MISTIK MANAGEMENT LTD.

2019 20-YEAR FOREST MANAGEMENT PLAN

Volume II Document III- Silviculture Ground Rules

Background Information Document

2019 FOREST MANAGEMENT PLAN – VOLUME II
SILVICULTURE GROUND RULES

for the

Mistik and L&M Forest Management Agreement (FMA) Areas

For the 20-year period from April 1, 2019 to March 31, 2039

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Changes Since Previous Submission

This document was previously submitted to Saskatchewan Ministry of Environment on December 5, 2017. The only changes from the version submitted on that date to this current and final version are listed below.

Section	Page	Change
N/A	N/A	Headers (changed to "2019 Silviculture Ground Rules")
N/A	ii	Changed date: April 1, 2019 to March 31, 2039
N/A	iii	Removed sign-off sheet and added this description of changes
N/A	N/A	Footers (changed to dates)
1	1	Corrected SGR #8 label. Changed from HS-tA to H-tA
N/A	N/A	Removed the old Section 10 (FTG Surveys) as it no longer applies with the new standard.

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1 Identification of Silviculture Ground Rule (SGR) Forest Types

Based on assessment of provincial forest type designations, Mistik forest development types (created for volume estimation, yield curves and wood supply analysis) and operational/silvicultural considerations, Mistik has identified eight broad forest types (Table 1-1) that will be used for assessing forest renewal success and associated successional transitions.

TABLE 1-1 SGR FOREST TYPE[1], YIELD CURVE LINKAGE, AND CURRENT AREA

Silviculture Ground Rule (SGR) Forest Type	Forest Development Type (Yield Curve)	Current Area (ha)	Currant Area (%)
#1 (S-wS)	#1 S-wS-A-A	23,015	3%
#2 (S-bS)	#2 S-bS-A-A	34,579	4%
#3 (S-jP)	#3 S-jP-LD-A-1	94,565	11%
	#4 S-jP-LD-A-2	29,871	3%
	#5 S-jP-HD-A-1	101,108	12%
	#6 S-jP-HD-A-2	57,705	7%
	#7 S-jP-L&M	17,962	2%
#4 (SH-jP/tA)	#8 SH-jP-A-A	54,045	6%
#5 (SH-wS/tA)	#9 SH-wS-A-A	51,773	6%
#6 (HS-tA/wS)	#10 HS-wS-A-A	54,378	6%
#7 (HS-tA/jP)	#11 HS-jP-A-A	42,185	5%
#8 (H-tA)	#12 H-A-LD-A-1	17,195	2%
	#13 H-A-LD-A-2	28,607	3%
	#14 H-A-HD-A-1	64,239	7%
	#15 H-A-HD-A-2	128,017	15%
	#16 H(S)-A-LD-A	31,105	4%
	#17 H(S)-A-HD-A	48,163	5%
Total		878,512	100%

[1] Forests change with time. Mixedwood forests invariably commence as hardwood-dominated stands. Successional changes and other environmental influences result in subtle shifts in species composition with time. The SGR forest types identified in Table 1-1 identify the species composition of stands near rotation age (≥ 70 yrs of age).

2 Discussion of SGR Forest Types with Low Certainty of Future Growth Patterns

Several of the forest types identified in Table 1-1 can exhibit highly variable growth patterns and successional characteristics. The mixedwood forest types (e.g., #s 4, 5, 6, and 7 in Table 1-1) have been identified as having low certainty with respect to future softwood growth[2]. One of the significant challenges of boreal forestry is forecasting future characteristics of harvested mixedwood stands including transition assumptions, individual tree and stand growth trajectories, successional processes and rotation-age stand characteristics. Boreal forest types, particularly mixedwoods, can exhibit a high degree of variability due to soils and a variety of other biotic and abiotic factors influencing stands from initiation through to maturity and old age (i.e., Senecal *et al.* 2004[3]). In undertaking its' forest renewal obligations,

Mistik is committed to maintaining naturally-occurring boreal forest ecosystems, successional processes, growth trajectories and volume yields in maturing forest stands.

Mistik accepts the inherent heterogeneity of natural boreal forest stands and attempts to manage the harvested areas within its forest management agreement (FMA) area on the basis of maintaining natural forest stand dynamics. Mistik prefers to let natural successional dynamics prevail (which requires time) in achieving final softwood (SGR forest types 1, 2 and 3), mixedwood (SGR forest types 4, 5, 6, and 7) and hardwood (SGR forest type 8) forest types at maturity. A common, alternative management strategy is to attempt to create final stand outcomes at juvenile stages of stand development through the use of various stand tending options (mechanical, manual, chemical).

The following documentation provides a brief review of some of the forest science literature pertaining to the maintenance of the natural productivity and yield of intimate mixtures of both softwood and hardwood species within a boreal mixedwood context.

[2] Comeau, P., J. Heineman and T. Newsome. 2006. Evaluation of relationships between understory light and aspen basal area in the British Columbia central interior. For. Ecol. and Man. 226: 80-87.

[3] Senecal, D., D. Kneeshaw and C. Messier. 2004. Temporal, spatial and structural patterns of adult trembling aspen and white spruce mortality in Quebec's boreal forest. Can. J. For. Res. 34: 396-404.

3 Mixedwood Establishment

Johnstone *et al.* 2004[4] observed a large recruitment pulse of white spruce immediately post-fire. The authors observed that the early post-fire species cohorts usually dominated the canopies of mature stands – early establishment patterns are likely strongly suggestive of future stand development. In similar studies, Purdy *et al.* 2002[5] and Peters *et al.* 2002[6] and 2005[7] comment that the establishment of white spruce in mixedwood stands immediately post-fire appears to be a key process in boreal mixedwood succession. Other research (Kabzems and Garcia 2004[8], Lieffers pers. comm.) has found evidence of significant delay in white spruce recruitment over extended periods of time. A detailed study by Peters *et al.* 2006[9], comparing initial versus delayed white spruce regeneration in boreal mixedwoods, showed that delayed white spruce regeneration in fire-origin boreal mixedwood stands occurred up to 45 yrs of age. The authors found two 'pulses' of white spruce regeneration – between 0 to 5 years and between 35 to 45 years. The study found that overall there was a relatively even distribution of white spruce regeneration between these two time periods. The authors surmise that even-aged mixedwood stands can be expected to develop if there is strong initial white spruce recruitment.

Management Implications

- In managing for mixedwood sites- 'incoculate' (i.e., plant) the site with softwood immediately post-harvest.

[4] Johnstone, J.F., F.S. Chapin III, J. Foote, S. Kemmet, K. Price and L. Viereck. 2004. Decadal observations of tree regeneration following fire in boreal forests. Can. J. For. Res. 34: 267-273.

[5] Purdy, B.G., S.E. Macdonald and M.R.T. Dale. 2002. The regeneration niche of white spruce following fire in the mixedwood boreal forest. Silva Fennica 36(1): 289-306.

[6] Peters, S.V., S. Macdonald and M.R.T. Dale. 2002. Aging discrepancies of white spruce affect the interpretation of static age structure in boreal mixedwoods. Can. J. For. Res. 32: 1496-1501.

[7] Peters, S.V., S. Macdonald and M.R.T. Dale. 2005. The interaction between masting and fire is key to white spruce regeneration. Ecology: Vol. 86, No. 7, pp. 1744–1750.

[8] Kabzems, R. and O. Garcia. 2004. Structure and dynamics of trembling aspen – white spruce mixed stands near Ft. Nelson, B.C. Can. J. For. Res. 34: 384-395.

