of Forest Management Licence # 3 (Forest Management Units 10, 11 and 13). Even though LP only uses hardwood, this licence responsibility includes all Quota Holders softwood harvest and hardwood harvest.

The FML Agreement (dated Sept. 21, 1994) states in section 22 (D):

"The Company acknowledges its primary forest management and renewal responsibility by ensuring that all harvested areas within FML 3 are regenerated to approved Provincial Standards."

This commitment to forest renewal shall ensure:

- A perpetual sustained timber yield from the productive forest lands harvested; and
- The maintenance of forested ecosystems within FML #3.

On Jan. 1st, 2007 the Mountain Forest Section Renewal Company (MFSRC) took responsibility for all softwood renewal in the Mountain Forest Section (Duck and Porcupine Mountain Provincial Forests, as well as FMUs 10, 11, and 13). Louisiana-Pacific Canada Ltd. remained responsible for all hardwood renewal, including hardwood Quota Holders.

The MFSRC and Louisiana-Pacific Canada Ltd. managed and maintained forest ecosystems on a landscape-level basis. One hundred percent (100%) of areas harvested were regenerated by either planting softwood seedlings, natural regeneration of hardwood, or natural regeneration of softwood. Hardwood, mixedwood, and softwood ecosystems were maintained through a variety of silvicultural systems and treatments, such as: variable retention harvesting; leaving conifer seed trees with wildlife clumps; softwood understory protection; hardwood natural regeneration, and planting conifer seedlings.

2.7.1. Cone Collection

A summary of the cone collection efforts are shown in Table 2.18. The cones and extracted seeds were stored at Pineland Forest Nursery in Hadashville, Manitoba until 2018. In early 2019 the seeds were moved to a private nursery in Prince Albert, Saskatchewan. The seeds were used to grow softwood seedlings to reforest cut blocks.

Table 2.18 Summary of cone collection and number of extracted seeds, by species and year.

Year	Type	black spruce (hecto litres)	white spruce (hecto litres)	jack pine (hecto litres)	Total (hecto litres)
2006	White Spruce (seed orchard)		8.2		8.2
2007					0.0
2008					0.0
2009					0.0
2010					0.0
2011					0.0
2012					0.0
2013					0.0
2014					0.0
2015	black spruce (wild)	1.5			1.5
2016	black spruce (wild)	1.1			1.1
2017	black spruce (wild)	9.8		0.5	10.3
2018					0.0
2019					0.0
Totals		12.4	8.2	0.5	21.1

2.7.2. Scarification and Site Preparation Practices

Scarification of a site involves preparing the ground for planting by creating microsites suitable for seedling establishment. Scarification was only utilized on softwood sites that were deemed necessary to mechanically create planting micro-sites. Although different site preparation and scarification techniques exist (*e.g.* ripper tooth plow, Bracke scalping, disc trenching, shark fin barrels and anchor chains) only the shark fin barrels and anchor chains (Table 2.19 and Figure 2.28) have been used since 2006. The other scarification and site preparation methods were discontinued due to:

- high cost
- promoted and increased competition (*e.g.* grass) on the sites
- damaged aspen roots, thereby creating a vector for pathogen entry
- not necessary on many sites due to hot planting (*i.e.* planting the same year as harvest)
- access constraints associated with winter harvest areas

In addition, scarification was only applied where necessary. Many areas did not require this treatment since larger seedlings can overcome much of the understory competition.

Table 2.19 Summary of annual scarification.

Year	Scarification Type	Annual Total Area (ha)
2006	Shark fin barrels and anchor chains	139
2007	Shark fin barrels and anchor chains	86
2008	Shark fin barrels and anchor chains	147
2009	Shark fin barrels and anchor chains	100
2010	Shark fin barrels and anchor chains	103
2011	none	0
2012	Shark fin barrels and anchor chains	126
2013	Shark fin barrels and anchor chains	99
2014	Shark fin barrels and anchor chains	81
2015	none	0
2016	none	0
2017	none	0
2018	Shark fin barrels and anchor chains	96
2019		0
Total		881



Figure 2.28 Scarification with barrels and chains

2.7.3. Snow Cache

Winter-only accessible areas that needed to be planted utilized snow caches as an over-winter storage method for seedlings (Table 2.20 and Figure 2.29). This ensured that seedlings would be on-site for planting in the spring. Boxes of seedlings were stored in strategically located areas and were stacked on pallets and wrapped in poly prior to being buried with one metre of clean snow. An insulating layer of sawdust was then placed over the snow to insulate the seedlings and regulate their temperature. Trees were removed from snow caches and planted in the spring. Snow caches have been replaced by the use of a helicopter to transport boxes of trees and tree planters onto the site.

Table 2.20 Annual summary of snow-cached trees by species.

Year	Black Spruce	White Spruce	Jack Pine	Total # of Seedlings
2006-2007	284,160	390,600	5,400	680,160
2007-2008	208,500	326,100	22,000	556,600
2008-2009	141,000	272,760	90,600	504,360
2009-2010	157,200	297,720	25,200	480,120
2010-2011	267,000	239,760	36,600	543,360
2011-2012	419,040	278,640	55,800	753,480
2012-2013	165,580	156,160	11,400	333,140
2013-2014	233,791	218,880	0	452,671
2014-2015	150,900	217,080	0	367,980
2015-2016	0	0	0	0
2016-2017	0	0	0	0
2017-2018	0	0	0	0
2018-2019	0	0	0	0
Totals	2,027,171	2,397,700	247,000	4,671,871



Figure 2.29 Boxes of softwood seedlings were snow cached by covering them with snow and then insulating sawdust.

2.7.4. Forest Renewal Methods

There are three main methods of forest renewal described below: leave-for-natural regeneration; tree planting; and natural regeneration from seed.

2.7.4.1. Leave-For-Natural

Hardwood natural regeneration was dependent upon suckering from the tree roots. Buds on both aspen and black poplar tree roots must be stimulated by sunlight warming the soil. Removal of the tree canopy allowed more sunlight to reach the ground and warm the soil. Excessive slash (*i.e.* tree tops and limbs) intercepted sunlight, keeping soils cool, and potentially inhibited natural regeneration. Soil compaction could reduce natural regeneration by reducing soil pore space, which impeded infiltration of air and moisture to the roots.

Coppicing or stump-suckers are a common natural regeneration method of birch trees. A disturbed tree, whether burnt from fire or harvested, will produce 10 to 50 stump suckers per tree. The suckers utilized the large existing adult root system, allowing the suckers to grow quickly and vigorously.

All local hardwood trees produced seeds, which assisted in naturally regenerating areas. Poplar regeneration from seed is far less common than root suckering, due to the very small seed size of poplar. White birch regenerates more readily from seed and has a much larger and vigorous seed than the poplars. Less abundant hardwoods, such as green ash, Manitoba maple, and American elm, have large seeds which are typically produced in abundance each year. Bur oak has the largest seed, an acorn, but produces less seed.

2.7.4.2. *Planting*

Planting softwood seedlings was a preferred method of reforestation for softwood cut blocks and clumps of softwood within hardwood blocks. Large high-quality softwood seedlings were planted each spring, immediately following harvest for prompt reforestation. Table 2.21 and Figure 2.30 summarize the species and numbers of trees planted from 2006 to 2019.

Table 2.21 Annual number of trees planted by species.

Year	black spruce	white spruce	jack pine	Total # of trees	area planted (ha)
2006	657,620	582,660	108,520	1,348,800	969.4
2007	599,925	660,465	123,900	1,384,290	1,070.5
2008	588,916	681,664	101,282	1,371,862	943.7
2009	364,366	412,611	144,730	921,707	616.6
2010	270,660	526,704	51,000	848,364	557.1
2011	802,965	556,635	57,600	1,417,200	887.2
2012	501,572	479,017	55,800	1,036,389	782.4
2013	422,409	689,031	11,400	1,122,840	782.5
2014	275,640	585,600	0	861,240	573.4
2015	403,200	603,720	0	1,006,920	738.1
2016	216,000	680,760	10,100	906,860	658.6
2017	226,560	706,320	0	932,880	702.8
2018	552,480	602,280	0	1,154,760	787.6
2019	622,080	515,040	0	1,137,120	773.0
Totals				13,159,352	9,282.2
<i>averages</i>				<i>1,096,613</i>	<i>773.5</i>

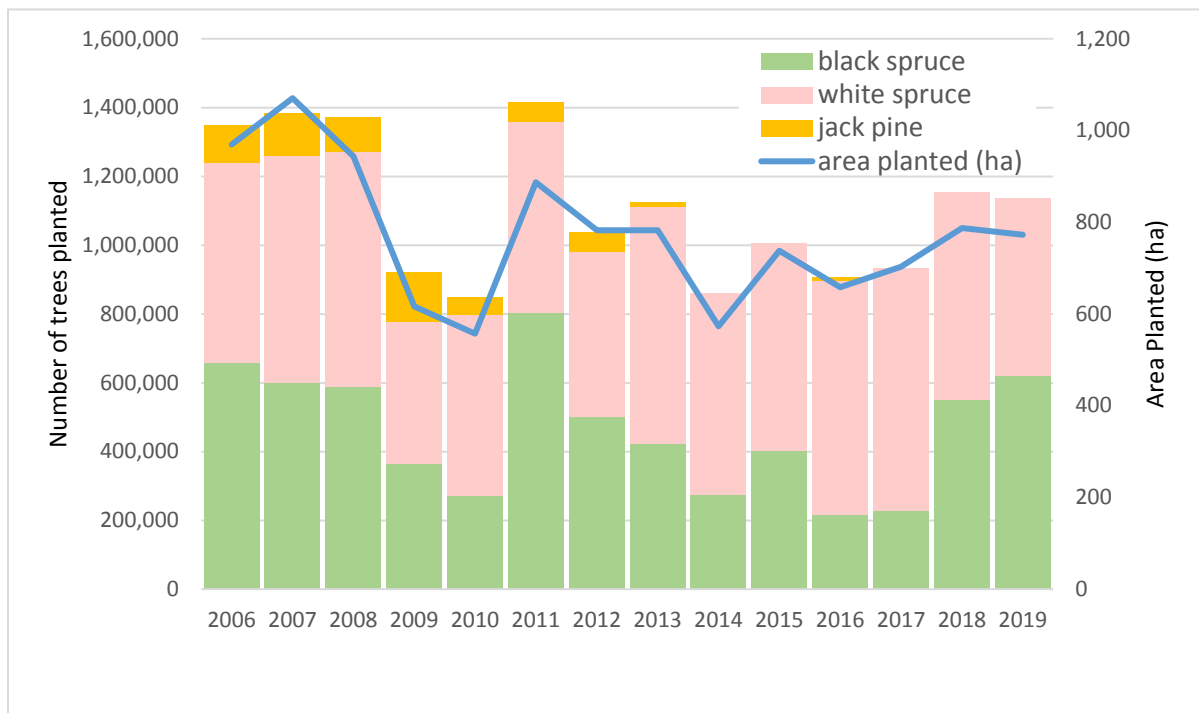


Figure 2.30 Area planted and number of trees planted by species.

2.7.4.3. *Natural Regeneration from Seed*

Although hardwoods can regenerate from seed, this section is limited to the regeneration of softwood species from seed. Jack pine seeds need mineral soil to successfully germinate. Black spruce seeds also germinate in mineral soil (Figure 2.31).



Figure 2.31 Jack pine and black spruce germinants from seed.

White spruce seeds can germinate on mineral soil, but are often found successfully growing on moist, rotting wood on the forest floor (Figure 2.32).

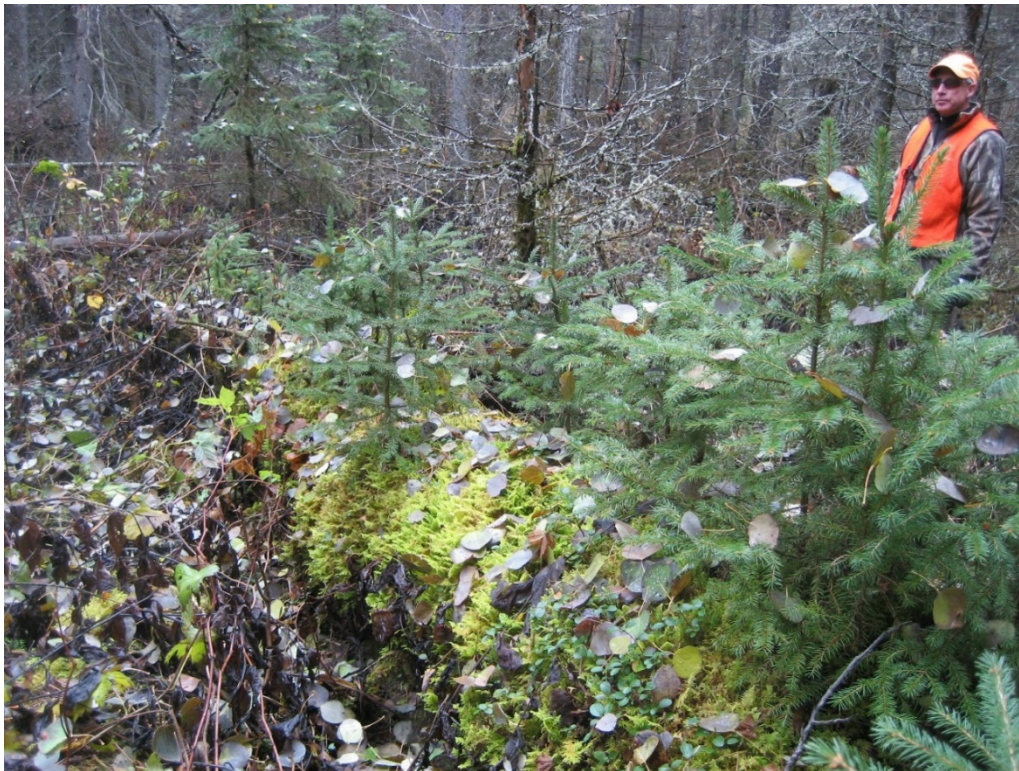


Figure 2.32 White spruce germinating on a rotting log.

