Alberta-Pacific Forest Industries – Forest Management Agreement Area

Forest Inventory Monitoring

Forest inventory is an accounting of trees and their related characteristics of interest over a well-defined land area. It may be compared to census methods for human populations. For example, one of the goals of the periodic decennial census of the US is to enumerate its human population and to retrieve demographic variables such as age, sex and race. This is accomplished by a comprehensive survey of all households in the country. Similarly, forest inventories seek to enumerate the population of trees within a forest and ascertain other information, such as their volume, value, growth and species composition. For all but the smallest tracts of land, complete enumeration of individuals is usually infeasible and survey sampling techniques are required.[*]

Inventory is the starting point for sustainable forest management. Changes in the inventory components over time provide valuable indicators of economic, environmental, and social sustainability.

Alberta-Pacific's forest inventory is based on aerial photography, LiDAR[†] imagery, helicopter reconnaissance, and ground-level observation. Skilled technicians analyse the photography and imagery to map and measure the species and approximate age of the trees. Helicopter reconnaissance helps to confirm tree composition, characteristics, and age. Ground-level observations include periodic measurement of sample plots that provide data about the growth rates and wood yield of typical stand types. Additional information comes from post-harvest surveys and the results of current and past harvests. This information is combined with mapping of features such as human use, topography, and hydrology in the geographical information system (GIS), and it is used to produce the timber supply analysis (TSA) and annual allowable cut (AAC) calculation.

The Al-Pac Forest Management Agreement area is so large that it is not practical to photograph and analyse the entire area in a single year; the availability of inventory technicians is one of the limiting factors. As a result, roughly one-tenth of the area is surveyed annually, and the cumulative results are combined in the TSA for the company's next Forest Management Plan (FMP).

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[*] "Forest inventory," Charles T. Scott & Jeffrey H. Gove, Volume 2, pp 814 – 820, in *Encyclopedia of Environmetrics* (ISBN 0471 899976) edited by Abdel H. El-Shaarawi and Walter W. Piegorsch, John Wiley & Sons, Ltd, Chichester, 2002.

[†] LiDAR (Light Detection and Ranging) is a surveying technology that measures distance by illuminating a target with a laser light.

Two results of the inventory process are important for monitoring purposes at the landscape level: the age-class distribution and the land base netdown. The age-class distribution shows not only the current and future availability of harvestable timber, it also approximates the distribution of habitat types for other species on the landscape. The land base netdown shows the amount of actually harvestable land after allowing for factors such as water bodies, wetlands, muskegs, protected areas, inoperable terrain, burned areas, settlements, First Nations reserves, transportation infrastructure, and industrial use.

The Alberta government began its forest inventory program in 1949. The initial inventories included a broad-scale survey of most provincial forests (Phase 1) and a more detailed survey of the foothills region (Phase 2). A new round of updated surveys (Phase 3) began in 1970. In 1991, the government and the holders of Forest Management Agreements (FMAs) adopted a standard called the Alberta Vegetation Inventory (AVI) as the minimum requirement for subsequent surveys. The AVI includes information about human use, water bodies, soils, and non-forest cover types in addition to tree stands.[*]

Exact comparisons of the components in Al-Pac's inventory since the initial 1991 FMA are not possible due to changes in the legal definition of the management area, but trends can be identified. There have been significant changes in the landscape due to forestry operations, other industrial activities and infrastructure, and wildfires. Improved inventory methods have also led to greater precision in mapping and categorizing the forest landscape. Advances have included higher-resolution digital colour photography, LiDAR imagery, and the growing body of data and observations recorded in the GIS.

Land Base Evolution

The area covered by the FMA, in which Al-Pac is responsible for forest inventories, is comprised of three broad categories:

1. Operable (productive land for forestry)
2. Non-merchantable (non-operable area--primarily bogs, fens, muskegs, and water bodies--plus recently burned landscapes and anthropogenic disturbances)
3. Other (not available for harvest—e.g. buffers, parks, reserves etc.)