[9] Peters, S.V., S.E. Macdonald and M.R.T. Dale. 2006. Patterns of initial versus delayed regeneration of white spruce in boreal mixedwood succession. Can. J. For. Res. 36: 1597-1609.

4 Stocking (Spatial Distribution) and Density

In modeled outcomes of white spruce stocking, Feng *et al.* 2005[10] found that for any level of site index, ~ 30% to 40% stocking was the lower threshold to achieve full volume in maturing mixedwood stands. The authors also found that at any site index, maximum softwood volume was achieved at ~ 700 sph. The authors also noted that within their study area there was a high degree of ingress of natural-origin spruce within the planted spruce areas. Greene *et al.* 2002[11] modeled the likelihood of success of various silvicultural alternatives for conifer regeneration in boreal mixed wood stands. The authors strongly endorse underplanting mature aspen stands with white spruce (essentially artificial establishment of an advanced regeneration component) prior to harvest as a preferred silvicultural approach.

Management Implications

- Moderate stocking and density levels of white spruce result in reasonable softwood volume yields at maturity;
- If there are adjacent stands of mature white spruce – expect some natural ingress of white spruce into the harvested area over time;
- Softwood establishment and stocking to create mixedwood conditions can be achieved in a variety of ways.

[10] Feng, Z., K.J. Stadt and V.J. Lieffers. 2005. Linking juvenile white spruce density, dispersion, stocking and mortality to future yield. Can. J. For. Res (submitted for publication). 32 pp.

[11] Greene, D.F., D.D. Kneeshaw, C. Messier, F. Lieffers, D. Cormier, R. Doucet, K.D. Coates, A. Groot, G. Grover and C. Calogeropoulos. 2002. Modelling silvicultural alternatives for conifer regeneration in boreal mixedwood stands (aspen/white spruce/balsam fir). For. Chron. Vol. 78(2). March/April: 281-295.

5 Mortality (Tree Death)

Johnstone *et al.* 2004[12] observed that post-fire aspen density peaked at year 10 and then commenced to decline. Self-thinning rates of aspen were significantly correlated with initial aspen densities. The highest mortality occurred in aspen stands with the greatest initial densities. Many mixedwood forest researchers and practitioners have found that aspen densities peak in years one or two post-disturbance[13]. Feng *et al.* 2006[14] found that juvenile (7 to 23 yrs) mortality of white spruce ranged from 0.1% to 0.8% mortality. The authors conclude that 0.7% per year mortality is likely a reasonable estimate for rotation length predictions for planted white spruce. The authors found that mortality in spruce was increased by taller, neighboring spruce. Spruce mortality was reduced when associated with aspen – even with aspen densities up to 35,000 sph. Senecal *et al.* 2004[15] found that canopy position had a significant impact on aspen mortality but not for white spruce. For example, suppressed and codominant aspen had much higher mortality than spruce for a given height class. Aspen also tended to die at a younger age (40 to 60 yrs) than spruce (110 to 150 yrs). Lee *et al.* 1995[16] found that overall canopy tree density decreased with stand age and that aspen density decreased exponentially in relation to stand age. However, canopy white spruce density increased with stand age. Frey *et al.* 2003[17] found that initial juvenile aspen densities, across a broad range of densities, generally converge to a common density. In a long term, well-maintained white spruce provenance trial in Ontario, Morgenstern *et al.* 2006[18] reported that mortality of white spruce in the provenance trial, over 44 years, ranged from 0.4% to 0.6% per year. Kabzems *et al.* 1986[19] generalize the succession of boreal mixedwoods in Saskatchewan in the following terms:

- Immediate recruitment of white spruce post-disturbance;
- 15 to 17 years for spruce to reach a height of 1.4 m with an aspen overstorey of ~ 9 to 10 m in height;
- 50 to 60 years of stand dynamics occurs;
- At 70 to 80 years some of the white spruce become co-dominant with the aspen;
- At 100 to 110 years, the co-dominant white spruce become dominant in the stand (black spruce, jack pine and balsam fir often co-mingled with the aspen and white spruce);
- Only a small percentage of initial softwood cohorts reach saw timber proportions.

Based on the results of a modeling study conducted in Mistik Management Ltd.'s Forest Management

[12] Johnstone, J.F., F.S. Chapin III, J. Foote, S. Kemmet, K. Price and L. Viereck. Decadal observations of tree regeneration following fire in boreal forests. Can. J. For. Res. 34: 267-273.

[13] i.e., pers. comm. with Gitte Grover (Alberta-Pacific) and Vic Lieffers (University of Alberta).

[14] Feng, Z. K.J. Stadt and V.J. Lieffers. 2006. Linking juvenile white spruce density, dispersion, stocking and mortality to future yield. Can. J. For. Res (in press). 32 pp.

[15] Senecal, D., D. Kneeshaw and C. Messier. 2004. Temporal, spatial and structural patterns of adult trembling aspen and white spruce mortality in Quebec's boreal forest. Can. J. For. Res. 34: 396-404.

[16] Lee, P.C., S. Crites and J.B. Stelfox. Changes in forest structure and floral composition in a chronosequence of aspen mixedwood stands in Alberta. In Stelfox, J.B. (editor) 1995. Relationships between stand age, stand structure, and biodiversity in aspen mixedwood forests in Alberta. Jointly published by Alberta Environmental Centre (AECV95-R1), Vegreville, AB, and Canadian Forest Service (Project # 0001A), Edmonton, AB. 308 pp.

[17] Frey, B.R., V.J. Lieffers, S.M. Landhauesser, P.G. Comeau and K.J. Greenway. 2003. An analysis of sucker regeneration of trembling aspen. Can. J. For. Res. 33: 1169-1179.

[18] Morgenstern, K., S. D'Eon and M. Penner. 2006. White spruce growth to age 44 in a provenance test at the Petawawa Research Forest. For. Chron. Vol. 82(4): 572-578.

[19] Kabzems, A., A.L. Kosowan and W.C. Harris. 1986. Mixedwood section in an ecological perspective. Technical Bulletin #8. 2nd Edition. Canada-Saskatchewan Forest Resource Development Agreement. 122 pp.

Agreement area in Saskatchewan, Welham *et al.* 2002[20] conclude that a two-entry harvest system would likely maximize harvest volume within mixedwood stands. A two-entry harvest regime potentially captures aspen mortality and maximizes spruce growth and sawlog volume.

Management Implications

- Mortality rates for planted white spruce are relatively low – ensure levels of initial stocking and density at stand establishment are adequate to allow for natural mortality rates to occur and result in target stocking and yield at maturity;
- Once established, white spruce is a highly-persistent species – focus renewal activities on maximizing survival and early growth of white spruce;
- Aspen density and proportion of aspen crown decreases and spruce slowly 'trades places' with aspen in the canopy over time in a natural successional process;
- Manage mixedwoods on longer rotations to allow for a variety of mixedwood stand attributes to develop;
- Consider utilizing 'multiple entry' harvesting regimes[21] to maximize aspen harvest volume and softwood piece size.

[20] Welham, C., B. Seely and J. Kimmins. 2002. The utility of the two-pass harvesting system in Saskatchewan mixedwoods: An analysis using the ecosystem simulation model FORECAST. Can. J. For. Res. 32: 1071-1079.

[21] There are forestry researchers and practitioners who espouse multiple harvest entries into mixedwood stands to maximize harvest volumes. Although Mistik has conducted research and undertaken field trials of multiple harvest regimes in mixedwoods, Mistik does not undertake this approach on an operational basis at the present time. Mistik's current approach to managing for mixedwoods will allow for a variety of harvest options to be exercised in the future.