2.7.5. Regeneration Success

One hundred percent (100%) of areas harvested were successfully regenerated by either planting softwood seedlings, natural regeneration of hardwood, or natural regeneration of softwood (Table 2.22 and Figure 2.33).

Table 2.22 Regeneration of all harvested areas.

Operating Year	FML 3 Area Harvested	Hwd Natural Regeneration	Planted Area	Swd Natural regeneration	<i>silvic exemption</i> *	REGENERATED TOTAL AREA	% harvested area regenerated
	(ha)	(ha)	(ha)	(ha)	(ha)	(ha)	(%)
2006-2007	2,364.2	1,394.1	969.4	0.7		2,364.2	100%
2007-2008	2,706.4	1,631.9	1,070.5	4.0		2,706.4	100%
2008-2009	1,130.5	186.2	943.7	0.6		1,130.5	100%
2009-2010	1,085.7	465.3	616.6	3.8		1,085.7	100%
2010-2011	1,814.1	1,248.0	557.1	9.0		1,814.1	100%
2011-2012	1,581.8	693.2	887.2	1.4		1,581.8	100%
2012-2013	1,242.3	458.0	782.4	1.9		1,242.3	100%
2013-2014	1,815.7	1,032.0	782.5	1.2	184.1	1,815.7	100%
2014-2015	2,655.5	2,081.8	573.4	0.3		2,655.5	100%
2015-2016	1,333.2	595.2	738.1	0.0	24.0	1,333.2	100%
2016-2017	1,640.5	981.3	658.6	0.6		1,640.5	100%
2017-2018	2,348.9	1647.0	701.9	0.0		2,348.9	100%
2018-2019	2,180.6	1,393.0	787.6	0.0		2,180.6	100%
Totals	19,370	10,767	8,579	24	208	19,370	

*silviculture exemption due to beaver flooding, cattle grazing, new cabins, fence line clearing *etc.*

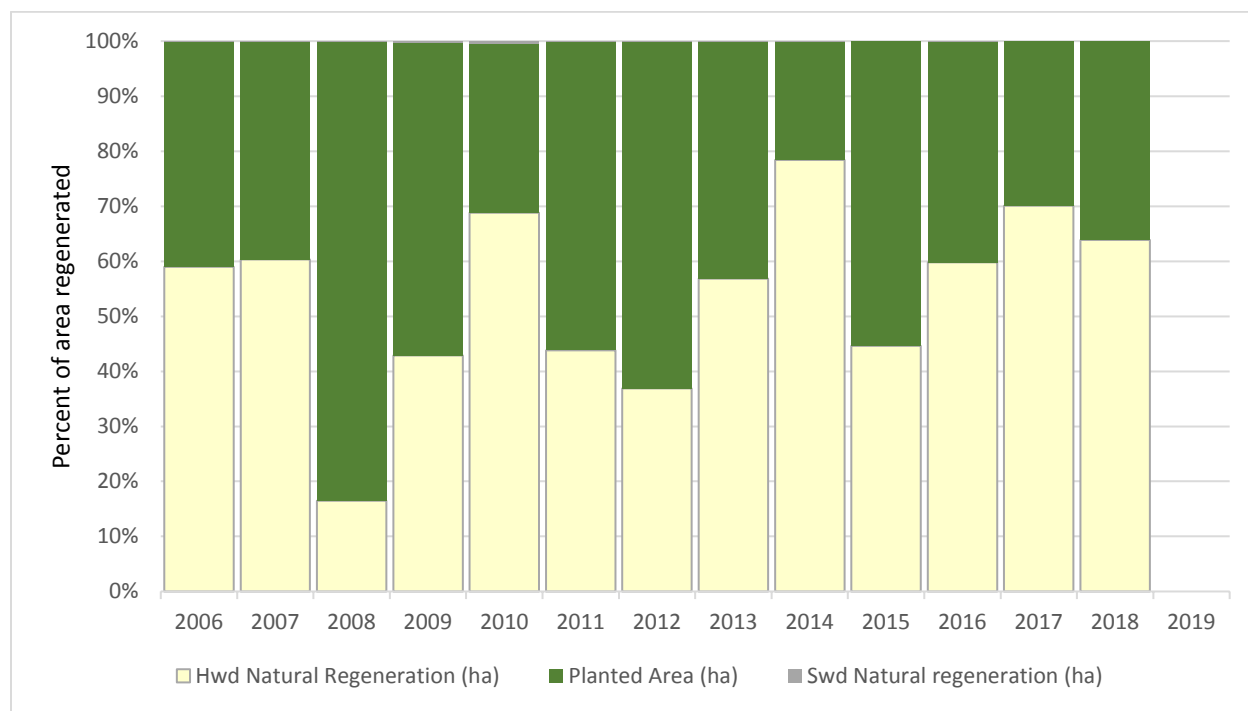


Figure 2.33 Regeneration of all harvested areas by natural regeneration or planting.

2.7.5.1. *Regeneration Summary*

Regeneration of harvested areas to approved Provincial standards depended upon original cover type (*e.g.* hardwood or softwood) and stand age. Hardwood regeneration surveys measured forest renewal success by assessing stocking (presence or absence of suitable crop trees), in addition to density, tree height, and competition measures. Naturally regenerating hardwood blocks required 80% or higher stocking to pass the survey and meet the requirement for 'Sufficiently Regenerated'. The Province of Manitoba forest regeneration survey manual (Forestry Branch 2014a) outlined procedures and regeneration standards. All surveyors performing regeneration surveys were certified by the Province of Manitoba. The regeneration surveys were check-surveyed by the provincial government.

Softwood regeneration surveys at age 7 years were discontinued in 2015 in favour of softwood Free To Grow surveys. In addition, the year of softwood survey changed from 14 years after planting, to 10 years after planting. The field procedures follow the provincial survey manual (Forestry Branch 2014b) and are check surveyed by the provincial government.

Table 2.23 summarizes all harvested blocks that have received either a 'Certificate of Reforestation' or Free To Grow certification.

Table 2.23 Number of harvest blocks issued Certificate of Reforestation or Free To Grow.

Year of Survey	Hwd regeneration		Swd regeneration		14 year Free To Grow		Total area surveyed (ha)	Total # surveyed blocks
	Hwd Area (ha)	# hwd blocks (H & N)	Swd Area (ha)	# swd blocks (M & S)	FTG area (ha)	# FTG blocks (M & S)		
2006	1,058	30	452	10			1,510	40
2007	1,196	47	810	24			2,006	71
2008*	0	0	202	8			202	8
2009	1,471	51	676	13			2,147	64
2010	1,996	31	1,180	33			3,176	64
2011	2,884	81	151	3	1,247	30	4,281	114
2012	2,235	90	932	24	503	13	3,669	127
2013	2,068	65	432	11	1,034	24	3,534	100
2014	516	29	255	6	714	24	1,485	59
2015	1,939	60			496	13	2,435	73
2016	2,833	89					2,833	89
2017	2,273	84					2,273	84
2018	1,878	72	1,077	26			2,955	98
2019	1,937	62	1,817	62			3,754	124
Totals	24,284	791	7,982	220	3,993	104	36,259	1,115

*in 2008 LP changed from surveying in the fall to surveying in the spring of the following year

**includes blocks from FMUs 12 & 14 (outside FML #3)

7 year swd regeneration surveys were discontinued by the Manitoba government

note that 14 year FTG surveys could not start until 2011

also note that 14 year FTG changed to 10 year FTG in 2013

FTG was discontinued in 2018 in favour of softwood regeneration survey

2.7.5.2. *Regeneration Surveys*

Sustainable Forest Management was a goal for the management of Forest Management Licence #3. A significant portion of sustainability was successful regeneration of harvested sites, producing goods and ecological services in the present and for future generations. The regeneration success of both naturally-regenerated hardwoods and planted softwoods was consistently excellent.

Regeneration surveys were measured five years post-harvest for hardwood, and seven years post-harvest for softwood. A summary of all regeneration surveys, both hardwood and softwood, is presented in Table 2.24, for all sites surveyed from the year 2000 to 2017. Provincial hardwood regeneration standards are a minimum of 80% stocking to pass (*i.e.* Sufficiently Regenerated). Hardwood sites averaged 97%, 95%, and 97% stocking for H-hardwood, H-hardwood leased land, and N-hardwood-softwood mixedwood sites, respectively. Softwood regeneration surveys measured between 2000 and 2014 averaged 95% stocking.

Table 2.24 Regeneration survey summary of both hardwood and softwood.

Pre Harvest cover group	# harvest blocks	Area Surveyed (ha)	STOCKING %			Density (trees per ha)			Hwd Avg Ht (m)	Swd Avg Ht (m)
			Swd	Hwd	Total	Swd	Hwd	Total		
H - hardwood	751	21,482	11	96	97	382	20,246	20,621	2	
H - hardwood leased land	83	1,720	3	95	95	111	19,438	19,548	2.5	
N - hardwood-softwood mixed	142	4,419	28	95	97	787	19,203	19,991	1.9	
*M - softwood-hardwood mixed & S - softwood	308	11,399	72	80	95	2,458	12,836	15,294	1.7	0.5
totals	1284	39,020								
averages			28.5	92	96	935	17,931	18,864	2.0	0.5

**softwood regeneration surveys were discontinued in 2014 in favour of free-to-grow surveys
H and N - hardwood surveyed (2000 to 2017)
softwood surveyed (2000 to 2014)*

Treatment and response percentages were calculated by the Provincial government and Louisiana-Pacific Canada Ltd., based on previous silviculture surveys. The Leave-For-Natural silviculture summary is shown in Table 2.25.

Table 2.25 Responses to Leave-For-Natural silviculture.

	post S	post M	post N	post H	Area (ha)	data sources:
pre-S	51%	34%	10%	5%	663	all historical survey data collected from FMU 13 (survey years: 1986 to 1995)
pre-M	28%	56%	8%	8%	967	all historical survey data collected from FMU 13 (survey years: 1986 to 1995)
pre-N	1%	6%	19%	74%	2,003	data collected from blocks at harvest year of 1996 and above from FML-3
pre-H	1%	2%	6%	91%	14,148	data collected from blocks at harvest year of 1996 and above from FML-3

2.7.5.3. Free-To-Grow Surveys

Free-To-Grow surveys are measured on softwood plantations at age 14 years. No plantations were old enough to measure until the year 2011. 3,393 ha (104 blocks) of softwood plantations were surveyed between 2011 and 2015 (Table 2.26).

Table 2.26 Free To Grow softwood plantation summary.

	Density (trees/ha)			Well-Spaced (trees/ha)			Free-To-Grow (trees/ha)					Total FTG
	Swd	Hwd	Total	Swd	Hwd	Total	WS	BS	JP	BF	TL	
avg	3,334	4,215	7,550	1,292	367	1,495	213	367	388	45	80	785
min	250	0	1,477	125	0	563	0	17	13	0	0	63
max	42,917	10,042	43,084	2,524	1,250	2,524	1,000	1,143	1,571	300	1,250	2,393
Std. dev	4,401	2,324	4,366	454	306	379	195	268	317	70	232	478

The Free To Grow survey system classifies surveyed sites into categories:

- FTG (Free-To-Grow)
- NFTG (Not Free To Grow) sufficient softwood trees, but hardwood trees are present and assumed to be significant competitors
- Mixed – mixedwood rather than softwood dominated site
- Hardwood – mostly hardwood trees

Furthermore, these categories are sub-divided into S – softwood and M – softwood mixedwood. Further subdivision based on softwood species (*e.g.* white spruce, black spruce, jack pine) exist, but are not shown for this summary. The pie graph (Figure 2.34) shows that the majority of softwood plantations were Free-To-Grow softwood (FTG-S) or mixedwood (FTG-M).

