Appendix 2 – TSA Impact of an Alternative Method to Forest Succession Modelling in Yield Curves and to Definition of Old Forest Characteristics.

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Rationale and Introduction

Little is known about the yield and development of older stands in the western boreal forest. Limited empirical data is available on the over-mature stages of boreal forest stands, consequently, these areas are poorly represented in growth and yield studies that have primarily focused on the growth of young and immature stands. In the absence of good information, growth and yield modellers have assumed that the merchantable volume in the stand eventually dwindles to zero as trees senesce and die. Timber supply modellers additionally assume that after the collapse of the original canopy a new stand will form, usually of the same strata and with volume development starting at age zero on the yield curves (this was the assumption used in the approved 2006 Al-Pac FMA Area TSA).

As has been illustrated in recent studies, in the absence of stand replacing disturbance this pattern of development (complete loss of all merchantable volume, regrowth of an even-aged stand starting at age zero) is highly unlikely under natural conditions. More likely (based on empirical and anecdotal observations) is that as the over-story of the stand gradually collapses a mid-canopy layer will form through seeding or layering and will eventually replace the original stand. In terms of ecological characteristics, these renewing stand conditions will likely contain high vertical diversity of living trees as well as standing dead trees and abundant coarse woody debris; old forest characteristics.

The mid-canopy layers and multiple age cohorts in forest stands develop through the process of 'gap dynamics' when no stand replacing disturbance (e.g. harvesting, fire, etc.) occurs. Gap dynamics are described as the canopy openings created by senescence and death of the early colonizing species resulting in the establishment or the release of slower growing and shade tolerant species, as well as the possible re-establishment of the original species.[1] Figure 1 illustrates some of the possible pathways that can occur in the boreal forest in the absence of a stand replacing disturbance.

[1] Bergeron, Y., et al, Boreal mixedwood stand dynamics: Ecological processes underlying multiple pathways. 2014. pg. 202-212 March/April 2014, Vol. 90, No 2 – The Forestry Chronicle Ecological processes underlying multiple pathways. Forestry Chronicle 90: 202-210.