6 Light Levels

In measurements from a range of natural, aspen-dominated boreal forest stands, Lieffers and Stadt 1994[22] found that hardwood overstories transmit between 14% and 40% incoming light allowing for acceptable rates of growth of white spruce saplings. The authors reported that average annual height increment of white spruce increased five-fold from 14% to 40% incoming light. 40% ambient light conditions resulted in white spruce growth approximately equivalent to 100% light conditions. In a similar study, Lieffers *et al.* 2002[23] modeled the impact of light levels on white spruce growth in mixedwood stands. The time of lowest light levels (referred to by the authors as the 'light bottleneck') in aspen stands is between 15 to 25 yrs of age. Light transmission increased after 25 yrs of age. Constabel and Lieffers 1996[24] found that old aspen stands had higher light transmission (32% of above canopy light) than young aspen stands (19% of above canopy light). The authors observed that seasonal changes in light transmission (spring and fall leaf-off periods) likely have an important role in adding additional periods of photosynthesis for understorey evergreen tree species. Man and Lieffers (1997)[25] found that understorey white spruce became photosynthetically active by early April and remained active until late October. The results of this study demonstrate that spring and autumn are important periods for photosynthesis for white spruce seedlings and that the species takes advantage of seasonal leaf-off conditions of the overstorey hardwood.

Management Implications

- White spruce can tolerate relatively low light conditions and grows moderately to well in a range of light conditions – white spruce does not have to be 'open grown' in order to achieve its growth potential.
- Light levels beneath an aspen-dominated canopy are at a minimum early in stand development (i.e., around the FTG assessment period). Light conditions improve thereafter. Spruce growth conditions (in terms of light availability) are most limiting early in stand development and improve with time. Softwood tree growth attributes under an aspen canopy are likely at a minimum at the FTG assessment (due to low light conditions). There is a high likelihood that future softwood growth attributes will continue at the same rate, or increase, due to increasing light conditions.

[22] Lieffers, V.J. and K. Stadt. 1994. Growth of understory *Picea glauca*, *Calamagrostis canadensis* and *Epilobium angustifolium* in relation to overstorey light transmission. Can. J. For. Res. 24(6): 1193-1198.

[23] Lieffers, V.J., B.D. Pinno and K.J. Stadt. 2002. Light dynamics and free-to-grow standards in aspen-dominated mixedwood forests. For. Chron. Vol. 78(1). January/February. 137-145.

[24] Constabel, A.J. and V.J. Lieffers. 1996. Seasonal patterns of light transmission through boreal mixedwood canopies. Can. J. For. Res. 26: 1008-1014.

[25] Man, R. and V.J. Lieffers. 1997. Seasonal variations of photosynthetic capacities of white spruce (Picea glauca) and jack pine (Pinus banksiana) saplings. Can. J. Bot. 75: 1766-1771.

7 Height and Diameter Growth

Feng *et al.* 2006[26] found that mortality of white spruce trees was not linked to height – short trees survive as well as tall trees. In a retrospective study of natural, mature mixedwood stands, Kabzems and Garcia 2004[27] found that upon reaching 1.3 m height, understory white spruce growth rates were similar across all sites - exhibiting growth rates of 0.2 to 0.3 m per year. In a well-maintained white spruce provenance trial in eastern Canada, which likely represents the 'top end' of spruce growth potential (open-grown with no overstorey aspen), Morgenstern *et al.* 2006[28] report that height growth increment ranged between 0.16 to 0.22 m per year in the first 15 years (for a total height of 2.51 m to 3.35 m total height) and 0.34 to 1.40 m (14.8 m to 17.4 m total height) per year over 44 years. In a retrospective study of understorey spruce growth, Lieffers *et al.* 1996[29], found that seedlings recruited more than 20 years after disturbance had reduced initial height growth compared to seedlings recruited earlier. The authors of the study noted a marked increase in height increment as total tree height increased. Maximum growth rates of ~ 0.3 m per year were attained when understorey white spruce trees were taller than 2.3 m height. It was noted that height growth rates for understorey spruce trees were comparable to growth rates of similar size and age from clearcut sites. The authors concluded that the understorey spruce in their study would likely exceed a height of 25 m in 100 years. Regeneration survey data analyses from Alberta (Lieffers *et al.* 2007[30]) and Saskatchewan (Mistik Management Ltd. 2006[31]) show little, if any, relationship between softwood height, softwood height increment, and aspen density. The analyses showed that current overall height was strongly correlated to current height increment – increasing overall height was associated with increased growth increment. The Lieffers et al. 2007 study also indicated that current softwood tree height is an excellent predictor of future height. Bokalo *et al.* 2003[32] found that overall height and height increment were not affected by increasing aspen densities but that diameter growth of white spruce was significantly reduced and height to diameter ratio was increased at increasing levels of aspen density. Bokalo *et al.* 2003 reported that a height to diameter ratio of over 60 may be indicative of competitive stress. However, Morgenstern *et al.* 2006[33] reported height to diameter (DBH) ratios for 44-year-old white spruce, grown in a well-tended and spaced provenance trial, of between 70 to 83. A recent study of an alternative 'tree-based' free-to-grow assessment commissioned by Alberta-Pacific Forest Industries Inc. (2006[34]) concluded that for jack pine:

- A height to diameter ratio of 1.1 or less and achieving a height of 1.5 m by year six was a reasonable indicator of free to grow for jack pine.

For white spruce, the authors of the study concluded that:

- height to diameter ratio does not distinguish between suppressed and non-suppressed white spruce

[26] Feng, Z. K.J. Stadt and V.J. Lieffers. 2006. Linking juvenile white spruce density, dispersion, stocking and mortality to future yield. Can. J. For. Res (in press). 32 pp.

[27] Kabzems, R. and O. Garcia. 2004. Structure and dynamics of trembling aspen – white spruce mixed stands near Ft. Nelson, B.C. Can. J. For. Res. 34: 384-395.

[28] Morgenstern, K., S. D'Eon and M. Penner. 2006. White spruce growth to age 44 in a provenance test at the Petawawa Research Forest. For. Chron. Vol. 82(4): 572-578.

[29] Lieffers, V.J., K.J. Stadt and S. Navratil. 1996. Age structure and growth of understory white spruce under aspen. Can. J. For. Res. 26: 1002-1007.

[30] Lieffers, V.J., K.J. Stadt and Z. Feng. 2007. Free-to-grow regeneration standards are poorly linked to future growth of spruce in boreal mixedwoods. For. Chron. Vol. 83(6): 818-824.

[31] Mistik Management Ltd. 2014. Analysis of eighteen free-to-grow mixedwood harvest blocks (14 years post-harvest)

[32] Bokala, M., P.G. Comeau and S.J. Titus. 2003. Early development of mixed stands of aspen and spruce: ten years of the Western Boreal Growth and Yield Association long term study. Can. J. For. Res. (submitted for publication). 35 pp.

[33] Morgenstern, K., S. D'Eon and M. Penner. 2006. White spruce growth to age 44 in a provenance test at the Petawawa Research Forest. For. Chron. Vol. 82(4): 572-578.

[34] The Forestry Corp. 2006. Height to diameter ratio: An assessment of competitive status for white spruce and jack pine. Prepared for Alberta-Pacific Forest Industries Inc. (G. Grover). Edmonton, Alberta. 25 pp.

trees;

- A simple height-age indicator was the most useful measure of future success – white spruce trees that reached 1.5 m by 13 years were most likely to be non-suppressed trees in the mature stand;

- Non-suppressed white spruce trees generally exhibited an average annual height increment of 0.2 m per year.