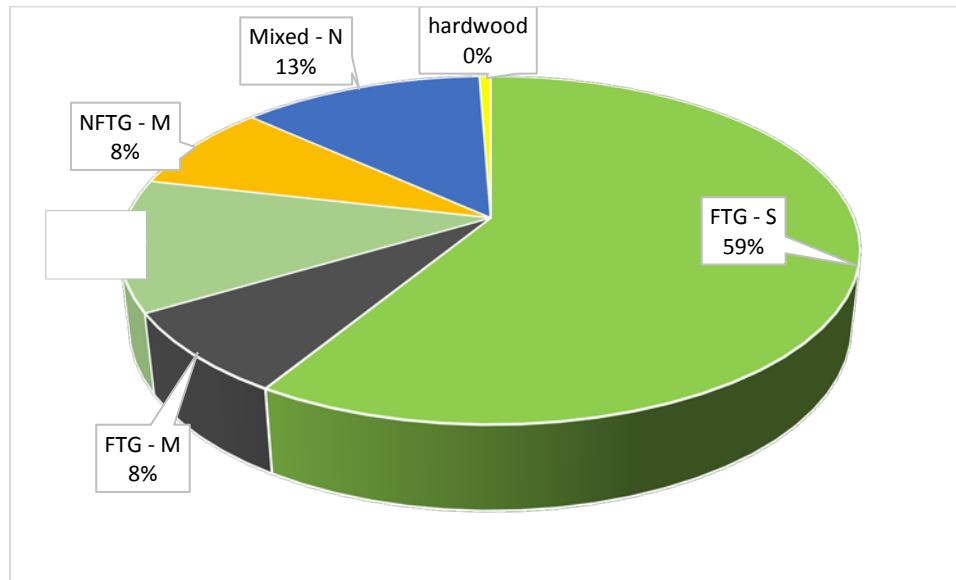


Figure 2.34 Free To Grow standards summary.

Free-To-Grow surveys are being discontinued in favour of a less complicated renewal assessment procedure. Softwood plantations are surveyed using the regeneration survey procedure from the 2018 field season and into the future.

Treatment and response percentages were calculated by the Provincial and Louisiana-Pacific Canada Ltd., based on plantation silviculture from existing surveys (Table 2.27).

Table 2.27 Responses to plantation silviculture.

PLANTED: Based on data collected from blocks at harvest year of 1996 and above from FML #3					
	post-S	post-M	post-N	post-H	Area (ha)
pre-S	62%	29%	8%	1%	2,436
pre-M	31%	44%	21%	4%	3,095
pre-N	24%	48%	23%	5%	8,020
pre-H	8%	40%	33%	19%	5,013

2.7.6. Stand Tending

Stand tending refers to mechanical or chemical release of softwood trees from competition (*e.g.* grass, shrubs, or hardwoods). There have only been two years (Table 2.28) where stand tending was performed, 2006 and 2010. The chemical used was Vision® Silvicultural Herbicide (glyphosate).

Since the initial implementation of the herbicide program, serious effort has been put into adopting techniques which reduce the amount of area to be treated. Techniques used to accomplish this include: planting immediately after harvest, the use of larger planting stock, and planting a higher density of trees. These various techniques all help to reduce the need for herbicides for plantations and other harvested areas to reach Free-To-Grow status.

Table 2.28 Stand tending in FML #3 (2006 to 2019).

Year	Tending Description	Area (ha)
2006	Aerial tending (helicopter) fall 2006	689
2007	none	0
2008	none	0
2009	none	0
2010	back pack spray	487
2011	none	0
2012	none	0
2013	none	0
2014	none	0
2015	none	0
2016	none	0
2017	none	0
2018	none	0
2019	none	0
totals		1,176

2.7.6.1. *Type of Herbicide Used*

Aerial spray 2006 – used Vision and VisionMax, both have the active ingredient glyphosate.

Backpack spray 2010 – used VisionMax with the active ingredient glyphosate. VisionMax is improved from Vision because can use ½ hour before rain. VisionMax can also be used later in the season, even when the competition vegetation's leaves are a little yellow. Mixes with water.

2.7.6.2. *Volume of Herbicide*

Aerial spray 2006 – used 3,487 litres of Vision and 128 litres of VisionMax for a combined total of 3,615 litres. Actual area sprayed was 689 ha. An average of 5.2 litres per ha of herbicide was used.

Backpack spray 2010 - actual sprayed area: 487.23 ha, 908.1 litres chemical used. 1.84 L/ha used on average at approximately 2% concentrations.

2.7.6.3. *Methods of Application*

Aerial spray in 2006 was with a helicopter. Aircraft used AgNav (GPS) guidance systems. Pilots and operators were provided cutover photography indicating “no spray” zones, as well GIS block shape files.

Backpack spray 2010 was ground spray with workers who had a spray backpack and wand. Backpack spray is more labour-intensive but allows for very precise spray application around conifer crop trees.

2.7.6.4. *Measures to Protect Human Health*

Aerial Spray 2006 – 15 metre no spray zone adjacent to the harvest blocks edges in order to avoid drift into adjacent forest edge. There is virtually zero drift. Aerial spraying must cease if the wind speeds exceed 10 km per hour.

Back pack spray 2010 - All recommended safety equipment was worn while performing all applications duties. This included chemical resistant CSA boots, long sleeve shirts or coveralls, hardhats, high visibility vests, and goggles or glasses.

Signs are posted while blocks are being sprayed (one-week pre and post-spray).

2.7.6.5. *Measures to protect Non-Target Species*

Aerial spray 2006 - 30 m no spray buffer around all water bodies. 30 m buffer on the Duck Mountain Provincial Park boundary. 15 m spray buffer on both the block boundary and residual tree patches within the cutblock. Aerial spraying must cease if wind speeds exceed 10 km per hour.

Back pack spray 2010 started on August 20 and was completed by September 15, 2010. The blocks were mapped and flagged. Only sprayed in favorable weather conditions, and stop spraying when local wind speed exceeds 10 km/hr.

2.7.6.6. *Measures to protect the Environment*

Leave areas include:

- Sections of the block that has 3 m or taller poplar was left.
- Any residuals in the block was left especially poplar.
- Areas with no to little competition was left unsprayed.

Spray Buffers include:

- 5 m buffers on wetlands, beaver ponds, and in-block streams.
- 5 m buffer on main access roads.
- 5 m buffer on in-block roads if road is used by ATV's.

A map depicting all forest renewal activities from 2006 to present is shown in Figure 2.35.

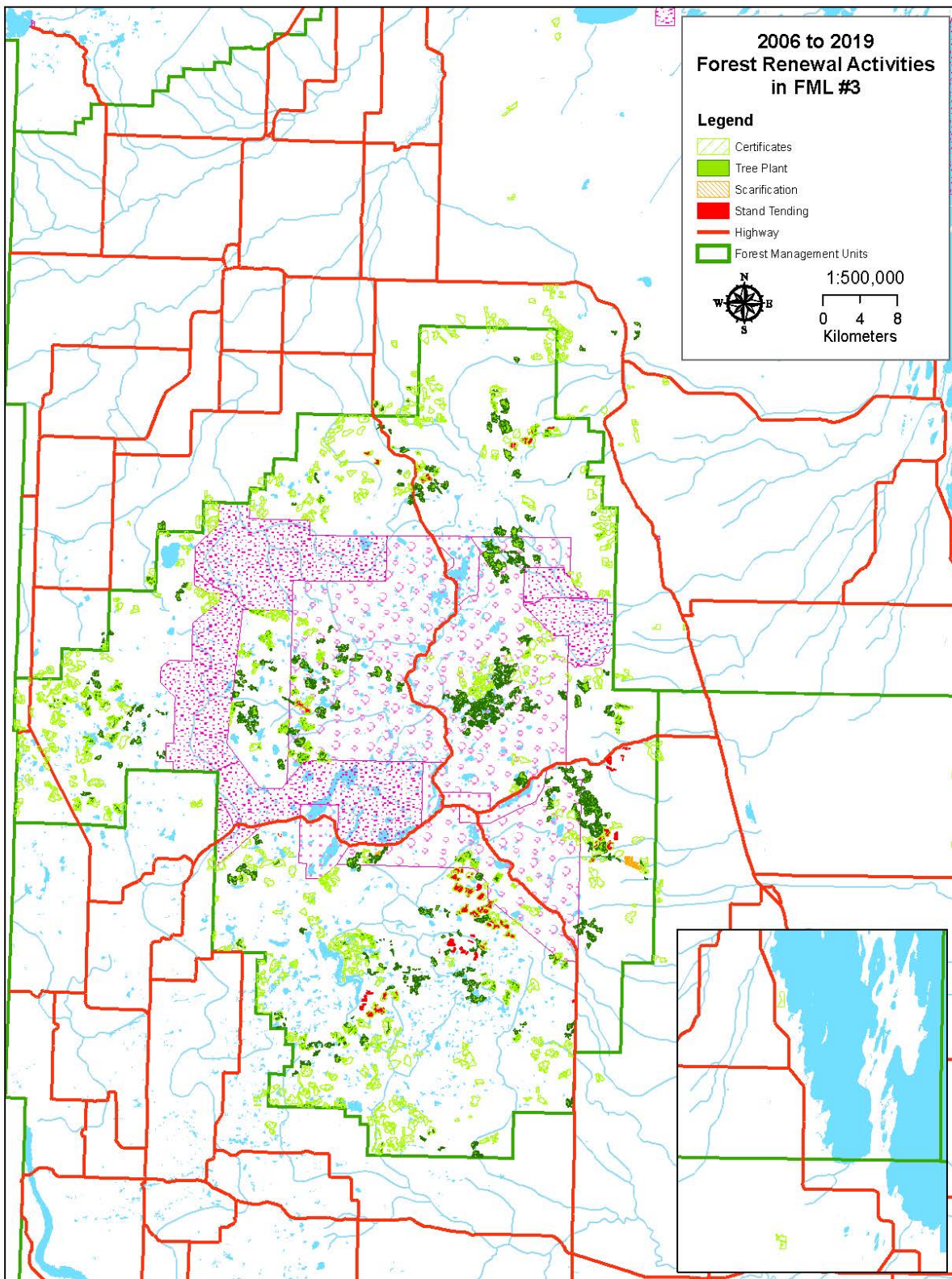


Figure 2.35 Renewal activities in Forest Management Licence #3 (2006 to 2019)

*note a second copy of this map with a much larger scale and detail exists in Appendix 3.

2.8. Research & Monitoring

Louisiana-Pacific Canada Ltd. was actively engaged in the development and implementation of research and monitoring in support of Sustainable Forest Management. Multi-scale, integrated management approaches increased our understanding of boreal ecosystems function and processes. The research and monitoring program addressed data and knowledge gaps, and acquired new knowledge related to terrestrial and aquatic ecosystems. Planning and operational practices were continuously improved, utilizing the research and monitoring knowledge.

A list and summary of research and monitoring projects from 2006 to present were presented in the following sections. Collaborative research partnership projects, research organization affiliations, and company-sponsored research projects were described. Results and data collected from these projects have been incorporated where possible into this Forest Management Plan.

2.8.1. Collaborative Research Projects

This section describes multi-agency collaborative research projects that Louisiana-Pacific Canada Ltd. has participated in. The agencies include conservation groups, universities, research organizations, provincial and federal government departments (Table 2.29). These collaborative research projects were supported by Louisiana-Pacific Canada Ltd. and other partners in various ways, depending on project requirements. Support by Louisiana-Pacific Canada Ltd. and Spruce Products Ltd. included direct research funds and in-kind contributions such as spatial data, aerial imagery, and forest management professional staff time.

Table 2.29 Collaborative research projects 2006 to present.

Year(s)	Principal Investigator	Project Description
2007	Kevin Smith (Ducks Unlimited Canada)	Wetlands mapping and classification across western Canada from LANDSAT 30 m pixels (DUC publication)
2007	Mike Bokalo, Philip G. Comeau and Stephen J. Titus (University of Alberta)	Early development of tended mixtures of aspen and spruce in western Canadian boreal forests. (published in Forest Ecology and Management)
2007	Theresa L. Mundell, Simon M. Landhausser, Victor J. Lieffers (University of Alberta)	Effects of <i>Corylus cornuda</i> stem density on root suckering and rooting depth of <i>Populus tremuloides</i> . The regeneration capabilities of over-aged aspen stands containing heavy hazel competition. (published in Can. J. Bot.)
2008	Theresa L. Mundell, Simon M. Landhausser, Victor J. Lieffers (University of Alberta)	Impacts of season of harvest on aspen regeneration. (published in Forest Ecology and Management)
2008	Iain Edye, M.Sc. candidate, Department of Biological Sciences, University of Alberta.	White-tailed deer movement, habitat use, and potential for disease transmission in the greater Riding Mountain and Duck Mountain ecosystems. (M. Sc. Thesis, University of Alberta)
2009	Kevin J. Kardynal, Keith A. Hobson, Steven L. Van Wilgenburg, Julienne L. Morissette	Moving riparian management guidelines towards a natural disturbance model: An example using boreal riparian and shoreline forest bird communities (published in Forest Ecology and Management)
2009	Dan Chranowski	Cow elk ecology, movements and habitat use in the Duck Mountains of Manitoba. (M.Env. thesis, University of Manitoba)