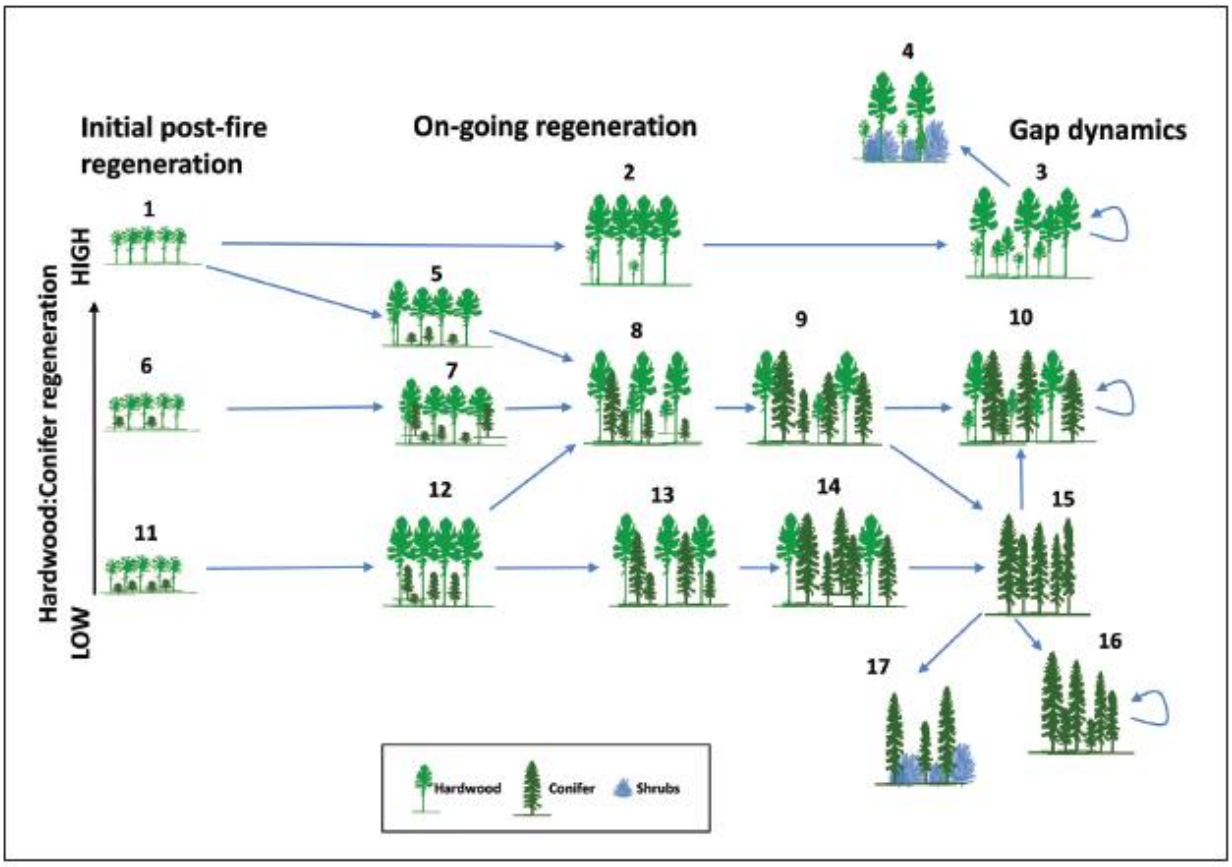


Figure 1. Examples of generalized pathways for mixedwood stand development in the boreal forest.

(Source: Bergeron, Y., et al, Boreal mixedwood stand dynamics: Ecological processes underlying multiple pathways. 2014. pg. 202-212 March/April 2014, Vol. 90, No 2 – The Forestry Chronicle)

Older boreal stands have been found to maintain multiple cohorts, albeit at lower stand volumes, using PSP data from Manitoba, Alberta and Quebec.[2] Figure 2 provides examples of yield curves developed for forest management planning in the boreal forest of Manitoba using data collected from PSPs in older undisturbed stands. Rather than being expressed as a young regenerating stand, a more conservative assumption would be that these stands contain and continue to develop older forest stand characteristics. Merchantable volume will always be present, although in an older structurally diverse stand it is most unlikely that the volumes will be as high as culmination volume found in a fully stocked, even-aged stand. Essentially, forest stands that meet this gap point in their successional pathway, remain as old forest stands throughout the remainder of the TSA time-line.

[2] LeBlanc, P., Incorporating multi-cohort old aspen and mixedwood dynamics into a long-term forest management plan. 2014. pg. 50-58. Jan/Feb 2014 Vol. 90 No 1, The Forestry Chronicle

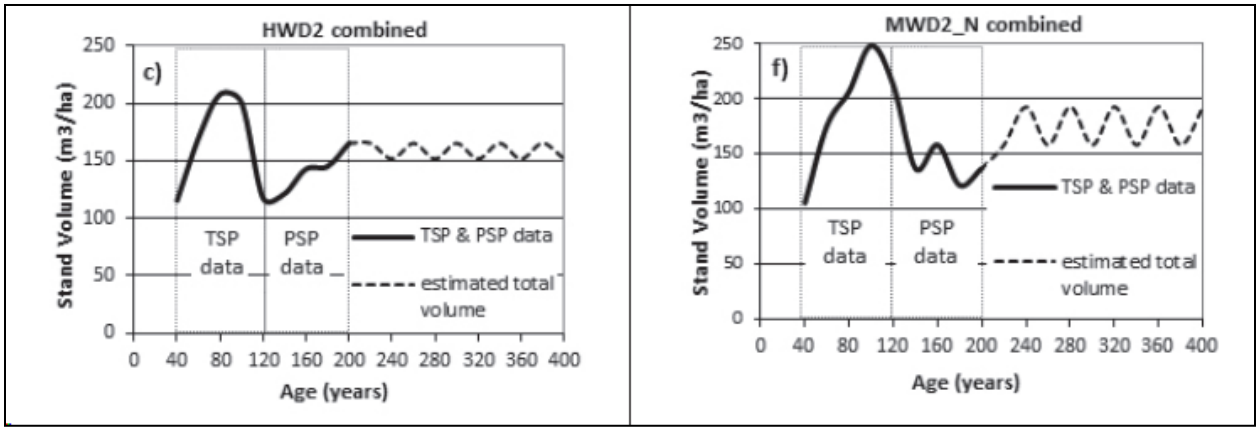


Figure 2. Example of 400 year volume curves derived from sample plot data in the Manitoba boreal forest. Curves show the start of stand senescence, lower yield estimates from 150 - 400 years, and a perpetuation of an old forest condition.