In a study undertaken by Navratil (2000)[35] (commissioned by Mistik Management Ltd.), juvenile spruce growth attributes (survival, height, height increment, diameter, etc.), were measured in a number of regenerating, post-harvest mixedwood sites in Alberta. Navratil's general observations included:

- White spruce survival was highly-varied at low aspen densities;

- Some of the worst spruce growth observed was in open-grown conditions;

- Some of the highest survival of white spruce was in very high aspen densities (> 25,000 sph);

- Spruce height and increment varied widely within a narrow range of aspen density;

- Spruce height and increment were consistently very negatively impacted by very high aspen densities – however, growth reduction versus aspen density was significantly confounded with other onsite factors (water table level);

- Reduced forest health (leader weevil impact, frost damage) was always associated with low aspen densities;

- Other site factors such as grass, shrubs, soil compaction and soil moisture conditions appeared to influence spruce growth far more profoundly than hardwood densities.

Juvenile white spruce growth across all the sites was so varied that the author concluded:

> *'My observations are that there are many factors affecting spruce growth – most of them hidden and unquantifiable – the variability and unpredictability of these factors and their strong influence on survival and growth makes any intensive aspen control prescriptions for spruce plantations extremely difficult and erratic.'*

Management Implications

- White spruce exhibits inherently slow or conservative growth rates. Over the longer term, the average rate of growth (growth increment) of white spruce is generally consistent (0.16 m to 0.40 m) across a broad range of hardwood overstorey densities – when managing for natural stand yields, minimize silvicultural treatments that attempt to 'speed up' softwood tree growth;

- Growth rates (growth increment) of white spruce tend to increase proportionately with overall height – the bigger the white spruce tree gets the faster it grows. Growth attributes measured at the FTG assessment likely represent a lower threshold for softwood tree growth - there is a high likelihood that future softwood growth attributes will continue at the same rate or increase as the trees grow taller;

- White spruce growth is strongly influenced by site factors other than aspen density – minimize

[35] Navratil, S. 2000. Strategies for the renewal phase of aspen-white spruce types. Prepared for Mistik Management Ltd. by Silfor Consulting, Hinton, Alberta. 61 pp.

silvicultural treatments that attempt to 'fix' aspen densities alone when there are likely other site factors that may be exerting a more profound effect on softwood tree growth;

- An overall softwood tree height of between 1.3 to 2.3 m appears to represent a minimum threshold for consistent height growth increment of 0.2 to 0.3 m per year – this range in height is likely an important benchmark for FTG designation;

- Early diameter growth, or height to diameter ratios, of softwood trees (particularly white spruce) may not be useful indicators of tree vigor – softwood trees growing in a variety of natural stand conditions, and seral stages, typically exhibit height to diameter ratios exceeding '60.

8 Productivity

Marsden *et al.* 1996[36] show evidence of a 'nurse crop' effect of aspen on white spruce seedling establishment and growth due to reductions in ambient humidity fluctuations. Man and Lieffers 1999[37] show evidence that mixtures of white spruce and aspen are likely more productive than single species stands under certain conditions. Macpherson *et al.* 2001[38] found increased total productivity in mixedwood white spruce / aspen stands versus pure aspen stands in relation to measures of basal area, biomass and periodic annual increment. Similarly, Legare *et al.* 2004[39] reported a positive influence of aspen on stand biomass and diameter growth of black spruce within a range of hardwood abundance (up to proportions of 41% basal area).

Management Implications

- Managing for mixedwoods may result in greater overall yield (biomass).

[36] Marsden, B.J., V.J. Lieffers and J.J. Zwiazek. 1996. The effect of humidity on photosynthesis and water relations of white spruce seedlings during the early establishment phase. Can. J. For. Res. 26: 1015-1021.
[37] Man. R. and V.J. Lieffers. 1999. Are mixtures of aspen and white spruce more productive than single species stands? For. Chron. Vol. 75(3). May/June: 505-513.
[38] MacPherson, D., V.J. Lieffers and P.V. Blenis. 2001. Productivity of aspens stands with and without spruce understory in Alberta's boreal mixedwood forests. For. Chron. 77(2): 231-356.
[39] Legare, S., D. Pare and Y. Bergeron. 2004. The responses of black spruce growth to an increased proportion of aspen in mixed stands. Can. J. For. Res. 34: 405-416.

9 Manual, Mechanical, Chemical Tending of Hardwood and Associated Impacts

A number of studies have shown significant growth-enhancing outcomes of various vegetation control treatments on crop tree yield[40]. Of particular interest in a boreal mixedwood context is the joint production of both softwood and hardwood yield in intimate mixture. Man *et al.*[41] undertook a study of the effects of both woody and herbaceous competition on young white spruce. The authors recommend a two-meter radius of complete vegetation control around white spruce trees to facilitate development of mixedwood stand conditions. A comprehensive assessment of a range of manual and chemical treatments on white spruce growth in a mixedwood context in Ontario has recently been reported (Pitt and Bell 2005[42] and Greifenhagen *et al.* 2005[43]). A variety of assessments were made of eleven-year-old post-harvest mixedwood sites. Silviculture 'release' treatments were conducted at age four. The release treatments were successful in enhancing some measures of spruce growth. For example, seven years after chemical 'release' treatments, the treated plots reflected 1.7 to 2.2 times the basal area for spruce versus untreated plots. Treated plots also showed an average increase in spruce stem volume index of 1.3 to 1.8 times over untreated plots. However, total basal area of all tree species combined was 2 to 3 times more in untreated plots than treated plots and stem volume index of all tree species combined was 2.4 to 5.6 times more in untreated plots that treated plots. Average spruce height (~ 2.5 m) in the 'release' treatments was only slightly greater (~ 10 cm) in treated plots versus untreated plots (in fact, there was no significant difference between treated and untreated sites relative to spruce height). In terms of forest health, there was significant increase (36 to 40%) in living but damaged hardwood and one chemical treatment resulted in a significant increase in unstocked area (34%). All the 'release' treatments generally resulted in reduced aspen health (increased stem decay), reduced stem quality (forks and crooks) and reduced overall volume. The authors state:

> *'Much of the aspen regenerating from current broadcast conifer release approaches may have reduced potential to develop into a valuable resource, both in terms of quality and growth.'*

Additionally, herbicide applications have a dramatic impact on carbon sequestration and release in forested ecosystems. In a modeled assessment of the short-term effect of herbicide application (first 20 years of growth) in a juvenile aspen stand, Johnston 2005[44] found that total carbon sequestration was reduced by 90% when applied in year 2 and by 51% when applied in year 13. Additionally, herbicide application in years 2 and 13 resulted in 1 ton and 11 tons of carbon, respectively, being released as a result of herbicide-induced tree mortality.

In modeled outcomes of future white spruce site index based on juvenile height growth, Feng *et al.* (2006[45]) found tended stands had an estimated 1.8 m higher site index than non-tended stands but this difference was not statistically significant.

[40] Wagner, R.G., K.M. Little, B. Richardson and K. McNabb. 2006. The role of vegetation management for enhancing productivity of the world's forests. Forestry. Vol 79 (1): 57-79.

[41] Man, C. D., P.G. Comeau and D. Pitt. 2006. Competitive effects of woody and herbaceous vegetation in a young boreal mixedwood stand. Can. J. For. Res. (submitted for publication). 35 pp.

[42] Pitt, D.G. and F. W. Bell. 2005. Juvenile response to conifer release alternatives on aspen-white spruce boreal mixedwood sites. Part I: Stand structure and composition. For. Chron. Vol. 81(4). July/August: 538-547.