Year(s)	Principal Investigator	Project Description
2009	Comeau, P., V. Reyes-Hernandez, H. Chen, N. Kenkel, M. Bokalo, C. Hawkins, K. Greenway, A. Velazquez-Martinez. (U of A)	Influence of relative density and composition on growth and understory in the boreal mixed-woods. SFMN project report.
2010	Triin Hart, Han Chen, Anthony Taylor, Paul LeBlanc, Steve Watson	Management Implications of Disturbance and Aging on Forest Stand Composition (Sustainable Forest Management Network)
2010	Julienne Morissette and Margaret Donnelly	Riparian Areas - Challenges and Opportunities for Conservation and Sustainable Forest Management (Sustainable Forest Management Network)
2010	Robert S. Rempel (CNFER) and Margaret Donnelly (LP)	A Spatial Landscape Assessment Modeling Framework for Forest Management and Biodiversity Conservation (Sustainable Forest Management Network)
2010	Jeff Renton (University of Manitoba), Andrew Park, and Richard Westwood (University of Winnipeg, Centre for Forest Interdisciplinary Research)	The Impact of Cattle Grazing on Aspen regeneration on Crown Lands in Western Manitoba. (U of Manitoba thesis)
2010 & 2015	Manitoba Agriculture and Food	Garland Grazing Trial (1997 - 2015). Draft report – Province of Manitoba
2011	Irena Creed, Gabor Sass, Fred Beall, Jim Buttle, Dan Moore, Margaret Donnelly	Hydrological principles for conservation of water resources within a changing forested landscape (SFMN: A State of Knowledge Report)
2011	K.J. Kardynal, J.L. Morissette, S.L. Van Wilgenburg, E.M. Bayne, and K.A. Hobson	Avian responses to experimental harvest in southern boreal mixedwood shoreline forests: Implications for riparian buffer management (published in Cdn. J. Forest Res.)
2013	Mike Bokalo, Kenneth J. Stadt, Philip G. Comeau, and Stephen J. Titus (University of Alberta)	The Validation of the Mixedwood Growth Model (MGM) for Use in Forest Management Decision Making. (published in Forests)
2013	J. L. Morissette & K. J. Kardynal & E. M. Bayne & K. A. Hobson	Comparing Bird Community Composition Among Boreal Wetlands: Was Wetland Classification a Missing Piece of the Habitat Puzzle? (published in Wetlands)
2014	Ducks Unlimited Canada	Forest Road Wetland Crossings. (DUC publication)
2015	Ducks Unlimited Canada	Field Guide Boreal Wetland Classes in the Boreal Plains Ecozone of Canada. (DUC publication)
2016-2019	Saskatchewan Research Council, Ducks Unlimited Canada, Louisiana-Pacific Canada Ltd., Spruce Products Ltd., University of Brandon, University of Saskatchewan	Carbon in Wetlands Project (2016-2019). Sampling wetlands for peat depth, peat samples, wetland type, vegetation, shrubs, and trees (if any). Quantifying carbon stocks by wetland type and across the landscape.
2017 (3-year project in progress)	Han Chen (Lakehead University), U of Wpg, U of A, CFS-Atlantic Forest Centre, provincial forestry branches of Ontario, Manitoba, and Saskatchewan, Resolute Forest Products, and Louisiana-Pacific Canada Ltd.	Assessing climate change impacts on timber resource availability in western-central Canada: Economic implications and mitigation. (NSERC funded)

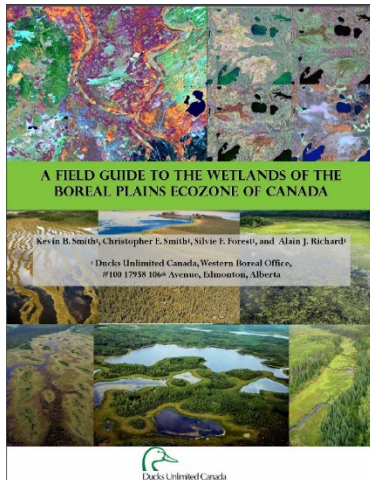
Year(s)	Principal Investigator	Project Description
2018 to 2020	Mark Johnston (Saskatchewan Research Council) and Dana Collins (Canadian Institute of Forestry) 13 project partners	Northern Prairie Forests Integrated Regional Assessment (NPFIRA) - climate change vulnerability assessment
2018 and 2019	Nicole Barker (University of Alberta) 17 project partners, including the Central and Western Canada SFI committees	BAM – Boreal Avian Modeling http://www.borealbirds.ca/ Applying data-driven measures to evaluate and improve the conservation value of managed forests for birds.

The following sub-sections provide a short summary for each of the projects listed in the table above, grouped by organization instead of chronologically.

2.8.1.1. *Ducks Unlimited Canada Collaborative Projects*

Ducks Unlimited Canada (DUC) has a long and productive history with Louisiana-Pacific Canada Ltd. Many mutually-beneficial projects were completed in the Duck Mountain area.

Smith, K., C.E. Smith, S.F. Forest, and A.J. Richard. 2007. A field guide to the wetlands of the boreal plains ecozone of Canada. Ducks Unlimited Canada publication.



The field guide to the wetlands of the Boreal Plains Ecozone of Canada provides a remote sensing-based wetland classification system. The Boreal Plains ecozone covers 740,632 square kilometers of the 2.6 million square kilometers of the Western Boreal Forest and extends across portions of British Columbia, Alberta, Saskatchewan and Manitoba.

This wetlands inventory utilizes 30 m resolution LANDSAT satellite imagery to outline an approach that incorporates information at various observation levels (ground, aerial, and satellite) into a comprehensive wetland classification system that can be used for field identification as well as for mapping purposes. The general wetland classes determined in the field guide were applicable at a national scale (bog, fen, marsh, swamp, open/shallow water) but designed to be interchangeable at a regional scale with the more detailed wetland classes (to compensate for regional scale differences in vegetation/climate/wetland type/distribution) with the more detailed wetland classes.

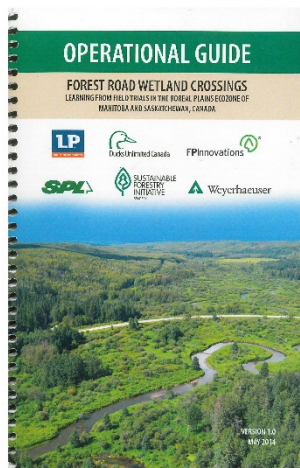
Morissette, J.L. & K. J. Kardynal & E. M. Bayne & K. A. Hobson. 2013. Comparing Bird Community Composition Among Boreal Wetlands: Was Wetland Classification a Missing Piece of the Habitat Puzzle? (published in *Wetlands* (2013) 33:653–665)



Despite making up 20–60% of the North American boreal landscape, wetlands and their associated bird communities remain poorly understood. In the context of forest management and avian conservation, wetland classification presents an opportunity to classify and investigate wetland bird communities. We compared bird communities among a suite of eight wetland classes in the southern Boreal Plains ecozone of Manitoba and tested whether wetland classification was a useful tool for delineating habitat for birds. To provide context for how wetlands fit into a managed forest setting, we compared wetland classes with structurally similar harvested deciduous and mixedwood stands early in succession (5–7 years) to assess potential overlap in community composition. We conducted fixed radius (100 m) point counts across 83 sites and used a combination of multivariate techniques to determine whether individual wetland classes supported characteristic bird assemblages and species. Our study suggests using established approaches to classifying wetlands will be helpful for documenting the full breadth of habitats used by boreal birds. Given ongoing industrial development, particularly in the boreal plains ecozone, further research is needed to determine effects of human disturbance and support the conservation of a full spectrum of wetland classes in the boreal landscape.

whether individual wetland classes supported characteristic bird assemblages and species. Our study suggests using established approaches to classifying wetlands will be helpful for documenting the full breadth of habitats used by boreal birds. Given ongoing industrial development, particularly in the boreal plains ecozone, further research was needed to determine effects of human disturbance and support the conservation of a full spectrum of wetland classes in the boreal landscape.

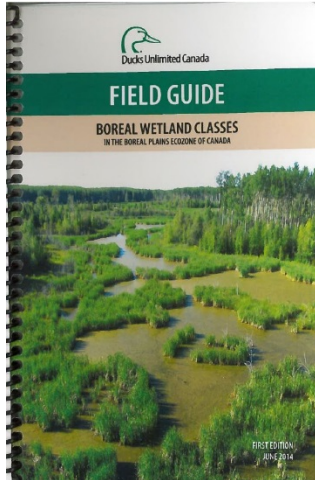
2014 Operational Guide - Forest Road Wetland Crossings (with Sustainable Forestry Initiative funding). Within FML #3, there were three test sites in the Porcupine Mountain and one in the Duck Mountains. The operational guide was developed for western Canada and led to a national guide being developed by FP Innovations.



Knowing where wetlands are located and understanding how water flows through them can help ensure a successful road project, while minimizing impacts to wetland ecosystems.

Many boreal wetlands are highly connected systems that move water and nutrients slowly across the landscape making them vulnerable to road development that can potentially block water flow. This impedance of flow may result in the die off of trees or other long-term vegetation changes. This can be a very gradual process depending on the extent of damming and can sometimes take decades to see the full effects of these hydrologic changes.

2015 Field Guide Boreal Wetland Classes in the Boreal Plains Ecozone of Canada



The wetland classes were a companion guide to the 2014 Forest Road Wetland Crossings. This guide was intended for resource managers to help them identify wetlands while in the field. This guide was based on the Enhanced Wetland Classification system developed by Ducks Unlimited Canada (DUC) for the Boreal Plains Ecozone of Western Canada and conforms to the Canadian Wetland Classification System. It will help identify five major wetland classes: marsh, swamp, fen, bog, open water. Furthermore, the user can then key and identify which of nineteen additional minor classes the wetland belongs to. It was intended to be useful at the planning and operational levels of business.

Garland Grazing Trial (GGT)

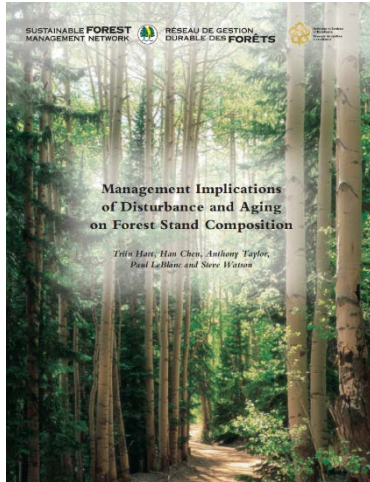
Manitoba Agriculture and Food established the Garland Grazing Trial in cooperation with LP in 1997. Manitoba Conservation–Forestry Branch (now Sustainable Development) established temporary regeneration plots. Five-year results in 2001 showed all regeneration plots being classified as Sufficiently Regenerated with stocking levels of 89% to 100%.

LP established Permanent Sample Plots (PSPs) within the various grazing (low and medium grazing levels) and harvest (summer and winter) treatments (Figure 2.36). The regenerating aspen PSPs were established in 2000, remeasured in 2005, 2010, and 2015. These PSPs quantify the aspen's growth rates, which have no significant difference in height growth rates between grazed and ungrazed plots.



Figure 2.36 Map of the Garland grazing trial (2008 imagery).

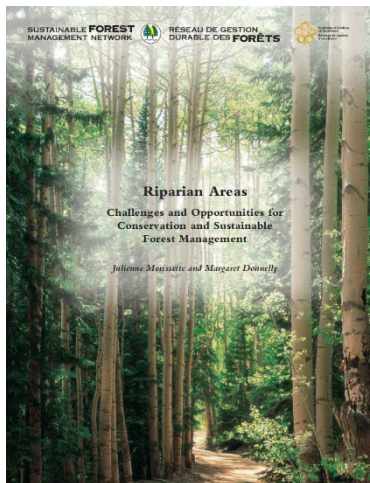
Hart, T., H. Chen, A. Taylor, P. LeBlanc, and S. Watson. 2010. Management Implications of Disturbance and Aging on Forest Stand Composition. SFMN synthesis report.



To meet sustainable forest management targets, there was a need for reliable succession models that would assist managers in predicting forest composition and structural development at both the stand and landscape levels. Future species composition and structure of forest stands are the key elements affecting future benefits of the forest, including biodiversity, timber supply, productivity, carbon dynamics, ungulate, fur-bearer, bird habitats, recreational opportunities, and non-timber forest products.

There was a strong correlation between pre- and post-disturbance species composition for shade intolerant tree species. In the prolonged absence of stand-replacing fire, compositionally similar stands undergo multiple succession pathways, depending on time since fire, soil conditions, intermediate disturbances, presence of advanced regeneration, and seed availability. This report demonstrated that succession rules should be applied to wood supply and habitat modeling analyses to get realistic future forest projections.

Morissette, J. and M. Donnelly. 2010. Riparian Areas Challenges and Opportunities for Conservation and Sustainable Forest Management. SFMN publication.