(Source: LeBlanc, P., Incorporating multi-cohort old aspen and mixedwood dynamics into a long-term forest management plan. 2014. pg. 50-58, Jan/Feb 2014 Vol. 90 No 1, The Forestry Chronicle)

The approach proposed for the 2015 Timber Supply Analysis is to assume that older stands do not go through a full breakup and renewal to a healthy juvenile stand, but in the absence of disturbance persist as old forest stands indefinitely. The rational for this choice is that the assumptions of breakup and renewal to even-aged stand conditions are poorly supported by available data in the western boreal forest, and anecdotal evidence and current literature review suggests that persistence of old forest conditions is more likely in the western boreal forest.

This approach will be implemented for the new Al-Pac FMA area TSA by eliminating the breakup and renewal rules (as used in the approved 2006 Al-Pac FMA area TSA), and altering the later portions of the yield curves. Understanding of volume development in these older stands is poorly studied, but the new Al-Pac FMA area TSA (2015/16) will assume that some merchantable timber remains and the volume curves will flat line to 50% of the of the culmination volume – this is a conservative estimate of the future forest situation.

In order to understand timber supply impacts within the strategic forest modeling environment the flat-line 50% post-culmination volume curves are compared to the old break-up methods using the same FMA area net landbase (DRAFT NLB - 2015). This report briefly outlines the development of the yield curves and the impacts to AAC levels using two Al-Pac FMA area FMUs: FMU S23 (south) and FMU A14 (northeast)

Yield curves and succession assumptions

Two sets of growth and yield curves were developed to carry out this comparison using the draft 2015 net landbase. The first set (referred to as "Original" in the following section) has all base strata 'breaking up' at predetermined old ages and 'renewing' at a young age (juvenile forest) within the same strata. These curves represent the traditionally modeled growth and yield of a stand that develops, senesces, and regenerates again in an even aged condition (as used in the approved 2006 Al-Pac FMA area TSA).

Table 1 shows the breakup and renewal age rules that were implemented for this succession sensitivity analysis. These ages are the same as used in the approved 2006 FMA area TSA. (Note: the 2006 TSA did not have “managed” stand yield curves). The 2006 TSA empirical yield curves were transitioned in a “back-to-itself” scenario.

Table 1. The breakup and renewal ages by strata used in the Original dataset. The same rules applied to both the natural and managed stands within the model. All strata renew to the same strata for this sensitivity analysis.

Yield curve	Breakup age	Renewal age
Aw	180	0
AwU	180	60
AwSx	180	0
SxAw	180	0
Sw	250	0
Sb	180	0
Pj/PjMx	180	0

The adjusted yield curves, that perpetuate an over-mature forest, were defined to represent the development of stands in which the old forest condition persists through time, and are referred to as "Adjust50". The curves were developed by determining the point at which a 50% decline in the peak volume occurs and extrapolating this value as a flat line for the remainder of the planning horizon.

Four of the pre-dominant strata groups (Aw, Sw, Pj, AwU) were selected to illustrate the differences between the original successional patterns and the adjusted flat lines (Figure 3 - Figure 6). These four strata constitute over 80% of the net landbase. The other strata (Sb, Mx) that represent only a small fraction of the available landbase forest follow similar patterns to these, and the impacts that they derive are similar.