[43] Greifenhagen, S., D.G. Pitt, M.C. Wester and F.W. Bell. 2005. Juvenile response to conifer release alternatives on aspen-white spruce boreal mixedwood sites. Part II: Quality of aspen regeneration. For. Chron. Vol. 81(4). July/August: 548-558.

[44] Johnston, M. 2005. Carbon budget analysis of herbicide control of deciduous tree species. Saskatchewan Research Council (an assessment conducted for Mistik Management Ltd. CSA Z809-02 certification). Saskatoon, Saskatchewan. 3 pp.

[45] Feng, Z., K.J. Stadt, V.J. Lieffers and S. Huang. 2006. Linking juvenile growth of white spruce with site index. For. Chron. (in press). 22 pp.

Lieffers 2006[46] has commented that reducing the hardwood component in mixedwood stands is difficult to justify in light of forecasted rapid rates of environmental change associated with climate change impacts. Lieffers proposes that a more reasonable approach is to maintain as much flexibility as possible in terms of maximizing tree species diversity and future volume. Lieffers *et al.* 2008[47] describe the incompatibility of current Alberta regeneration standards with principles of ecological management in an extensive forest management context where maintenance of biodiversity, species composition and forest structure has as much importance as wood production goals.

Management Implications

- Expect increased overall softwood tree size (particularly basal area) – conduct manual, mechanical or chemical brushing treatments to increase basal area of softwood in as short a period as possible;
- Expect increased carbon emissions and reduced carbon sequestration post-tending;
- Expect significantly reduced hardwood tree health and stem form quality;
- Expect significantly reduced overall site productivity and yield;
- Expect reduced levels of biodiversity and site quality.

[46] Lieffers, V.J. 2006 (presentation to Alberta Forest Service and forest industry staff, November 2, 2006). What type of forests should we have on public lands: The twisted path of development of Alberta's regeneration standards? University of Alberta. Edmonton, Alberta.

[47] Lieffers, V. J., G.W. Armstrong, K.J. Stadt and E.H. Marenholtz. 2008. Forest regeneration standards: are they limiting management options for Alberta's boreal mixedwoods?. For. Chron. Vol. 84(1). January/February: 76-82.

10 Characteristics of Mature Natural Forest Stands Attributes in the Mistik FMA Area

Figure 1 and Table 10-1 to Table 10-6 depict natural stand characteristics for forest stands ≥ 70 years of age[48] in the Mistik FMA area. The average stand conditions shown below provide a future reference benchmark for various forest stand attributes that are near rotation age.

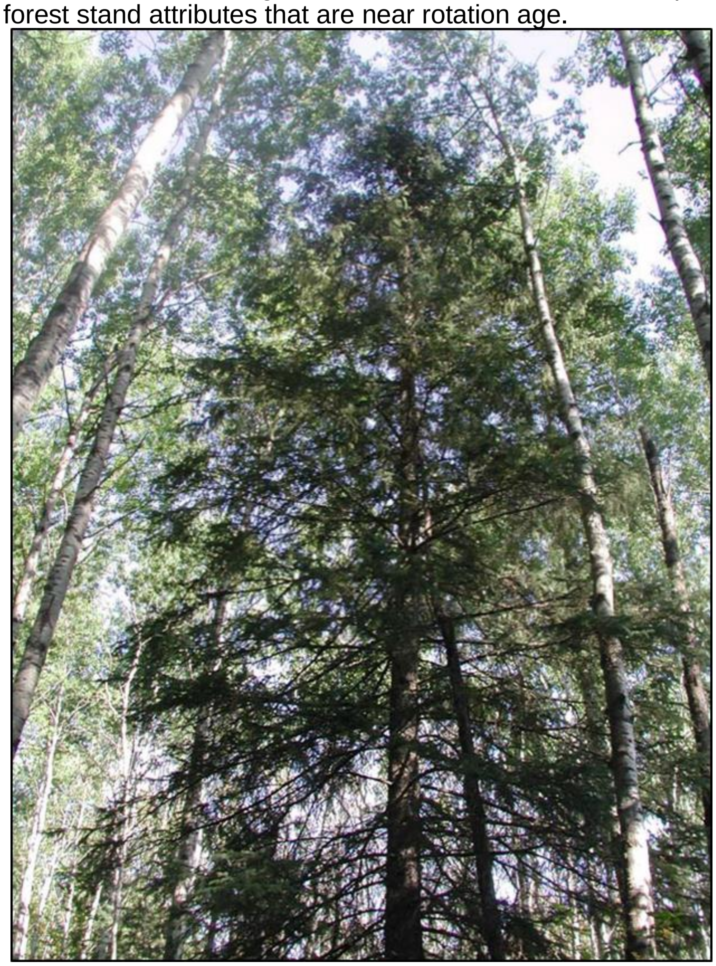

FIGURE 1: A ~100 YEAR-OLD MIXEDWOOD STAND IN THE MISTIK FMA AREA

[48] The data shown in Table 10-12 to Table 10-6 are based on tree measurements from Mistik's 1999-2006 Temporary Sample Plot (TSP) program in the Mistik FMA area (encompassing 1.8 million ha and representing 85,230 individual tree measurements sampled from 174 UTM mapsheets, 1,054 forest stands, 5,616 plots). The statistics shown in the tables reflect data for only those trees that contribute to licensee wood utilization specifications.

TABLE 10-1 NATURAL AVERAGE STAND DENSITY CHARACTERISTICS FOR FOREST STANDS ≥ 70 AND ≤ 110 YRS OF AGE

Silviculture Ground Rule (SGR) Forest type	Hardwood Density (sph)	Softwood Density (sph)	Total Density (sph)
#1 (S-wS)	136	453	589
#2 (S-bS)	59	431	490
#3 (S-jP)	81	639	720
#4 (SH-jP/tA)	330	302	632
#5 (SH-wS/tA)	227	308	535
#6 (HS-tA/wS)	375	195	570
#7 (HS-tA/jP)	442	246	688
#8 (H-tA)	705	66	771

**Stem density represents the average plot level density (stems/ha) of all stems that are considered merchantable under the licensee specified utilization standards.*

TABLE 10-2 NATURAL STAND AVERAGE HEIGHT CHARACTERISTICS FOR FOREST STANDS ≥ 70 AND ≤ 110 YRS OF AGE

Silviculture Ground Rule (SGR) Forest type	Hardwood Height (m)	Softwood Height (m)	Combined Avg Height (m)
#1 (S-wS)	18	19	19
#2 (S-bS)	19	16	17
#3 (S-jP)	17	17	17
#4 (SH-jP/tA)	19	18	19
#5 (SH-wS/tA)	22	20	21
#6 (HS-tA/wS)	20	18	19
#7 (HS-tA/jP)	21	16	19
#8 (H-tA)	21	17	20

**Average tree height represents the average of all measured stems that are considered merchantable under the licensee specified utilization standards.*

TABLE 10-3 NATURAL STAND AVERAGE DIAMETER-AT-BREAST HEIGHT (DBH) CHARACTERISTICS FOR FOREST STANDS ≥ 70 AND ≤ 110 YRS OF AGE

Silviculture Ground Rule (SGR) Forest type	Hardwood DBH (cm)	Softwood DBH (cm)	Combined Avg DBH (cm)
#1 (S-wS)	22	24	23
#2 (S-bS)	20	19	19
#3 (S-jP)	17	19	19
#4 (SH-jP/tA)	20	23	21
#5 (SH-wS/tA)	27	24	26