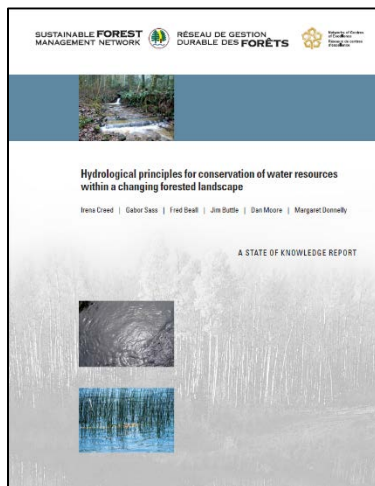


Generally riparian areas are described as the "...interface between aquatic and terrestrial systems." However, definitions pertaining to riparian areas range from simple to complex and can be ecologically-based or defined in terms of management applications. Regardless of the definition, the management of these highly productive, complex components of the landscape was a challenge to forest managers and policy makers. The planning and application of riparian guidelines and buffer retention strategies was further complicated since approval for forest management plans for these areas falls under the jurisdiction of both federal and provincial regulatory agencies. Management guidelines provided by these agencies are generally updated infrequently and thus do not incorporate new knowledge or new approaches easily. They are also developed in isolation of

other values and resource sectors (*e.g.* private vs. crown land, forestry vs. fisheries concerns) leading to problems with integrated management of multiple resources and values. In recent years, there has been increased interest in developing alternate management strategies for riparian areas to more fully integrate their management with the rest of the forest. In several jurisdictions, there was interest in applying natural disturbance-based approaches to manage these systems, and potentially integrate landscape-level strategies to minimize cumulative effects to both terrestrial and aquatic components of the forest ecosystem. This has resulted in considerable debate among scientists, policy makers and resource managers regarding the long- term consequences of current methods and policies, as well as the development of new

policies and practices for managing and conserving riparian areas and water resources. Related to the interest in alternative management practices, a series of questions regarding the management of riparian areas in the boreal forest were developed through consultation with several SFM Network industrial partners in western Canada. These questions are addressed in this synthesis document through the use of case studies, as well as a review of the literature and guidelines pertaining to riparian systems. Ultimately, we hope to stimulate dialogue and knowledge exchange among forestry companies, governments and other stakeholders to build a stronger riparian management framework for decision making. The challenges faced during the riparian guidelines development, review and implementation process are also discussed as well as some of the potential solutions for the sustainable management of riparian areas.

Creed, I., G. Sass, F. Beall, J. Buttle, D. Moore, and M. Donnelly. 2011. Hydrological principles for conservation of water resources within a changing forested landscape (SFMN: A State of Knowledge Report)

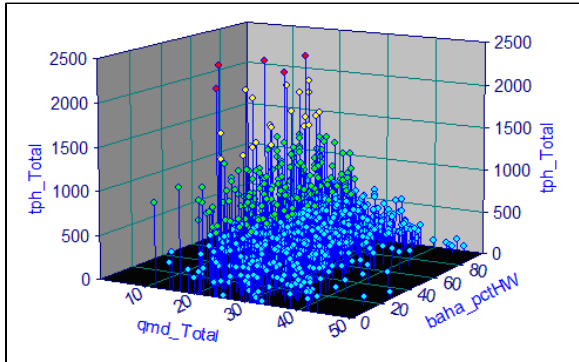


This report presents a set of hydrological principles that can be used to inform forest policies and practices and be translated into actions for sustainable forest management in Canada. These principles were developed as part of a backcasting-from-principles approach to planning that envisions a desired future constrained a set of principles, and then considers the policy and practical steps necessary to arrive there. Many of the concepts underlying the hydrological principles are currently represented in some provinces and territories. However, these principles should serve as the first step in opening a dialogue between forest hydrologists, managers and policy makers. This will help to establish a unified framework for sustainable forest management across the country.

The way forward for scientists, managers, and policy makers to implement our suggested backcasting-from-principles approach was to:

- 1) Reach consensus on hydrological principles through open dialogue;
- 2) Embed the hydrological principles into a framework of principles, policies and practices;
- 3) Integrate the hydrological principles with social, economic and ecological principles; and
- 4) Develop a process for effective monitoring and adaptation of the backcasting-by-principles process.

Comeau, P., V. Reyes-Hernandez, H. Chen, N. Kenkel, M. Bokalo, C. Hawkins, K. Greenway, A. Velazquez-Martinez. 2009. Influence of relative density and composition on growth and understory in the boreal mixed-woods. SFMN project report.



Sustainable forest management requires the ability to estimate or predict the potential outcomes (in terms of forest structure, habitat and other ecological services, timber production, economics, and social implications) of forest management practices. There was a need for research which will improve knowledge about “whether young stands arising from forest management practices today will develop into the stands which we predict” and better knowledge of successional pathways in managed and

unmanaged mixedwood forests. Results reported here indicate that species composition may play a significant role in the maximum density – size relationships in boreal mixedwoods.

Carbon in Wetlands (2016-2019)

This project was awarded \$150,000 funding through the Sustainable Forestry Initiative Conservation and Community Grant Program. LP contributed \$50,000 cash plus in-kind contributions to complete the field work. Sustainable Development contributed student time to complete additional field work.

The carbon in wetlands project's objective was to:

Develop methodologies and estimates of carbon sequestration in upland forests and wetlands on SFI-certified boreal forest landscapes.

Project partners include:

SFI (Sustainable Forestry Initiative) \$150,000 in grant funds

<http://www.sfiprogram.org/>

SRC (Saskatchewan Research Council) <http://www.src.sk.ca>

DUC (Ducks Unlimited Canada) <http://www.ducks.ca/> - project used the DUC wetland inventory, many DUC staff for wetland expertise, and GIS staff for site selection

LPC (Louisiana-Pacific Canada Ltd.) \$50,000 in cash for two years of field work (2016 and 2017), field procedure facilitation, field supervision, additional mapping support

SPL (Spruce Products Ltd.)

SD (Sustainable Development) Province of Manitoba – staff and student time

BU (Brandon University) - lab analyses and field expertise

University of Saskatchewan – advice on field procedures

Forests and forested wetlands provide critical carbon storage and may play an important role in mitigating climate change, but the quantification methods for boreal wetlands were poorly understood. To investigate these dynamics, the project partners developed practical methods for quantifying carbon sequestration in upland forests and wetlands.

The field protocol developed was efficient, based on international accepted methods, and applicable across other SFI-certified landscapes. SRC created tools to sample carbon in the field and to calculate carbon based on vegetation and soil field data. A case study on forestlands managed by SFI Program Participant Louisiana-Pacific Canada Ltd. was developed to ensure the accuracy of tools and protocol.

The carbon of the sampled wetlands will be calculated, based on peat depths and peat sample carbon density. These estimates will be used to quantify carbon estimates by wetland type as well as across all wetlands at the landscape level.

Northern Prairie Forests Integrated Regional Assessment (NPFIRA) - climate change vulnerability assessment

The objectives of the NPFIRA project are to:

1. Assist our partner organizations in understanding their vulnerability to climate change and variability;
2. Assist partners in identifying adaptation options that can be mainstreamed into planning and decision-making systems;
3. Integrate the results across companies, governments and a large multi-use landscape into a regional assessment of climate change vulnerability with real-world implementable adaptation options for the partner organizations;
4. Provide partners with tools for vulnerability assessment and adaptation planning that can be incorporated into their planning systems after project completion.

The project has two primary outputs:

1. An assessment of regional climate change vulnerability, integrated across the study area landscape and across partner organizations, including across multiple branches of the SK and MB governments. Components of the assessment will include an understanding of recent (CMIP5) projections of future climate (i.e. exposure), the sensitivity of these forest ecosystems to climatic variability and climatic change, and an assessment of each organization's adaptive capacity given the impacts identified.
2. In addition to the vulnerability assessment, we will work with each partner organization to identify adaptation options related to the vulnerabilities. The options will focus on those that are cost effective and that are within the capacity of the organizations given their levels of staff expertise, technology availability, and the policy environments within which they operate. Economic analysis will be included in the screening of adaptation options.

The University of Alberta has done a lot of research in Manitoba, either as a specific study or as part of a larger group study.

Bokalo, M., P.G. Comeau and S.J. Titus. 2007. Early development of tended mixtures of aspen and spruce in western Canadian boreal forests. Published in: *Forest Ecology and Management* 242 (2007) 175–184.



In 1992, the Western Boreal Growth and Yield Association (WESBOGY) began a long-term study to evaluate the dynamics of regenerated aspen (*Populus tremuloides* Michx.) - white spruce (*Picea glauca* (Moench) Voss) mixedwood stands following manipulation of aspen to a range of densities. In this study six levels of aspen (0, 200, 500, 1500, 4000 stems per ha and natural) and three levels of spruce (0, 500 and 1000 stems per ha) densities have been created.

Data from four locations demonstrate substantial

variation in initial aspen densities following clearcutting of aspen dominated stands. After 9 years densities begin to converge with the highest rates of mortality associated with high starting densities. A model was developed that shows a significant relationship between the proportion of trees surviving to the end of a year and the density at the beginning of the year. Size-density relationships based on quadratic mean root collar diameter, mean tree volume and mean tree height are presented. Three to four years following spacing of aspen to densities ranging from 200 to 4000 stems per ha there were no significant effects of density on aspen size. In addition, spacing of the aspen had no significant effect on spruce height at year 9 (3–4 years after spacing), but spruce root collar diameter (RCD) was significantly smaller in the unspaced compared to the spaced plots. The ratio of height to root collar diameter (HDR) for white spruce showed a significant and clear response to aspen density and increased with increasing aspen density.

Mundell, T.L., S.M. Landhausser, and V.J. Lieffers. 2007. Effects of *Corylus cornuda* stem density on root suckering and rooting depth of *Populus tremuloides*. The regeneration capabilities of over-aged aspen stands containing heavy hazel competition. Published in: *Canadian Journal of Botany*. 85: 1041-1045 (2007).



Aspen stands with a high density of understory hazel (>45,000 stems per hectare) and a low density of hazel (<5,000 stems per hectare) were harvested in the fall of 2005. After one growing season, aspen sucker density, height and leaf area were assessed. Soil trenches were excavated to examine the root density and rooting depth of both aspen and hazel. Aspen sucker regeneration was 68,200 stems per hectare in areas with low hazel density, and 43,600 stems per hectare in areas with high hazel density. The cross-sectional surface area of aspen roots in shallow soil layers (0-10 cm) was

significantly lower under high densities of hazel. As aspen usually produces most of its' root suckers from shallow roots, the reduction of roots in the upper 10 cm of soil was the likely cause of lowering sucker densities. Height growth of the suckers was not influenced by pre-harvest hazel density, possibly owing to high light transmission as a result of the reduced leaf area of the hazel after the harvest.

T.L. Mundell, S.M. Landhausser, and V.J. Lieffers. 2008. Root carbohydrates and aspen regeneration in relation to season of harvest and machine traffic. Published in: *Forest Ecology and Management* 255 (2008) 68–74.



Season of harvest has often been suggested as a driver for the erratic success of aspen (*Populus tremuloides*) sucker regeneration, partially due to root carbohydrate reserves and soil conditions at the time of harvest. A field experiment in western Manitoba, Canada, assessed root suckering and root carbohydrates of aspen in response to season of harvest and machine traffic. Six sites (120 m X 120 m) were selected within two large mature aspen stands slated for summer harvest. Plots (50 m X 50 m) were hand-felled (without machine traffic) in mid-summer, late summer,

winter, and one plot was left uncut as a control. Season of cut with no traffic had no effect on sucker density, height or leaf dry mass per sucker. During the dormant season, root starch reserves were highest in the winter cut plots, however, just prior to suckering, this difference in carbohydrate reserves among the three seasons of harvest disappeared and by the end of the first growing season root reserves in all three seasons of cut had recovered to near control levels. Adjacent plots that were conventionally harvested in the summer and impacted by logging traffic had similar sucker densities but had 19% less height growth of suckers and 29% less leaf dry mass per sucker compared to suckers in plots harvested at the same time without traffic. After one growing season, root carbohydrate levels were similar whether or not machine traffic was used; however, the reduction in leaf dry mass in plots with machine traffic could have negative implications for carbohydrate accumulation and growth. The study suggests that the phenological state of the mature aspen plays a very small role in aspen regeneration and that harvesting practices and site conditions are likely the main drivers of aspen regeneration success.

Edge, I. and E. Bayne. 2008. White-tailed deer movement, habitat use, and potential for disease transmission in the greater Riding Mountain and Duck Mountain ecosystems. M.Sc. thesis, Department of Biological Sciences, University of Alberta.



Very little information exists in regards to deer home range size, movement and dispersal as well as information about sub-populations and degrees of interaction among them within the greater RMNP and Duck Mountain ecosystems. The project wanted to gain an understanding of the potential spread of bovine Tuberculosis by deer within and out of the RMNP area, and to develop appropriate deer disease management strategies.

The detailed objectives of this project were:

- Document seasonal home range, inter-seasonal movements, philopatry, and dispersal of deer in the study area;
- Determine the effect of landscape/habitat values on resource use by deer, and produce predictive maps illustrating the relative probability of deer use of space.
- Use molecular methods to delineate any existing subpopulations and determine genetic structure, in order to identify long-term trends in deer movement over the landscape in the greater Riding and Duck Mountain ecosystems.

Bokalo, M., K.J. Stadt, P.G. Comeau, and S.J. Titus. 2013. The Validation of the Mixedwood Growth Model (MGM) for Use in Forest Management Decision Making.

Published in: *Forests* 2013, 4, 1-27



We evaluated the Mixedwood Growth Model (MGM) at a whole model scale for pure and mixed species stands of aspen and white spruce in the western boreal forest. MGM was an individual tree-based, distance-independent growth model, designed to evaluate growth and yield implications relating to the management of white spruce, black spruce, aspen, lodgepole pine, and mixedwood stands in Alberta, British Columbia, Saskatchewan, and Manitoba. Our

validation compared stand-level model predictions against re-measured data (volume, basal area, diameter at breast height (DBH), average and top height and density) from permanent sample plots using combined analysis of residual plots, bias statistics, efficiency and an innovative application of the equivalence test. For state variables, the model effectively simulated juvenile and mature stages of stand development for both pure and mixed species stands of aspen and white spruce in Alberta. MGM overestimates increment in older stands likely due to age-related pathology and weather-related stand damage. We identified underestimates of deciduous density and volume in Saskatchewan. MGM performs well for increment in postharvest stands less than 30 years of age. These results illustrate the

comprehensive application of validation metrics to evaluate a complex model and provide support for the use of MGM in management planning.