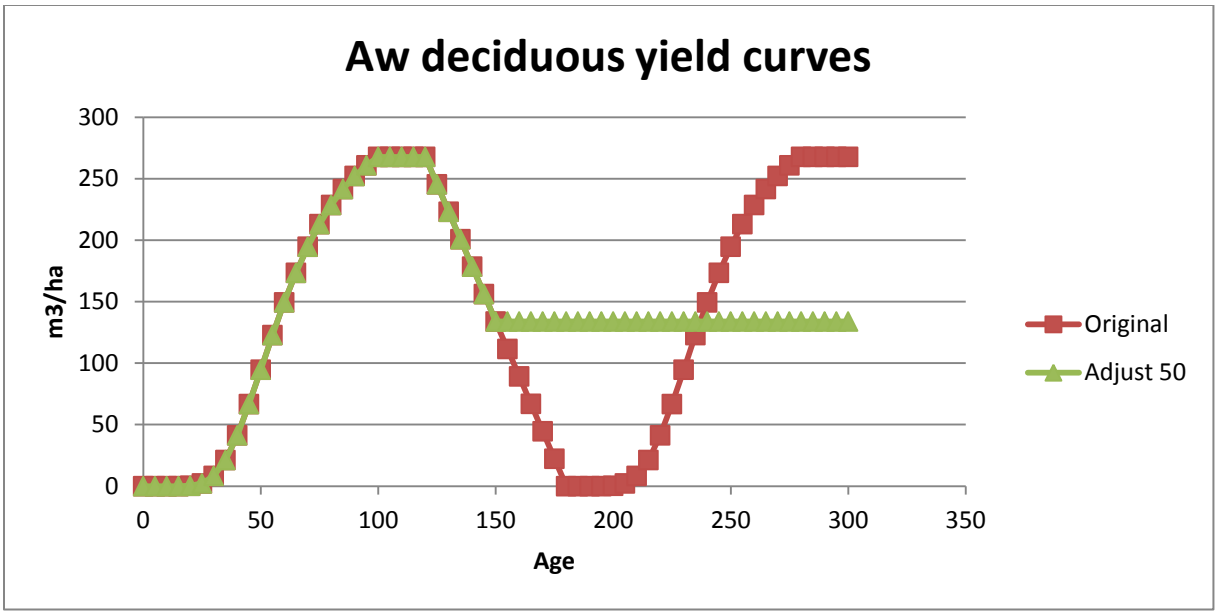


Figure 3. Comparison of differences between the original and 50% flat line yield curves, Aw strata. The red line shows the traditionally modeled growth and yield of a stand that develops, senesces, and regenerates again in an even aged condition. The green (50%) line represents the development of stands which the older forest condition persists as a steady state between overstory collapse and understory recruitment.

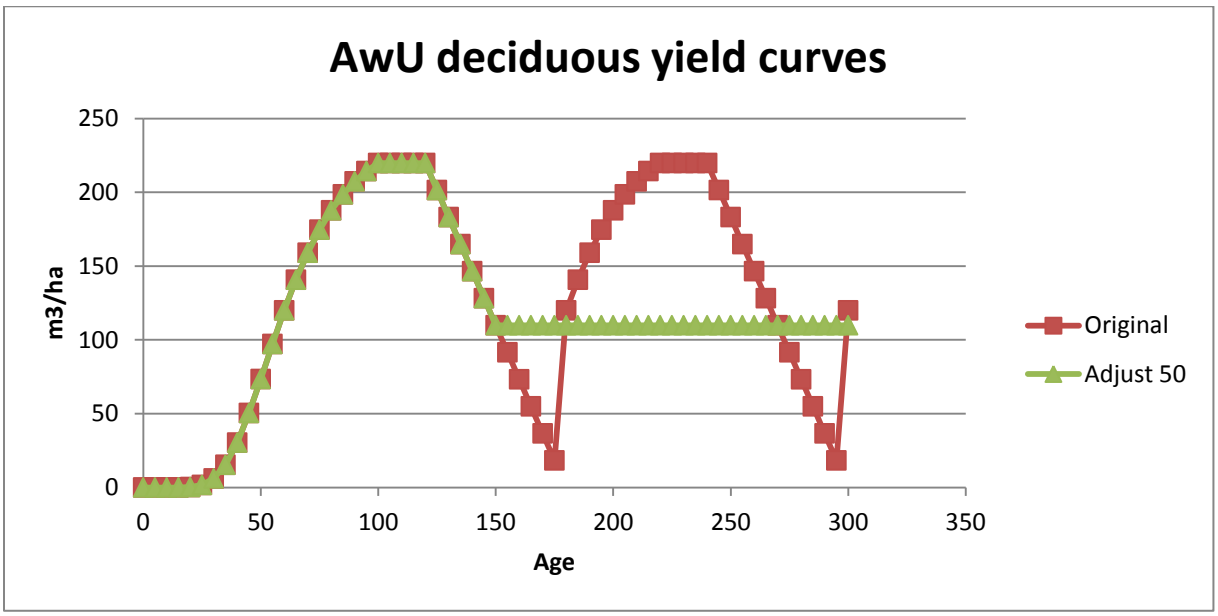


Figure 4. Comparison of differences between original and 50% flat line yield curves, AwU strata. The deciduous curve recovers quickly and eventually becomes much higher than the flat-line. Note that the successional transition used in the 2006 TSA had the Aw understory transition to Aw/Spruce types however, for this assessment we used a simplifying assumption that AwU succeeds to a 60 year old AwU stand.