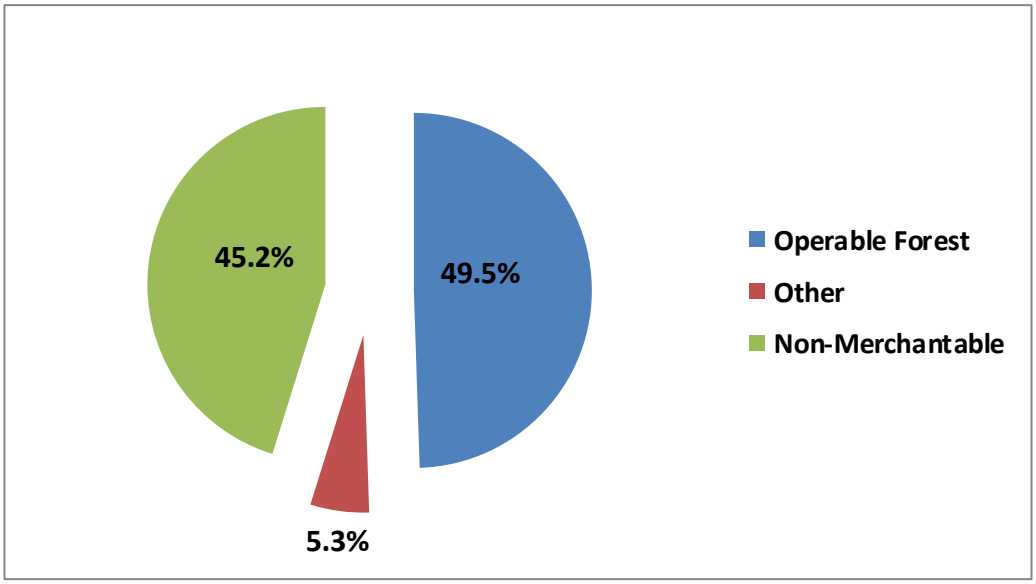
Both the gross area and the categories have evolved over time. As indicators, the changes primarily reflect socio-economic change rather than environmental impacts.

[*] Alberta Agriculture and Forestry, "Forest & Vegetation Inventories - Vegetation Inventory Standards," http://www.agric.gov.ab.ca/app21/forestrypage?cat1=Vegetation%20Inventory%20Standards&cat2=Forest%20%26%20Vegetation%20Inventories (accessed April 21, 2016)

1991

At the time of Al-Pac's initial FMA signing in 1991, and until completion of its own AVI survey in 2001, the inventory information came from the provincial Phase 3 data compiled for the FMA area in 1988. Under this program, the cover types were interpreted from aerial photography (mainly 1:15 000 black and white) to generate a hardcopy map base. Field data were collected to determine stand volumes. Ground checks clarified and enhanced the photo interpretation. Forest cover polygons were identified to a minimum stand size of 2 hectares and included the following attributes: species composition, crown density, height, date of stand origin, site index class, and coniferous commercialism class. The Phase 3 inventory could also include information about stand condition, type and severity of disturbance, slope category, and understorey growth.

Figure 1. Future FMA Area in 1988 (Phase 3 Inventory): 7.4 million hectares in 22 Forest Management Units (FMUs)

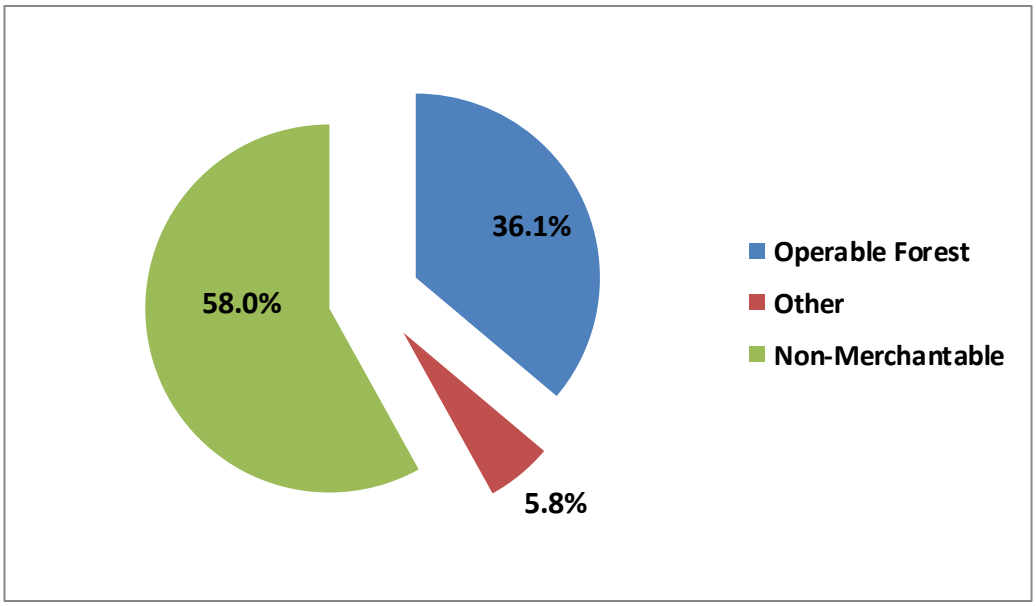


The 1988 Phase 3 inventory "operable" category included black spruce stands that were subsequently deemed non-merchantable. At the time of the inventory, oil sands activity was confined to a limited area close to Fort McMurray. The survey covered 22 Crown Forest Management Units that totaled about 7.4 million hectares. This included all operable areas and a huge amount of non-merchantable landscape, mainly bog and muskeg complexes.