BAM – Boreal Avian Modeling

Applying data-driven measures to evaluate and improve the conservation value of managed forests for birds. The Boreal Avian Modelling Project (BAM) is a biome-scale program providing data-driven scientific information for conservation and management of boreal birds.

This project addresses Objective 4 in SFI's Standard: "Protection of Biological Diversity" by developing methods for measuring and improving sustainability of forest management using birds as bio-indicators. Models will evaluate the conservation value of sustainable forest management for bird biodiversity and inform sampling recommendations. Where possible, existing bird models will be enhanced with new data provided by partners. This grant will facilitate further engagement with industry partners interested in enhancing conservation value of managed forests. <http://www.borealbirds.ca/>

2.8.1.6.

U of Manitoba

Chranowski, D. 2009. Cow elk ecology, movements and habitat use in the Duck Mountains of Manitoba. M.Env. thesis, University of Manitoba.



This study conducted baseline research to determine home range, movements and habitat selection of Manitoban elk (*Cervus elaphus manitobensis*) in the Duck Mountain of west-central Manitoba. Cow elk (n=22) were captured by helicopter net-gun and GPS radio-collared in 2005/06. Data was analyzed with ArcView 3.3 for Windows (ESRI). Duck Mountain elk show selection for deciduous forest and avoidance of roads. Mean 100% MCP home ranges were 127.85 km² with 95% and 50% adaptive kernel home range sizes of 58.24 km² and 7.29 km², respectively. Home range overlap occurs at all

times of the year with many elk using farmland. Elk moved the least in late winter. Movements increased in the spring, declined in June with a gradual increase from July to October. Elk had generalized movement in southerly directions. No cow elk dispersed from the study area. Mean estimated calving date was June 3rd and mean estimated breeding date was September 27th. Duck Mountain elk were found in mature deciduous/mixed-wood forest and shrub/grassland/prairie savannah ecosites, but not found within 200 m of a road or water feature more often than expected by random. Elk were found in areas with <10% and <81% crown closure, on middle slopes and variable aspects. Elk displaced from forestry cut-blocks. Only 149 of 79,284 elk locations were within 100 m of a winter cattle operation. Recommendations to mitigate forestry and BTB impacts focus on riparian areas, road management, farming practices and hunting.

Renton, J., A. Park, and R. Westwood. 2010. The Impact of Cattle Grazing on Aspen regeneration on Crown Lands in Western Manitoba. (University of Manitoba thesis)



In western Manitoba there has been an increasing appreciation for the value of trembling aspen (*Populus tremuloides* Michx) as a source of timber. Moreover, aspen stands and the understory vegetation that they support also provide valuable forage for livestock and wildlife. Timber harvesting and cattle grazing are often done on the same area of land, though not simultaneously. The purpose of this project was to investigate the effects cattle grazing have on commercial tree regeneration, forest health and understory species diversity in post-harvest aspen

stands. Tree density; tree health; and understory herbaceous and shrub diversity were compared in nine grazed and nine ungrazed sites across a 10-year harvesting chronosequence, consisting of three stand age classes (2-3 years, 5-8 years and 9-11 years-old). Environmental data were collected to establish supplementary correlates of species performance. These variables included soil compaction, soil texture, drainage class and an index of grazing pressure. Ungrazed 9 to 11-year old stands had a significantly higher stem density and stem height for aspen and all other commercial species ($p < 0.1$). Tree health was not found to differ significantly between grazed and ungrazed treatments within any stand age.

Kardynal, K.J., K.A. Hobson, S.L. Van Wilgenburg, and J. Morissette. 2009. Moving riparian management guidelines towards a natural disturbance model: An example using boreal riparian and shoreline forest bird communities. Published in: Forest Ecology and Management.



Moving riparian management guidelines towards a natural disturbance model: An example using boreal riparian and shoreline forest bird communities

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ABSTRACT

Forest harvesting strategies that approximate natural disturbances have been proposed as a means of maintaining natural species diversity and richness in the boreal forests of North America. Natural disturbances impact shoreline forests and upland areas at similar rates. However, shoreline forests are generally protected from harvest through the retention of treed buffer strips. The riparian bird community responses to forest management guidelines intended to approximate disturbance frequency (1–4 years post-burn) and harvested forest adjacent habitat and the adjacent shoreline forest. We sampled riparian areas with adjacent (1) natural merchantable shoreline forest (n = 21), (2) burned non-merchantable shoreline forest (n = 29), (3) 10 m treed buffer with 25% retention in the next 30 m (n = 18), and (4) 30 m treed buffer (n = 21). Only minor differences were detected in riparian species' abundance and bird community composition between treatments with greater differences in these parameters occurring between post-fire and post-harvest upland bird communities. Indicators of all merchantable habitats and forest specialists being typical upland indicator species of burned merchantable habitats and forest specialists being typical upland indicator species of harvested treatments. Riparian species indicative of burned riparian habitats were Common Yellowthroat (*Geothlypis trichas*), Le Conte's Sparrow (*Ammodramus leconteii*) and Eastern Kingbird (*Tyrannus tyrannus*) and indicators of 30 m buffers were Alder Flycatcher (*Empidonax alnorum*) and Wilson's Warbler (*Wilsonia pusilla*). Multivariate Redundancy Analysis (RDA) of the overall (riparian and upland birds) community showed greater divergence than RDA with only riparian species suggesting less effect of fire and forestry on riparian birds than on upland birds. Higher natural range of variability (NRV) of overall post-fire bird communities compared to post-harvest communities suggests that harvesting guidelines currently do not achieve this level of variability. However, lack of a large negative effect on common riparian species in the first 4 years post-disturbance allows for the exploration of alternative shoreline forest management that better incorporates bird community composition of post-fire riparian areas and shoreline forests.

1. Introduction

Increasing anthropogenic pressures in the North American boreal forest (Cunning et al., 1994; Hobbie, 2003) have accelerated the adoption of forest management practices that attempt to maintain natural ecosystem processes (Patterson, 2002; Atwell, 1994). Recent research has highlighted the impacts of such anthropogenic alterations on boreal wildlife (e.g., Voths,

1997; Kirk et al., 1997; Hobson and Rejne, 2000). Over 200 species of birds exist in the western Canadian boreal forest (Smith, 1981), many of these show their highest abundance there (Bartcher, 2002) and few are considered threatened (Stuart, 2002). In such conservation practices that focus on single-species management are neither practical nor feasible, and a species-rich approach (i.e., one that considers multiple species) to forest management is more appropriate (Amundson et al., 2002).

Current hypotheses proposed to maintain wildlife populations in managed forests suggest using natural disturbance regimes to guide forest harvesting operations (Patterson, 2002). This natural disturbance hypothesis assumes that forest birds will be more likely to adapt to anthropogenic disturbances that mimic structural

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Forest harvesting strategies that approximate natural disturbances have been proposed as a means of maintaining natural species diversity and richness in the boreal forests of North America. Natural disturbances impact shoreline forests and upland areas at similar rates. However, shoreline forests are generally protected from harvest through the retention of treed buffer strips. We examined bird community responses to forest management guidelines intended to approximate shoreline forest fires by comparing bird community structure in early (1–4 years) post-burned and harvested boreal riparian habitats and the adjacent shoreline forest. We sampled riparian areas with adjacent: (1) burned merchantable shoreline forest (n = 21), (2) burned non-merchantable shoreline forest (n = 29), (3) 10 m treed buffer with 25% retention in the next 30 m (n = 18), and (4) 30 m treed buffer (n = 21). Only minor differences were detected in riparian species' abundance and bird community composition between treatments with greater differences in these parameters occurring between post-fire and post-harvest upland bird communities. Indicators of all merchantable habitats and forest specialists being typical upland indicator species of burned merchantable habitats and forest specialists being typical upland indicator species of harvested treatments. Riparian species indicative of burned riparian habitats were Common Yellowthroat (*Geothlypis trichas*), Le Conte's Sparrow (*Ammodramus leconteii*) and Eastern Kingbird (*Tyrannus tyrannus*) and indicators of 30 m buffers were Alder Flycatcher (*Empidonax alnorum*) and Wilson's Warbler (*Wilsonia pusilla*). Multivariate Redundancy Analysis (RDA) of the overall (riparian and upland birds) community showed greater divergence than RDA with only riparian species suggesting less effect of fire and forestry on riparian birds than on upland birds. Higher natural range of variability (NRV) of overall post-fire bird communities compared to post-harvest communities emphasizes that harvesting guidelines currently do not achieve this level of variability. However, lack of a large negative effect on common riparian species in the first 4 years post-disturbance allows for the exploration of alternative shoreline forest management that better incorporates bird community composition of post-fire riparian areas and shoreline forests.

2.8.2. Forest Research Organization Affiliations

Forest research organizations (Table 2.30) in this section are agencies that include conservation groups, universities, research organizations, or government departments. These organizations were supported by LP and other partners in various ways, depending on project requirements. The partnerships have been established to pursue research and monitoring related projects in order to enhance sustainable forest management planning and operational practices on crown and private lands. These joint ventures demonstrate the ability to apply a holistic approach in managing the forest land base for all values (biological, social and economic) in order to achieve an effective model of forest sustainability.

Table 2.30 Forest research organization affiliations 2006 to present (in alphabetical order)

Forest research organizations
Assiniboine Community College (ACC)
Canadian Forest Service (CFS) - Northern Forestry Centre (NoFC) in Edmonton, AB
Ducks Unlimited Canada (DUC)
Intermountain Conservation District (IMCD)
Manitoba Agriculture and Food
Manitoba Feasibility Assessment of Afforestation for Carbon Sequestration (FAACS)
Manitoba Model Forest (MMF) shut down in 2007
National Council for Air and Stream Improvement (NCASI)
Natural Sciences and Engineering Research Council (NSERC)
Nature Conservancy Canada (NCC)
Poplar Council of Canada (PCC)
Swan Lake Watershed Conservation District
Sustainable Forest Management Network (SFMN)
University of Alberta (U of A)
University of Manitoba (U of M)
University of Winnipeg (U of W)
Western Boreal Growth and Yield association (WESBOGY)

Assiniboine Community College (ACC)

<http://public.assiniboine.net>

Assiniboine Community College (ACC) was a progressive post-secondary institution that provides individuals with knowledge, skills and credentials that are highly valued in the workforce. ACC was committed to be a college that was the first choice of students. LP contributes to the Geographic Information Systems (GIS) advisory committee and has assisted with joint GIS student projects.

Canadian Forest Service (CFS) - Northern Forestry Centre (NoFC)

<http://www.nrcan.gc.ca/forests/research-centres/nofc/13485>

The Northern Forestry Centre was one of five research centres operated by the Canadian Forest Service. It was located in Edmonton, Alberta. The work underway at the centre supports Natural Resources Canada's national research priorities, and addresses forestry issues in Alberta, Saskatchewan, Manitoba, and the Northwest Territories.

The centre's program includes four main areas of research:

Boreal ecosystem ecology

Sound management of Canada's largest forest ecosystem depends on sound knowledge of the structure, composition, and function of boreal forests and of how they respond to natural and human-made disturbances. Current projects at the centre include studying the response of the boreal to novel pest invasions; assessing and predicting forest ecosystem responses to harvesting and fire; and transferring new knowledge to forest managers to promote better management of resources. The flagship EMEND project was one example of the work underway to develop better forest practices.

Climate change and forests research

In this research area, the focus was on mitigating and adapting the effects of climate change on Canada's forests. Work includes modelling forests as carbon sinks or sources; tracking and assessing the impacts of climate change on forest ecosystems; and developing tools and strategies to facilitate adaptive sustainable forest management. The centre also leads outreach activities related to the CFS Carbon Budget Model and was an active member of the Canadian Council of Forest Ministers' Climate Change Task Force.

Land reclamation

This area was a relatively new initiative within the CFS. Work was underway with a wide range of stakeholders and collaborators to develop innovative approaches to: minimizing resource development impacts on forest land, and accelerating reclamation of forest ecosystems on oil sands mining and *in situ* sites. Research activities focus on developing baseline conditions and reclamation technologies, establishing indicators of ecosystem recovery, and engaging industry, academia and other sectors in increasing CFS contributions to land reclamation issues.

Wildland fire

The centre works with partners across the country to increase knowledge about wildland fires. It also provides national-level information on current and forecasted fire conditions. Its fire research, information systems and decision support tools—among them, Canada's Wildland Fire Information System—improve the ability of Canada's fire management agencies to predict and manage the risks and benefits associated with wildland fire. Other research activities include developing new techniques to reduce the impacts of fire on communities, and creating tools to undertake risk analysis, projections and modelling related to wildland fire behaviour, smoke distribution and burn probability.