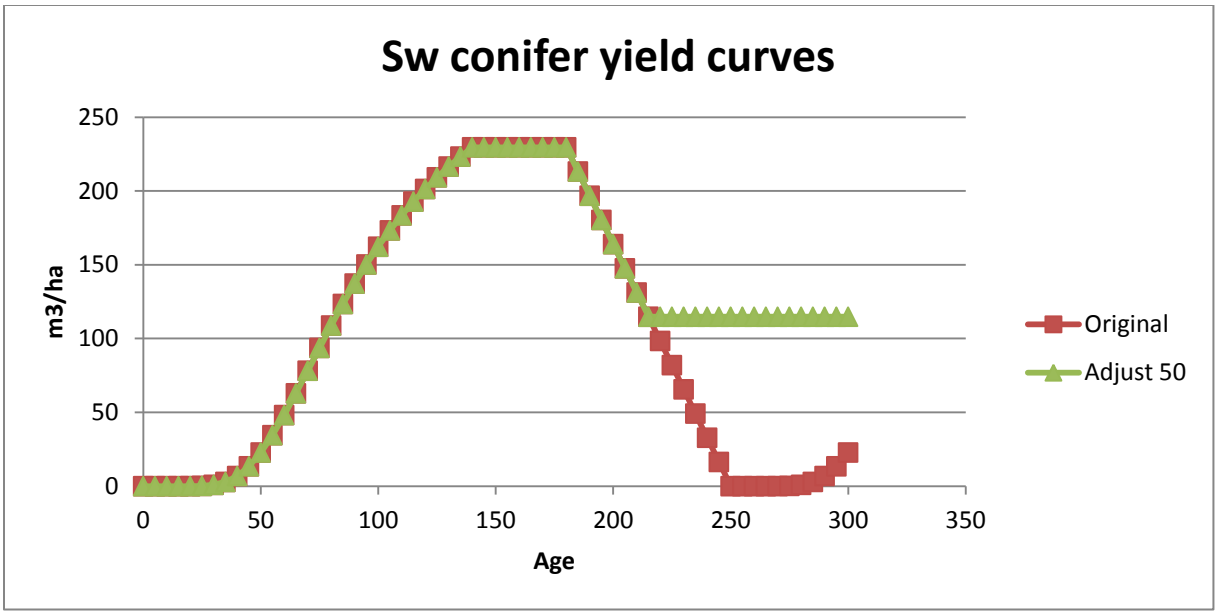


Figure 5. Comparison of differences between original and 50% flat line yield curves, Sw strata.