Silviculture Ground Rule (SGR) Forest type	Hardwood DBH (cm)	Softwood DBH (cm)	Combined Avg DBH (cm)
#6 (HS-tA/wS)	23	21	22
#7 (HS-tA/jP)	23	18	22
#8 (H-tA)	20	21	20

**Average DBH represents the average of all measured stems that are considered merchantable under the licensee specified utilization standards.*

TABLE 10-4 NATURAL STAND AVERAGE HEIGHT TO DIAMETER-AT-BREAST HEIGHT (DBH) RATIO (HDR) CHARACTERISTICS FOR FOREST STANDS ≥ 70 AND ≤ 110 YRS OF AGE

Silviculture Ground Rule (SGR) Forest type	Hardwood HDR	Softwood HDR	Combined Avg HDR
#1 (S-wS)	88	85	86
#2 (S-bS)	96	89	90
#3 (S-jP)	103	95	96
#4 (SH-jP/tA)	101	84	93
#5 (SH-wS/tA)	89	85	86
#6 (HS-tA/wS)	95	89	93
#7 (HS-tA/jP)	92	89	90
#8 (H-tA)	106	85	104

**Average height to diameter-at-breast height (DBH) ratio represents the average of all measured stems that are considered merchantable under the licensee specified utilization standards.*

TABLE 10-5 NATURAL STAND AVERAGE VOLUME CHARACTERISTICS FOR FOREST STANDS ≥ 70 AND ≤ 110 YRS OF AGE

Silviculture Ground Rule (SGR) Forest type	Hardwood Volume (m^3/ha)	Softwood Volume (m^3/ha)	Total Volume (m^3/ha)
#1 (S-wS)	42	176	218
#2 (S-bS)	17	75	92
#3 (S-jP)	14	120	134
#4 (SH-jP/tA)	93	93	186
#5 (SH-wS/tA)	139	132	271
#6 (HS-tA/wS)	147	51	198
#7 (HS-tA/jP)	162	40	202
#8 (H-tA)	210	15	225

**Volume represents the average plot level volume (m^3/ha) considering all stems that are merchantable under the licensee specified utilization standards.*

TABLE 10-6 NATURAL STAND AVERAGE INDIVIDUAL TREE SIZE CHARACTERISTICS FOR FOREST STANDS ≥ 70 AND ≤ 110 YRS OF AGE

Silviculture Ground Rule (SGR) Forest type	Hardwood Tree Size (m^3/ha)	Softwood Tree Size (m^3/ha)	Combined Avg Tree Size (m^3/ha)
#1 (S-wS)	0.31	0.39	0.37
#2 (S-bS)	0.28	0.17	0.19
#3 (S-jP)	0.17	0.19	0.19
#4 (SH-jP/tA)	0.28	0.31	0.30
#5 (SH-wS/tA)	0.61	0.43	0.51
#6 (HS-tA/wS)	0.39	0.26	0.35
#7 (HS-tA/jP)	0.37	0.16	0.29
#8 (H-tA)	0.30	0.23	0.29

**Tree size data are based on average plot volumes divided by average stem density.*

11 Mistik's Approach to Regenerating Mixedwood Forest Stands

Comeau *et al.* 2005[49] describe a variety of approaches to the management of boreal mixedwoods. They note that there is a strong trend in mixedwood management from 'conifer management' to 'mixed-species management'. They note a need for regulatory flexibility. Clear objectives related to softwood and hardwood growth and final yield expectations must be stated and measured over time. Mixedwood management options range from a low intensity 'do nothing' approach to intensive management aimed at optimizing spruce and aspen yields within a mixedwood context[50]. Within the context of the options described in this paper, Mistik's mixedwood management approach can be characterized as low intensity (natural regeneration augmented with a significant planting program) with final harvest of both hardwood and softwood at age 90 to 100 years of two-storied, intimate mixtures of hardwood and softwood (softwood in the lower portion of the canopy and aspen dominating the upper portion of the canopy).

Mistik will not seek to grow pure stands of the biggest spruce trees in the least amount time at whatever the cost. Mistik's mixedwood management approach is to allow natural stand dynamics prevail to rotation age. Mistik has established rotation ages for mixedwood stands that reflect the growth rates of understorey softwood species. This approach will result in a diverse mosaic of varying mixedwood types across the harvested mixedwood land base. Instead of an active 'interventionist' approach early in forest stand development, Mistik adheres to a 'hands off' approach – letting natural successional processes dominate stand development. Due to short fire return intervals and relatively large areas burned in the Mistik FMA area each year, Mistik has tailored its renewal program to minimize risk to silvicultural investment, maximize future forest management and timber product options and allow for flexibility in the face of uncertainty (climate change). In general, Mistik attempts to maximize the area of mixedwood renewal, minimize investment per hectare and accept natural forest succession dynamics. Mistik's approach has received support from FMA-area community advisory / co-management groups, Public Advisory Group, environmental organizations, forest certification auditors, other industry peers and the academic community. The approach is science-based and is consistent with current notions of ecosystem-based management (see for example Simard and Vyse 2006[51]).

[49] Comeau, P.G., R. Kabzems, J. McClarnon and J.L. Heineman. 2005. Implications of selected approaches for regenerating and managing western boreal mixedwoods. For. Chron. Vol. 81(4). July/August: 559-574.

[50] There are forestry practitioners who espouse multiple harvest entries into mixedwood stands to maximize harvest volumes. Although Mistik has had some practical experience with the multiple harvest regimes in mixedwoods, Mistik does not currently undertake this approach on an operational basis. Mistik's current approach to managing for mixedwoods will allow for a variety of harvest options to be exercised in the future.

[51] Simard, S. W. and A. Vyse. 2006. Trade-offs between competition and facilitation: a case study of vegetation management in the interior cedar-hemlock forests of southern British Columbia. Can. J. For. Res. 36: 2486-2496.

12 Silviculture Strategies and Treatment Options

The range of harvest silviculture treatments to be used for forest renewal of harvested sites is shown in Table 12-1. The silviculture treatments identified are based on current operational practices. No major changes to harvest practices or renewal practices are anticipated for the period 2017 to 2026.

TABLE 12-1 SILVICULURE TREATMENT OPTIONS

SILVICULTURE TREATMENT OPTIONS							
Silviculture Treatment Reference	Harvest Method[1]	Slash Management[2]	Site Preparation Method	Regeneration	Tending	Post-Free Growing Tending	General Comments
1	CCWR	S/RB/RS	None	Natural	Nil	Nil	None
2	CCWR	S/RB/RS	Scarification	Natural	Nil	Nil	None
3	CCWR	S/RB/RS	None	Plant	Nil	Nil	None
4	CCWR	S/RB/RS	Scarification	Plant	Nil	Nil	None
5	CCWR	S/RB/RS	Other Mechanical	Plant	Nil	Nil	None

Notes:

1. Harvest Method Descriptions:
   - CCWR=Clearcut with Retention (including shelterwood). When addressing forest health issues such as dwarf mistletoe the predominant harvest method will be clearcut with retention of all non-pine species.
2. Slash Management Descriptions:
   - S=Process at Stump;
   - RB=Process at Roadside and Burn;
   - RS=Process at Roadside and Spread.

13 Silviculture Ground Rules for the Determination of Free-to-Grow Status

For compliance purposes Chapter D.1.1 of the Forest Regeneration Assessment Code and Standard for surveying and compilation including the definitions of not-sufficiently-regenerated (NSR) areas, takes precedence over Mistik's approach to field surveying and data compilation methods.