Ducks Unlimited Canada

<http://www.ducks.ca/>

Ducks Unlimited Canada (DUC) and Louisiana-Pacific Canada Ltd., Swan Valley Forest Resources Division, signed a Memorandum of Understanding (MOU) 2005-2010 that outlined a commitment to effective watershed-based conservation within Forest Management License Area #3. This MOU identifies several strategic priorities that will guide the partnership including:

- The development of forest management strategies to promote sustainable management of aquatic resources through appropriate watershed-based management planning and operations;

- Collaborate on the development and implementation of research and monitoring projects and share information and research results related to water, wetlands, riparian and watersheds;
- Development and promotion of Best Management Practices that protect the integrity of watersheds, riparian habitats, water and wetlands;
- Develop and participate in an implementation project in the Duck Mountains to test the effects and effectiveness of new planning and management approaches;
- Promote sustainable private land forestry that maintains long-term forest cover and protects the integrity of watersheds, riparian habitats, water and wetlands, and
- Communication and Knowledge Exchange

The MOU was followed by a five-year Contribution Agreement which outlines the commitment by both agencies to financial and other resources required to facilitate program development. A key component to the Contribution Agreement was the development of activities and work plan to accomplish the objectives identified in the MOU. Various activities, such as the continued monitoring of the boreal riparian bird project sites, refinement of the DUC Enhanced Wetland Classification System for the Boreal Plains Ecozone, and the development of a knowledge exchange workshop on watershed and riparian management were carried out over the five-year time-frame.

Inter Mountain Conservation District

www.intermountaincd.com



Both LP and the Inter Mountain Conservation District (IMCD) have worked on new approaches to achieve improved environmental outcomes, including working with others to establish a long-term vision, implementing a watershed-based planning approach, sharing the awareness for environmental quality, establishing a comprehensive database of water management objectives, and working continuously to monitor and improve watershed-based standards, practices and outcomes. LP and the IMCD have jointly discussed common concerns and many areas of mutual interest.

Manitoba Agriculture and Food

Manitoba Agriculture and Food established the Garland Grazing Trial in cooperation with LP. LP has established permanent sample plots within the various grazing (low and medium grazing levels) and harvest (summer and winter) treatments. The regenerating aspen PSPs were established in 2000, and remeasured in 2005, 2010, and 2015.

Manitoba Feasibility Assessment of Afforestation for Carbon Sequestration (FAACS)

The objective of FAACS was to determine if a large-scale national tree planting program for the purposes of carbon sequestration was feasible to help Canada achieve its greenhouse gas emission reduction targets. LP was a member of FAACS and contributed to advising potential research projects and trials.

Manitoba Model Forest

The Manitoba Model Forest (MMF) officially ended on March 31st, 2007. LP was an active participant with the Forest Communities Program (FCP), which was the successor to the MMF. LP was funding and actively participating in the FCP. LP contributed to the formal proposal "Sustaining Manitoba's Forests and Forest-Based Communities", submitted in October 2006 to the Canadian Forest Service and the Forest Communities Program. FCP provided outdoor educational programming geared towards elementary, junior and intermediate school levels. The Forest Communities Program has received federal funding and significant financial contributions and leveraging from the many FCP partners.

The Forest Communities Program five-year program and broad objectives were:

- Capacity Building of Communities;
- Integrated Landscape Management;
- Forest-based Opportunities; and
- Projects with International Model Forests.

National Council for Air and Stream Improvement (NCASI)

<http://www.ncasi.org/>

The National Council for Air and Stream Improvement (NCASI) was an independent, non-profit research organization that conducts technical studies on environmental topics or issues facing the forest products industry in the United States and in Canada. NCASI maintains a technical staff of approximately 80 scientists and engineers with expertise in areas such as chemistry, chemical engineering, environmental engineering, pulp and paper science, forestry, toxicology, aquatic biology, wildlife biology, forest biology and computer science. NCASI distributes a number of publications used within industry but are also used among academic researchers, regulatory agencies and within other organizations. LP was a corporate member of NCASI and was represented on the NCASI Canadian Steering Committee, NCASI Environmental Task Group and on the Forestry Task Group.

Natural Sciences and Engineering Research Council (NSERC)

http://www.nserc-crsng.gc.ca/index_eng.asp

NSERC's role was to make investments in people, discovery and innovation for the benefit of all Canadians. We invest in people by supporting more than 9,000 students in their advanced studies. We promote discovery by funding more than 8,700 researchers every year. And we help make innovation happen by encouraging more than 1,000 Canadian companies to invest in university research.

NSERC (the Natural Sciences and Engineering Research Council of Canada) was the national instrument for making strategic investments in Canada's capability in science and technology.

NSERC supports both basic university research through research grants and project research through partnerships of universities with industry, as well as the advanced training of highly qualified people in both areas.

NSERC was a separate employer of the Government of Canada, reporting to Parliament through the Minister of Industry. NSERC was governed by a Council of 22 members selected from private sectors, public sectors, and universities.

Nature Conservancy Canada (NCC)

<http://www.natureconservancy.ca/en/>

The Nature Conservancy of Canada (NCC) was Canada's leading national land conservation organization. NCC was a private, non-profit group that partners with corporate and individual landowners to achieve the direct protection of our most important natural treasures through property securement (donation, purchase, conservation easement and the relinquishment of other legal interests in land) and long-term stewardship of our portfolio of properties.

VISION - The Nature Conservancy of Canada will protect areas of biological diversity for their intrinsic value and for the benefit of future generations.

MISSION - A Nature Legacy Through Partnership. To accomplish this mission, the Nature Conservancy of Canada will lead, innovate and use creativity in the conservation of Canada's natural heritage by securing ecologically significant natural areas through purchases, donations, conservation agreements or other mechanisms, and by achieving long-term stewardship through management plans and monitoring arrangements.

VALUES - The earth's biological diversity was being lost at a rate that impoverishes our quality of life and threatens our future. NCC's work was guided by the belief that our society will be judged by what it creates in the present and what it conserves for the future. Wherever we work across Canada, we share and apply values that reflect this philosophy:

- We are guided by the best available conservation science;
- We work in a non-confrontational manner;
- We manage lands and waters for their intrinsic, natural values;
- We respect and promote nature's own processes of growth, succession and interaction;
- We recognize the need to create avenues for people to sustain themselves and live productively while conserving biological diversity.

Poplar Council of Canada (PCC)

<http://www.poplar.ca/>

PCC undertakes studies and review of poplar resources, management and utilization and has an excellent base of information and expertise in our members' and data sources. PCC also assists in the process of research on poplar issues through contract administration, lobbying for funding, member contacts, and technological committees to evaluate projects and knowledge gaps. Although not a research agency, the PCC regularly publishes current information from research for its members.

PCC, as Canada's national 'poplar commission', was involved with the International Poplar Commission (IPC), which was a Statutory Body of the Food and Agriculture Organization (FAO) of the United Nations. Through IPC, PCC has links with poplar and willow scientists throughout the world. PCC has copies available of the IPC Directory of Poplar and Willow Scientists. Several PCC members are actively involved in the work of the Executive Committee and Working Parties of IPC.

Swan Lake Watershed Conservation District

<http://www.mcda.ca/swan-lake-watershed-conservation-district/>



The Swan Lake Watershed conservation district delivers incentive-based programming to address land and water issues, including stream bank stabilization, grassed waterway construction and repair, abandoned well sealing, well head protection, private well water testing, tree planting, and fisheries and riparian enhancement. The SLWCD plays an important role in environmental education initiatives; it works closely with its local schools and Envirothon team. The conservation district has completed its integrated watershed management plan for the Swan Lake Watershed.

Sustainable Forest Management Network

<http://sfmn.ualberta.ca/>

LP was very active in the Sustainable Forest Management Network (SFMN) Centres of Excellence, until the SFMN shut down in 2010. Based out of the University of Alberta, the SFMN was a unique national organization of university, forest industry, First Nations and government agencies, and conservation organizations conducting research on various components of sustainable forest management. LP had a representative on the Board of Directors and the Industry Partners Committee and was been active in formulating research priorities for research funding. The SFMN conducted approximately \$6.5 million of research annually related to natural disturbance regimes, harvesting effects on forest ecosystems, biodiversity assessment and monitoring, modeling approaches and social and economic issues related to forest management.

LP was a collaborating partner on several multi-year research proposals. The SFMN had a very strong emphasis on collaborative research, partnerships, and Knowledge Exchange and Technology Extension.

Western Boreal Growth and Yield association (WESBOGY)

<http://www.ales.ualberta.ca/rr/Research/WESBOGY.aspx>



LP is a member of the Western Boreal Growth and Yield (WESBOGY) association based out of the University of Alberta. The association works to:

- develop and disseminate natural and managed growth and yield information;
- develop and improve modeling technology (*i.e.* MGM - Mixedwood Growth Model);
- encourage member agencies work in a coordinated fashion to improve the efficiency of their research and development efforts;
- facilitate data sharing; and
- provide a forum for communication between professionals.

WESBOGY members collaborated on the development and dissemination of growth and yield modeling technology and information. Research, development, extension activities, and growth and yield data sharing were completed. Current membership in the association includes seven forest companies, three provincial/territorial governments (Alberta, Saskatchewan and the Northwest Territories) and the federal government.

University of Alberta

www.ualberta.ca

The University of Alberta has a faculty of Forest Science and Management. U of Alberta faculty and their students have conducted forest research projects in west-central Manitoba. U of Alberta's research aim is to provide a scientific basis for improvements to forest management practices which aim to ensure economic and ecological sustainability now and in the future.

University of Manitoba

http://www.umanitoba.ca/institutes/natural_resources/

The University of Manitoba has the Natural Resources Institute (NRI), which integrates knowledge gained from the natural and social sciences to develop holistic perspectives on environmental and natural resources management problems. Research conducted at the NRI may have an economic, social, or ecological perspective, or may integrate all three disciplines.

University of Winnipeg

Centre for Forest Interdisciplinary Research (C-FIR)

<http://www.uwinnipeg.ca>

Several research initiatives with the University of Winnipeg have been developed. LP has contributed funding towards the initial development of C-FIR at the University of Winnipeg. LP also participates on an advisory committee involved with setting research priorities, development of curricula, programs, and Centre administration. LP staff have participated in several forest research symposiums.

2.8.3. LP Research

The projects included within this section were solely funded by Louisiana-Pacific Canada Ltd., Swan Valley - Forest Resources Division. Project coordination, implementation, field work, and preliminary data analysis were conducted internally. Additional analyses were sometimes conducted by external researchers.

2.8.3.1. Forest Bird Monitoring

The Duck Mountain Forest Bird Monitoring Project was initiated in 1997 to 2002 and 2004, in order to gather baseline information on the distribution and habitat associations of neo-tropical, riparian, and resident bird species inhabiting the Duck Mountain Provincial Forest.

In 2007 the forest bird monitoring project focused on describing the local abundance and habitat requirements of Golden-Winged Warbler (GWWA), a migratory bird species designated as threatened under provincial and federal species at risk legislation.

In 2009 to present, LP continues to conduct bird surveys specifically to identify the presence of species at risk within proposed harvest areas. This information allows LP to support the conservation of priority species through the implementation of various planning strategies and specific Best Management Practices for migratory birds.

2.8.3.2. Permanent Sample Plots

Permanent Sample Plots (PSPs) are the primary source of forest change data (*e.g.* species composition, volume gain, ecological attributes, heights, diameters, mortality *etc.*). These data are extremely valuable for assessing sustainability, since PSP data quantifies the actual growth rate of the forest.

LP's Environment Act Licence 2191E states in Section 13 iii:

"The Licensee [LP Canada Ltd.] shall co-operate in the establishment of permanent monitoring and research sites within the no-harvest areas of the F.M.L. Area and in long-term ecological monitoring on those sites;"

PSPs were established, due to uncertainty of growth rates of hardwoods in the Duck Mountains (TetrES consultants 1995). It was also recognized that PSPs were needed to develop habitat relationships for various stand type and age combinations for future long-term ecological monitoring.

From 2006 to present, the PSP network of 489 PSPs was improved through remeasurement and establishing new PSPs at research trials. In 2006, 69% of the PSP network had never been remeasured. 112 PSPs were remeasured during the 2006 to 2016 period (Figure 2.37), decreasing the number of PSPs that had never been remeasured to 57%.