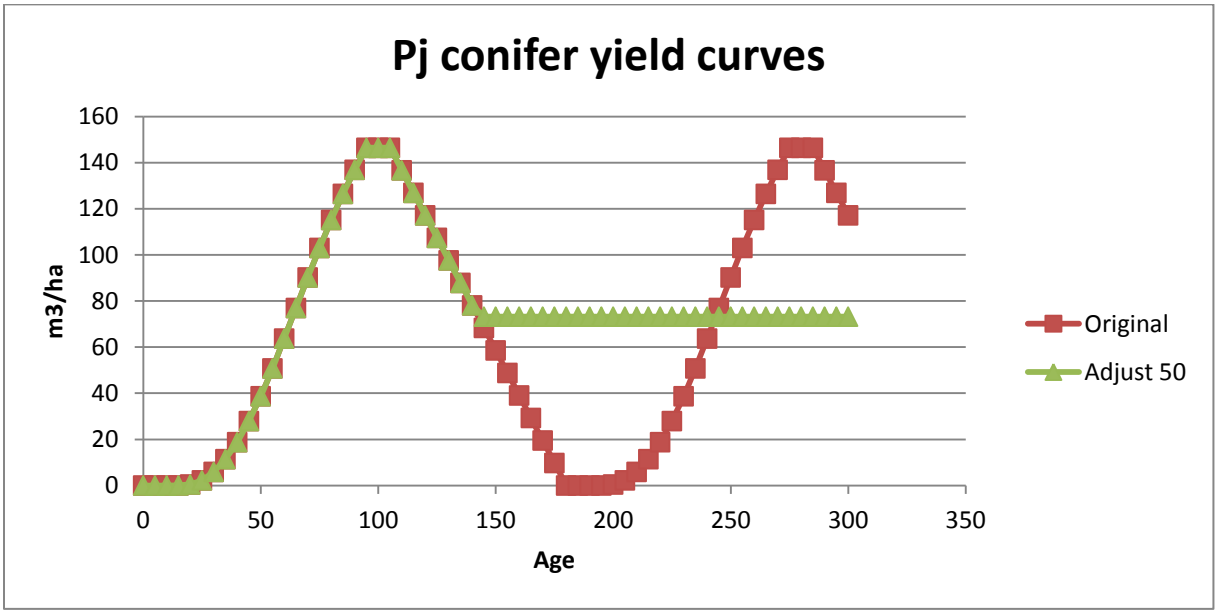


Figure 6. Comparison of differences between original and 50% flat line yield curves for Pj strata.

Impact Analysis and Assessment

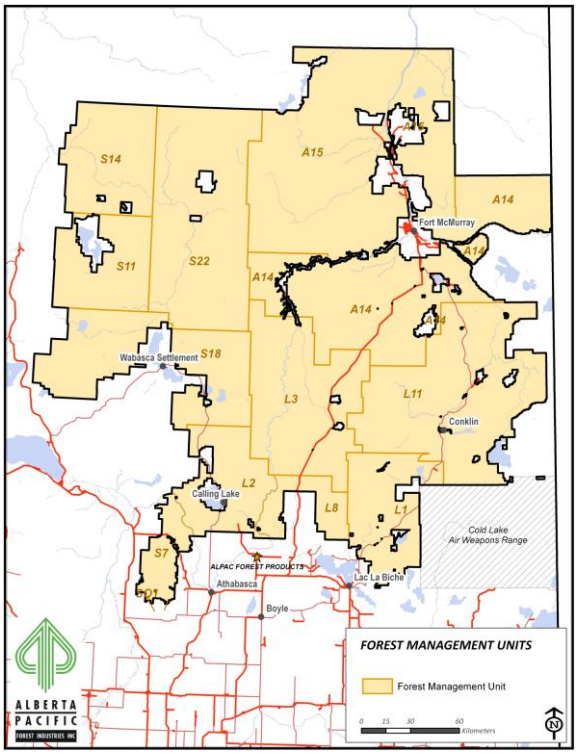
Supply impacts were assessed on two FMUs within the Alberta Pacific FMA: S23 in the south, and A14 in the northeast. (See Map 1) Two scenarios were run with similar objectives while the input dataset was altered between scenarios to reflect the alternative succession methods.

The two scenarios used different yield curves with alternative succession rules, and with identical draft 2015 net land-bases:

Original	Original yield curves, using successional breakup and renewal rules from Table 1. *DRAFT* 2015 Net Landbase
Adjust 50	Older portion of yield curves flat lined at 50% of culmination volume, no successional transitions. *DRAFT* 2015 Net Landbase.

Results from the scenarios were compared and indicators were developed to assess and quantify impacts between succession methods within the wood supply model. The impact analysis examined the amount of area within the managed landbase that 'escaped' succession (beyond the breakup age) and was subsequently harvested, as well as the impacts to overall supply levels (AAC) over a 150 year planning horizon.

Map 1- Al-Pac FMA Area – Forest Management Units



Note: S7 is now S23

FMU S23

The Original scenario was assessed to determine how much operable area became old enough to go through a succession event, and of this area, how much was subsequently harvested. Over the entire 150 year planning horizon 939 ha of area succeeded in the Original scenario, as compared to a total area harvested of 20,589 ha (4.5%). The majority of the area succeeding was in the AwU strata (deciduous landbase). Very little area succeeds until 50 years in the future and the even flow TSA objectives essentially prevent some area from being harvested prior to 'escape' through succession.

547 hectares were harvested after senesce and the succession event to a juvenile state, of which 482 hectares were in the AwU strata (deciduous landbase). Some of the post-successional AwU stands are harvested within 10 years of the event when the volume has recovered to approximately 140m^3/ha (this is because in the 2006 TSA AwU stands renew at age 60 on the AwU yield curve). Other strata do not recover volume as rapidly after succession and are typically not harvested until 80 years or more post succession. Usually well past the 200 year time-line of the TSA and thus have no effect on the average AAC.