The following documentation describes Mistik's approach to assessing silviculture success. Table 13-1 describes a number of measurement attributes to be assessed on a harvest block basis in order to meet Mistik's SGR free-to-grow status. Mistik will also submit survey data to the Ministry of Environment according to the requirements of the Forest Data Submission Code Chapter and Standard.

TABLE 13-1 SILVICULTURE GROUND RULES

SILVICULTURE GROUND RULES								
Saskatchewan Provincial Forest Type	**Mistik Forest Development Type and Yield Curve[1]**	**Current Landbase Area (ha)**	**Rotation Age (yrs)**	**Transition Assumptions (Future Development Type at Rotation Age)**	**Preferred Species Group and Leading Tree Species**	**Minimum Height (m)**	**Perf. Survey Window (Years Since Harvest)**	**SGR Option Reference # (refer to Table 13-1)**
WSF *(SGR 1)*	#1 (S-White spruce)	23,015	80	#1 = 100%	S-wS	jP ≥ 2.0 m and all other softwood ≥ 1.5 m	8 to 14	#3 = 95% #5 = 5%
BS *(SGR 2)*	#2 (S-Black spruce)	34,597	100	#1 = 10% #2 = 90%	S-bS / wS	jP ≥ 2.0 m and all other softwood ≥ 1.5 m	8 to 14	#3 = 95% #5 = 5%
JP *(SGR 3)*	#3 (S-Jack pine) Low Density Low Productivity	95,565	80	#3 = 35% #5 = 55% #8 = 10%	S-jP	jP ≥ 2.0 m and all other softwood ≥ 1.5 m	8 to 14	#2 = 90% #3 = 5% #4 = 5%
	#4 (S-Jack pine) Low Density High Productivity	29,871	80	#4 = 35% #6 = 55% #8 = 10%	S-jP	jP ≥ 2.0 m and all other softwood ≥ 1.5 m	8 to 14	#2 = 90% #3 = 5% #4 = 5%

SILVICULTURE GROUND RULES

Saskatchewan Provincial Forest Type	Mistik Forest Development Type and Yield Curve[1]	Current Landbase Area (ha)	Rotation Age (yrs)	Transition Assumptions (Future Development Type at Rotation Age)	Preferred Species Group and Leading Tree Species	Minimum Height (m)	Perf. Survey Window (Years Since Harvest)	SGR Option Reference # (refer to Table 13-1)
	#5 (S-Jack pine) High Density Low Productivity	101,108	80	#5 = 90% #8 = 10%	S-jP	jP ≥ 2.0 m and all other softwood ≥ 1.5 m	8 to 14	#2 = 90% #3 = 5% #4 = 5%
	#6 (S-Jack pine) High Density High Productivity	57,705	80	#6 = 90% #8 = 10%	S-jP	jP ≥ 2.0 m and all other softwood ≥ 1.5 m	8 to 14	#2 = 90% #3 = 5% #4 = 5%
	#7 (S-Jack pine) L&M Jack pine	17,962	80	#7 = 100%	S-jP	jP ≥ 2.0 m and all other softwood ≥ 1.5 m	8 to 14	#2 = 90% #3 = 5% #4 = 5%
PMW *(SGR 4)*	#8 (SH - Jack pine mixedwood)	54,045	100	#8 = 65% #9 = 10% #11 = 20% #17 = 5%	SH-jP / tA	jP ≥ 2.0 m and all other softwood ≥ 1.5 m Hardwood ≥ 3.0 m	8 to 14	#1 = 10% #2 = 60% #3 = 20% #4 = 10%
SMW *(SGR 5)*	#9 (SH - Spruce mixedwood)	51,773	120	#1 = 10% #9 = 70% #10 = 20%	SH-wS / tA	jP ≥ 2.0 m and all other softwood ≥ 1.5 m Hardwood ≥ 3.0 m	8 to 14	#3 = 95% #5 = 5%
HSM *(SGR 6)*	#10 (HS - Hardwood w/ spruce)	54,378	100	#9 = 40% #10 = 60%	HS-tA / wS	jP ≥ 2.0 m and all other softwood ≥ 1.5 m Hardwood ≥ 3.0 m	8 to 14	#3 = 95% #5 = 5%
HPM *(SGR 7)*	#11 (HS - Hardwood w/ jack pine)	42,185	100	#8 = 20% #9 = 20% #10 = 20% #11 = 30% #17 = 10%	HS-tA / jP	jP ≥ 2.0 m and all other softwood ≥ 1.5 m Hardwood ≥ 3.0 m	8 to 14	#1 = 40% #2 = 20% #3 = 30% #4 = 10%

SILVICULTURE GROUND RULES

Saskatchewan Provincial Forest Type	Mistik Forest Development Type and Yield Curve[1]	Current Landbase Area (ha)	Rotation Age (yrs)	Transition Assumptions (Future Development Type at Rotation Age)	Preferred Species Group and Leading Tree Species	Minimum Height (m)	Perf. Survey Window (Years Since Harvest)	SGR Option Reference # (refer to Table 13-1)
TAB *(SGR 8)*	#12 (H – Hardwood) Low Density Low Productivity	17,195	80	#9 = 15% #10 = 15% #12 = 5% #14 = 65%	H-tA / bP	Hardwood ≥ 3.0 m	8 to 14	#1 = 90% #3 = 10%
	#13 (H – Hardwood) Low Density High Productivity	28,607	80	#9 = 15% #10 = 15% #13 = 5% #15 = 65%	H-tA / bP	Hardwood ≥ 3.0 m	8 to 14	#1 = 90% #3 = 10%
	#14 (H – Hardwood) High Density Low Productivity	64,239	80	#9 = 15% #10 = 15% #12 = 5% #14 = 65%	H-tA / bP	Hardwood ≥ 3.0 m	8 to 14	#1 = 90% #3 = 10%
	#15 (H – Hardwood) High Density High Productivity	128,017	80	#9 = 5% #10 = 5% #15 = 90%	H-tA / bP	Hardwood ≥ 3.0 m	8 to 14	#1 = 90% #3 = 10%
	#16 (H – Hardwood) Significant Softwood Incidental Low Density	31,105	80	#9 = 35% #10 = 35% #17 = 30%	H-tA / bP	Hardwood ≥ 3.0 m	8 to 14	#1 = 90% #3 = 10%
	#17 (H – Hardwood) Significant Softwood Incidental High Density	48,163	80	#9 = 25% #10 = 25% #17 = 50%	H-tA / bP	Hardwood ≥ 3.0 m	8 to 14	#1 = 90% #3 = 10%

Notes:

1. Tree densities vary considerably from one location to another depending on site-specific characteristics. Metrics of natural systems are most usefully described and shown as distributions rather than as simple minimums, means and maximums. The frequency with which a particular metric occurs over the natural range of measured outcomes is of significant importance in reflecting the natural range of variability (NRV). An understanding of NRV for a given metric is of profound assistance in ascertaining management 'risk' and prescribing management actions. Mistik's approach to defining forest renewal success is built on the NRV premise described above. The following points describe in detail the specific stocking thresholds that will be adhered to in determining forest renewal success within harvest blocks on the Mistik FMA area:

   - ***'S'***-designated harvest blocks are those surveyed blocks with ≥ 80% overall stocking in which pure conifer plots occur in ≥ 80% of all plots measured;

   - ***'SH'***-designated harvest blocks are those surveyed blocks with ≥ 80% overall stocking in which pure conifer plots + mixed plots occur ≥ 50% and pure conifer plots occur in < 80% of all plots measured;

   - ***'HS'***-designated harvest blocks are those surveyed blocks with ≥ 80% overall stocking in which pure conifer plots + mixed plots occur ≥ 20% and pure conifer plots occur in < 50% of all plots measured;

   - ***'H'***-designated harvest blocks are those surveyed blocks with ≥ 80% overall stocking in which pure conifer plots + mixed plots occur in < 20% of all plots measured.