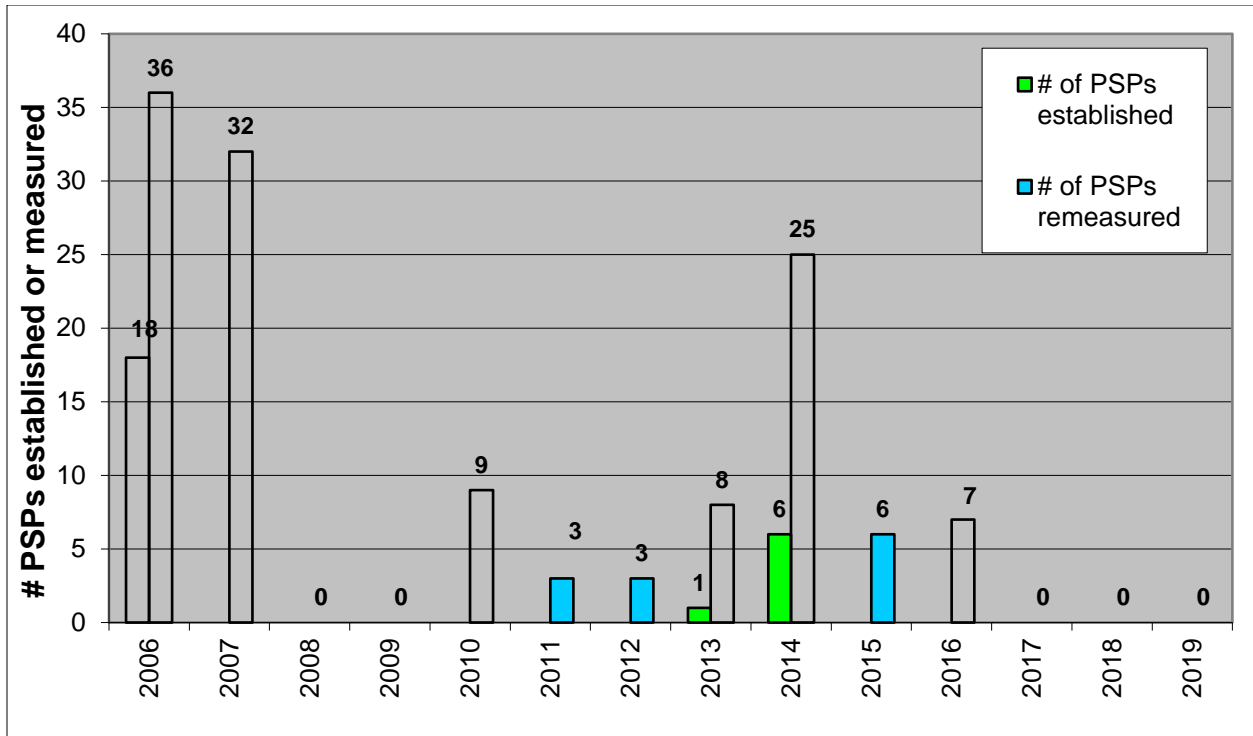


Figure 2.37 Permanent Sample Plot establishment and measurement 2006 to 2019.

In 2012 there was a significant blow down event which destroyed approximately 20 PSPs. From 2010 to 2019 there were 30 PSPs decommissioned due to harvesting, reducing the total PSP network.

2.8.3.3.

WESBOGY Mixedwood Density Experiment



LP Swan River (Figure 2.39) has the eastern-most installation of 11 identical mixedwood density experimental installations across western Canada. Note that LP Dawson Creek, BC (LPDC) was the western-most installation. Membership in the WESBOGY association includes seven forest companies, three provincial/territorial governments (Alberta, Saskatchewan and the Northwest Territories) and the federal government of Canada.

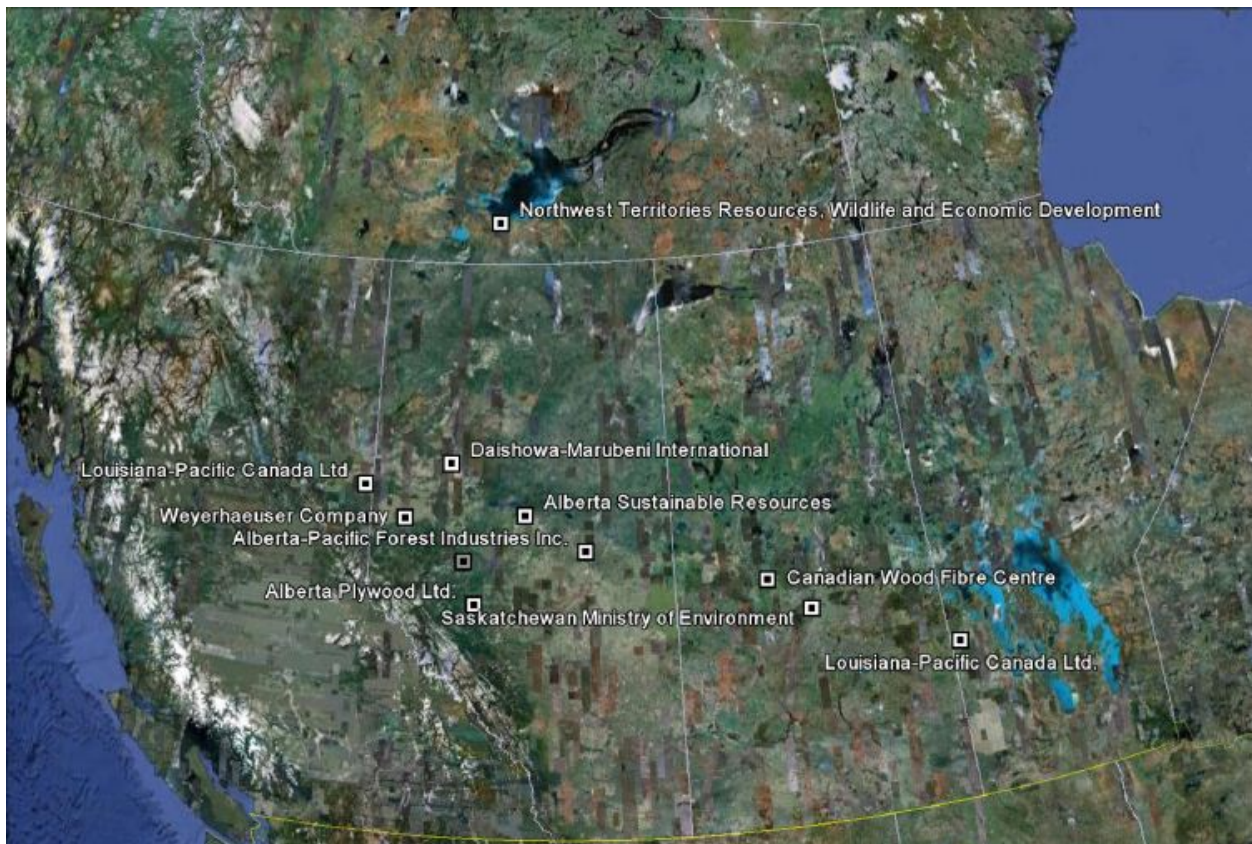


Figure 2.38 WESBOGY mixedwood experimental trials in western Canada.

LP established their mixedwood density installation in 1998 and has consistently maintained and remeasured these valuable aspen and white spruce permanent plots. There are 60 permanent plots on two sites; Alpine-high site quality, and Boggy Creek-medium site quality. The mixedwood plots range from pure white spruce to pure aspen, with four levels of mixed aspen-spruce densities.

Two of the WESBOGY association's main goals are:

To evaluate the effect of spruce and aspen density levels on the development of plantations from establishment to final harvest (Bokalo *et. al.* 2007); and

To develop and refine growth and mortality relationships and incorporate these new relationships into the Mixedwood Growth Model growth simulator (Bokalo *et. al.* 2013).

2.9. Literature Cited

- Bokalo, M., P.G. Comeau and S. J. Titus. 2007.** Early development of tended mixtures of aspen and spruce in western Canadian boreal forests. *For. Ecol. Manage.* 242 (2007) 175-184.
- Bokalo, M., K.J. Stadt, P.G. Comeau and S. J. Titus. 2013.** The validation of the Mixedwood Growth Model (MGM) for use in forest management decision making. *Forests* 2013, 4, 1-27
- Chranowski, D. 2009.** Cow elk ecology, movements and habitat use in the Duck Mountains of Manitoba. M.Env. thesis, University of Manitoba. Winnipeg, MB. 153 pp.
- Comeau, P., V. Reyes-Hernandez, M. Bokalo, H. Chen, N.C. Kenkel, C. Hawkins, K. Greenway, A. Velazquez-Martinez. 2009.** Influence of relative density and composition on growth and understory in the boreal mixedwoods. Final Project Report, Sustainable Forest Management Network, Edmonton, AB. 15 pp.
- Creed, I., S. Gabor, F. Beall, J. Buttle, D. Moore, and M. Donnelley. 2011.** Hydrological principles for conservation of water resources within a changing forested landscape. Sustainable Forest Management Network. State of Knowledge Report. Sustainable Forest Management Network, Edmonton, AB. 80 pp.
- Environment Act Licence 2191E. 1996.** Issued to Louisiana-Pacific Canada Ltd. Dec. 10th, 1996. Manitoba Environment Act (C.C.S.M. c. E125) 9 pp.
- Ducks Unlimited Canada. 2014.** Forest Road Wetland Crossings: Learning from field trials in the boreal plains Ecozone of Manitoba and Saskatchewan. version 1.0. Ducks Unlimited Canada, Edmonton, AB. 43 pp.
- Ducks Unlimited Canada. 2015.** Field Guide Boreal Wetland Classes in the Boreal Plains Ecozone of Canada. Version 1.1. Ducks Unlimited Canada, Edmonton, AB. 92 pp.
- Edge, I. and E. Bayne. 2008.** White-tailed deer movement, habitat use, and potential for disease transmission in the greater Riding Mountain and Duck Mountain ecosystems. M.Sc. thesis, Department of Biological Sciences, University of Alberta. Edmonton, AB. 38 pp.
- Hart, T., H. Chen, A. Taylor, P. LeBlanc and S. Watson. 2010.** Management Implications of Disturbance and Aging on Forest Stand Composition. Sustainable Forest Management Network. Edmonton, AB. 44 pp.
- Kardynal, K.J., K.A. Hobson, S.L. Van Wilgenburg, and J. Morissette. 2009.** Moving riparian management guidelines towards a natural disturbance model: An example using boreal riparian and shoreline forest bird communities. *Forest Ecology and Management* 257 (2009) 54–65.
- Kavanagh (ed). 2006.** Hinterland Who's Who: Canada's Boreal Forest Hinterland. Blancher, P., Bradbury, S. Cobb, T., Fisher, C., Hannah, K.C., Johns, B., Lane, J., MacIsaac, D., Paszkowski, C., Scrimgeour, G. and S.J. Song. (<http://www.hww.ca/hww2.asp?id=354>).
- Louisiana-Pacific Canada Ltd. 1996.** Forest Management Licence #3 Ten Year Forest Management Plan 1996-2005. Volume 1. Swan River, MB. 129 pages plus appendices.

- Louisiana-Pacific Canada Ltd. 2018.** Field Procedures for Water Crossing Inspections. Swan River, MB. 8 pages.
- Manitoba Agriculture and Food. 2015.** Draft – Garland Project: Managed Grazing Systems on Hardwood Timber Harvested Areas (1997 - 2015). 26 pp.
- Manitoba Natural Resources. 1994.** Forest Management Licence Agreement (dated Sept. 21, 1994). 49 pp. plus schedules.
- Manitoba Conservation. 2008.** Forest Management Guidelines for Riparian Management Areas. Manitoba Conservation and Water Stewardship. 200 Saulteaux Crescent, Winnipeg, MB. 47 pp.
- Manitoba Conservation and Water Stewardship, Forestry Branch, Forest Health and Renewal Section (a).2014.** Manitoba Hardwood Renewal Survey Manual. 200 Saulteaux Crescent, Winnipeg, MB. 28 pp. plus appendices.
- Manitoba Conservation and Water Stewardship, Forestry Branch, Forest Health and Renewal Section (b).2014.** Manitoba Free to Grow Survey Manual. 200 Saulteaux Crescent, Winnipeg, MB. 23 pp. plus appendices.
- Morissette, J. and M. Donnelly. 2010.** Riparian Areas Challenges and Opportunities for Conservation and Sustainable Forest Management. SFMN publication.
- Morissette, J.L. & K. J. Kardynal & E. M. Bayne & K. A. Hobson. 2013.** Comparing Bird Community Composition Among Boreal Wetlands: Was Wetland Classification a Missing Piece of the Habitat Puzzle? *Wetlands* (2013) 33:653–665.
- Mundell, T.L., S.M. Landhausser, and V.J. Lieffers. 2007.** Effects of *Corylus cornuda* stem density on root suckering and rooting depth of *Populus tremuloides*. The regeneration capabilities of over-aged aspen stands containing heavy hazel competition. *Canadian Journal of Botany*. 85: 1041-1045 (2007).
- Mundell, T.L., S.M. Landhausser, and V.J. Lieffers. 2008.** Root carbohydrates and aspen regeneration in relation to season of harvest and machine traffic. *Forest Ecology and Management* 255 (2008) 68–74.
- Rempel, R.S. and M. Donnelly. 2010.** A spatial Landscape Assessment Modeling framework for forest management and biodiversity conservation. Sustainable Forest Management Network, Edmonton Alberta. 36 pp.
- Renton, J., A. Park, and R. Westwood. 2010.** The Impact of Cattle Grazing on Aspen regeneration on Crown Lands in Western Manitoba. University of Manitoba thesis.
- Saskatchewan Research Council. 2016.** Carbon in Wetlands Project (2016-2018).
- Smith, K.B., C.E. Smith, S.F. Forest and A. Richard. 2007.** Version 1.0.A field guide to the wetlands of the boreal plains ecozone of Canada. Ducks Unlimited Canada, Western Boreal Office. #100 17958 106th Avenue, Edmonton, AB. 98 pp.
- TetrES consultants. 1995.** Environmental Impact Statement Volume 1. Louisiana-Pacific Canada Ltd. Forest Management Licence #3. 10-Year Forest Management Plan (1996-2005). 14-33 pp.

2.10. APPENDICES

APPENDIX 1: Roads and Water Crossings in Forest Management Licence #3
(1:150,000 scale map).

APPENDIX 2: Area harvested in Forest Management Licence #3 (2006 to 2019) (1:150,000 scale map).

APPENDIX 3: Renewal activities in Forest Management Licence #3 (2006 to 2019) (1:150,000 scale map).