The Adjust 50 scenario was assessed by examining the amount of area harvested within the 'gap' (the time during which the adjusted yield curve estimate is higher than the original yield curve) to determine the impacts of higher yield estimates during that time. The S23 Adjust 50 scenarios showed little area is harvested in the AwU strata within the gap. For example, 233 hectares of AwU were harvested within the gap when the yield estimates are higher out of a total of 11,683 hectares harvested over the planning horizon. Overall, the amount of area being harvested during the 'gap' when using the adjusted yield curves is relatively small compared to the total area harvested within FMU S23.

Impacts to AAC in FMU S23

The percent difference in the average primary deciduous harvest is -1.3% for the 50% adjusted scenario as compared to the original TSA scenario. The primary conifer harvest is less than 1% for the Adjust 50 scenarios (Table 2) as compared to the original TSA scenario. These outcomes show very little difference, indicating that the impact of the alternative approach on FMU S23 AAC is negligible.

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FMU A14

A similar sensitivity analysis was carried out on FMU A14 to test succession impacts on a different area of the Al-Pac FMA. The A14 unit is located in the northeastern portion of the FMA and represents different initial landbase conditions from the S23 in terms of strata and age classes. The A14 has a greater amount of landscape in an older forest situation with a higher conifer component – greater hectares of Jack pine and Black spruce (F/M/G sites).

The Original scenario was assessed to determine how much area within the strata types escaped through succession on the operable landbase and how much of the 'escaped' area was harvested past the breakup age. The A14 unit differs from the S23 in that older initial age classes are succeeding earlier in the planning horizon for some conifer strata. The amount of area available for harvest for the Sb-FM strata in the A14 is restricted to allow only 63.33%[3] of the operable area to be harvested within a planning period. This restriction on the Sb harvest forces a portion of the operable Sb area to 'escape' at 180 years of age. Within A14 only 3,780 hectares is harvested after a succession event, out of a total harvest area of 62,272 ha (6%). Similar to the S23 assessment, the harvest after succession does not occur until 60 years into the simulation, indicating that this is not an impact for short term planning or immediate AAC.

The adjusted scenario for the A14 was assessed by measuring the amount of area harvested within the gap for the 50% adjusted yield curves (representing the time at which estimated volume would be higher than original yield curves). Very little area was harvested within the gap as compared to the total area harvested. For example, only 999 hectares of Sw were harvested when within the gap over the 150 planning horizon out of a total of 23,000 net hectares.

Impacts to AAC in FMA A14

Overall, the comparison of the Original and Adjust 50 illustrates relatively small and insignificant changes to AAC. The 50% adjusted curve scenario shows negligible difference to overall wood supply in both the conifer and deciduous primary harvest (Table 2).

[3] The AAC from Fair/Medium Black spruce sites within FMU A14 are dedicated to conifer Quota Holder Millar Western. Their AAC allocation is 63.33%. Accordingly, 36.67% of the Sb F/M sites are not included in the timber merchantable net landbase.

Conclusion

A summary of AAC impacts for both FMUs is shown in Table 2. Overall observations indicate that relatively little area is affected from harvesting escaped stands. At the 50% flat-line level there is negligible impact on long term allowable cut.

Table 2. Summary of allowable cut impacts across FMUs.

FMU	AAC (150 year average)			
	Primary Deciduous (net m3/year)		Primary Conifer (net m3/year)	
	Adjust 50	Original	Adjust 50	Original
A14	208,292	210,226	148,629	149,375
	-0.9%	-	-0.5%	-
S23	110,021	111,429	27,760	27,574
	-1.3%	-	0.7%	-

TSA Parameter for 2015/16 TSA

The 50% value of the peak volume for each strata was selected as the point to "flat-line" the curve. In this study it shows that there is no significant impact on AAC as compared to the original set of curves; stand senescence and succession to juvenile state. Using the curves and succession assumptions (flat-line) in the Adjust 50 scenario allows the model to recognize that older stands on the undisturbed portion of the forest retain old forest characteristics as they age throughout the TSA timeline.[4] This in turn makes a more effective model that will allow forest planners to explore strategies for managing the retention and distribution of old forest values throughout the FMA area.

[4] Wildfire is not modeled within the TSA, thus harvesting is the only disturbance allowed within this environment.