14 Compilation of Regeneration Survey Data and Assignment of SGR Forest Types to Regenerating Harvest Blocks

Mistik will submit survey data to the Ministry of Environment according to the requirements of the Forest Data Submission Code Chapter and Standard.

Based on regeneration survey data, Mistik will compile the data (Table 14-1 and Table 14-2) and forecast the expected rotation-age SGR forest type. The key question to be addressed in Mistik's compilation process is:
'On average, will the softwood trees within a regenerating mixedwood harvest block have a reasonable likelihood of forming part of the canopy at maturity (rotation age)?'

TABLE 14-1 COMPILATION PROCESS FOR ESTABLISHMENT SURVEY DATA

A. Designation of Initial Forest Type Based on Establishment Survey Results			
1. Stock Criteria (softwood/hardwood)- This is likely the single most important factor in that it establishes physical presence and spatial dispersion of trees			
S (softwood plots ≥80%)	**SH** (softwood + mixed ≥ 50% and softwood <80%)	**HS** (softwood + mixed ≥ 20% and <50%)	**H** (softwood + mixed ≤20%)
2. Leading Species Criteria – this step identifies the leading softwood species and hardwood species based on the relative abundance of each species (stocking x density)			
S (bS,wS,jP)	**SH** (bS/tA, wS/tA, jP/tA)	**HS** (tA/bS, tA/wS, tA/jP)	**H** (tA)
3. Forest Type Designation-this step identifies the potential forest type for each harvest block based on steps 1 and 2 above			
S (1-wS, 2-bS, 3-jP)	**SH** (4-jP/tA, 5-wS/tA)	**HS** (6-tA/wS, 7-tA/jP)	**H** (8-tA)

TABLE 14-2 COMPILATION PROCESS FOR FREE-TO-GROW SURVEY DATA

B. Designation of Future Forest Type Based on Free-to-Grow Survey Results			
1. Stock Criteria (softwood/hardwood)- This is likely the single most important factor in that it establishes physical presence and spatial dispersion of trees			
S (softwood plots ≥80%)	**SH** (softwood + mixed ≥ 50% and softwood <80%)	**HS** (softwood + mixed ≥ 20% and <50%)	**H** (softwood + mixed ≤20%)
2. Density Criteria (softwood/hardwood)- minimum densities are prescribed.			
S (Softwood density ≥ 1,500 sph) If no, go to B. 6 and forest type = 'Uncertain'	**SH** (Softwood density ≥ 700 sph and hardwood density ≥1,000 sph) If no, go to B. 6 and forest type = 'Uncertain'	**HS** (Softwood density ≥ 300 sph and hardwood density ≥2,000 sph) If no, go to B. 6 and forest type = 'Uncertain'	**H** (Hardwood density ≥ 3,000 sph) If no, go to B. 6 and forest type = 'Uncertain'
3. Average Softwood Height Criteria- an integrative measure of the local growth environment of each dominant softwood sapling by species and average across all plots			
S (≥2.0 m for jack pine and 1.5 m for other softwood species) If no, go to B.6 and forest type = 'Uncertain'	**SH** (≥2.0 m for jack pine and 1.5 m for other softwood species) If no, go to B.6 and forest type = 'Uncertain'	**HS** (≥2.0 m for jack pine and 1.5 m for other softwood species) If no, go to B.6 and forest type = 'Uncertain'	**H** (n/a)
4. Average Softwood Height Increment Criteria – an integrative measure of the local growth environment of each dominant softwood sapling by species and averaged across all plots			
S (≥ 0.15m) if no, go to B 6 and forest type = 'Uncertain	**SH** (≥ 0.15m) if no, go to B. 6 and forest type = 'Uncertain	**HS** (≥ 0.15m) if no, go to B. 6 and forest type = 'Uncertain	**H** (n/a)
5. Leading Species Criteria – this step identifies the leading softwood species and hardwood species based on the relative abundance of each species (stocking x density)			
S (bS,wS,jP)	**SH** (bS/tA, wS/tA, jP/tA)	**HS** (tA/bS, tA/wS, tA/jP	**H** (tA)
6. Forest Type Designation- this step identifies the potential forest type for each harvest block based on steps 1 and 2 above			
S (1-wS, 2-bS, 3-jP) or Uncertain	**SH** (4-jP/tA, 5-wS/tA) or Uncertain	**HS** (6-tA/wS, 7-tA/jP) or Uncertain	**H** (8-tA) or Uncertain

Table 14-3 describes the estimated area planned for forest renewal assessments for the period 2017 to 2026. The area to be surveyed for forest renewal success includes those areas harvested from 2013 to 2022.

TABLE 14-3 SUMMARY OF PLANNED FOREST RENEWAL SURVEY[52] AREA BY SGR FOREST TYPE[53] FOR THE PERIOD 2017 TO 2026

SGR Forest Type	Percentage	Estimated Establishment Survey Area (ha)[54]	Estimated Free-To-Grow Survey Area (ha)
#1 (S-wS)	2	700	700
#2 (S-bS)	1	350	350
#3 (S-jP)	10	3,500	3,500
#4 (SH-jP/tA)	11	3,850	3,850
#5 (SH-wS/tA)	11	3,850	3,850
#6 (HS-tA/wS)	32	11,200	11,200
#7 (HS-tA/jP)	7	2,450	2,450
#8 (H-tA)	26	9,100	9,100
Total	100	35,000	*35,000

*The 35,000 estimated hectares eligible for free to grow surveys may actually be somewhat less depending on the number of blocks (and hectares) meeting early free to grow requirements and declared early free to grow through the establishment survey process.

This document maintains the theme and intent of the original SGR document as submitted and approved for the 2007 20-yr FMP. Information within this document has been updated with the most recent data available (e.g. up to and including Mistik's 2014 Annual Report). This document and the 2007 20-yr FMP process was the first in Saskatchewan formally amalgamating a FMP and an Annual report into a results based process that incorporated values, objectives, indicators and targets (VOITs) into a comprehensive system for the evaluation of the cumulative results of commercial forestry. Mistik's series of Annual Reports indicate that over the term of the 2007 20-yr FMP Mistik has maintained achievement of over 85% of its' VOITs. The FMP process and the associated results based reporting is a system based on continuous improvement where areas of weakness are revisited, revamped and revised to improve results and reduce uncertainty.

It is in this spirit that Mistik proposes that for the balance of the 2007 20-Yr FMP associated Annual Reports that the status quo be maintained – no changes. The desired objective to be achieved for the results reporting associated with the first Annual Report (e.g. 2017 Annual report) of the 2017 20-Yr FMP is a revamping of the process (e.g. data collection, data analysis or a combination of both) to garner more

[52] Mistik will not be conducting any formal free-to-grow surveys until 2017.

[53] The % and area indicated for each SGR forest type is based on past harvest history for the period 2007 to 2016. The assumption is that near-term (10-year), future harvest patterns will not deviate significantly from past harvest patterns.

[54] Assuming an average harvest area of ~ 3,500 ha per year x 10 year period = 35,000 ha (encompassing harvest years 2014 to 2023).

accurate results that confirm Mistik FMP modeling assumptions. Mistik will work cooperatively with the Ministry of Environment Forest Service Brach during the term of the 2017-2018 operating year to develop and implement an acceptable solution to the above described deficiency.