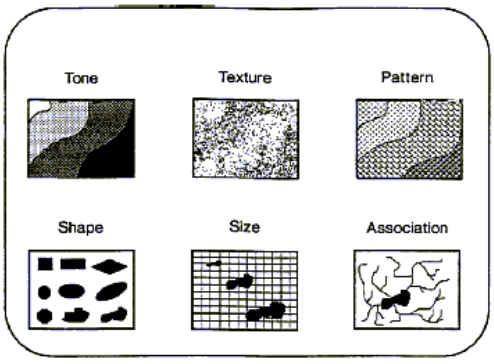
2000

With the signing of the FMA in 1991, and the subsequent initialization of the AVI program, Al-Pac compiled new AVI inventory for some FMUs and components of the old Phase 3 inventory in other FMUs to create the 2000 Detailed Forest Management Plan (DFMP). The AVI was at this time was still based on hardcopy interpretation of black-and-white photography, but it also included enhanced GIS processes. At the time of the DFMP, the FMA land gross area was about 5.8 million hectares after more than 1.1 million hectares of bogs and muskegs were removed from the legal land base and deemed non-FMA, government-managed landscapes. One FMU was also eliminated from the FMA in 1998, leaving only 21 of the original FMUs in the 2000 DFMP.

Figure 2. Gross FMA Area in the 2000 DFMP (AVI and Phase 3 Inventory): 5.8 million hectares in 21 FMUs



The company's AVI was well underway by the time of the 2000 Detailed Forest Management Plan (DFMP). Many of the black spruce stands were no longer considered merchantable. The pace of oil sands development had begun to accelerate and included some in situ projects within the FMA area.

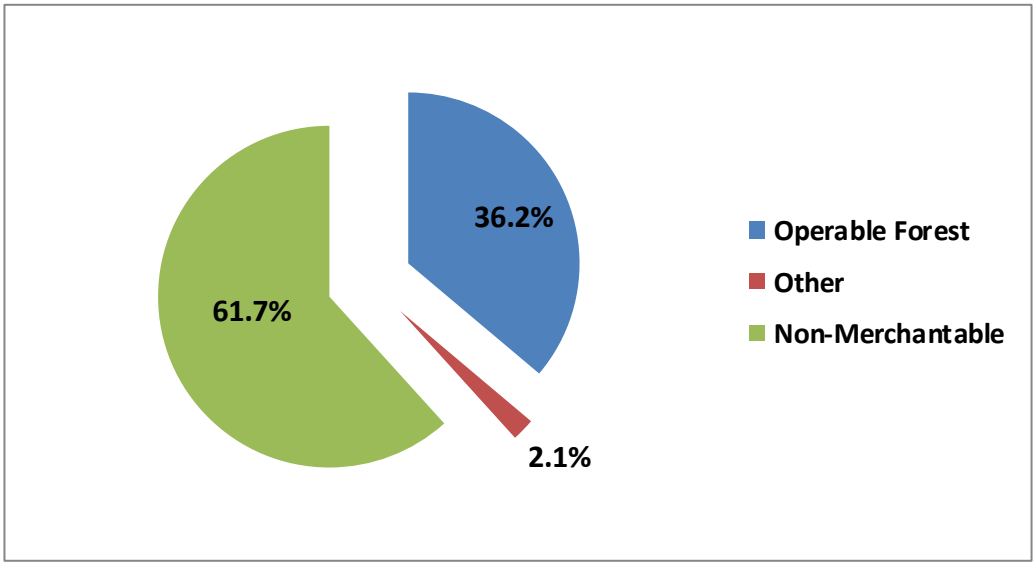


2006

In 2006, the AVI had been completed for the gross FMA area, and a new program called Softcopy Alberta Vegetation Inventory (SAVI) was initiated for use in the 2006 FMP. SAVI updated the AVI to include former burn areas and human impacts such as harvest areas, energy sector activities, and infrastructure. SAVI continued to use black-and-white photography, at 1:30 000 resolution, now interpreted digitally on computers. Enhanced software converted results directly into GIS format.

This FMP utilized 11 FMUs (decreased due to administrative FMU amalgamations). For purposes of the Quota Holder timber supply calculation, the previously excluded 1.1 million hectares of bogs and muskegs were added to the FMA area. Al-Pac's AAC was based on the legally defined 5.75 million hectares of FMA area, while a gross area of 6.9 million hectares was used for the Quota Holder AAC forecast. Only 11 per cent of the Quota Holders' additional area was considered operable.

Figure 3. Al-Pac Gross FMA Area 2006 FMP (AVI and SAVI): 5.75 million hectares in 11 FMUs

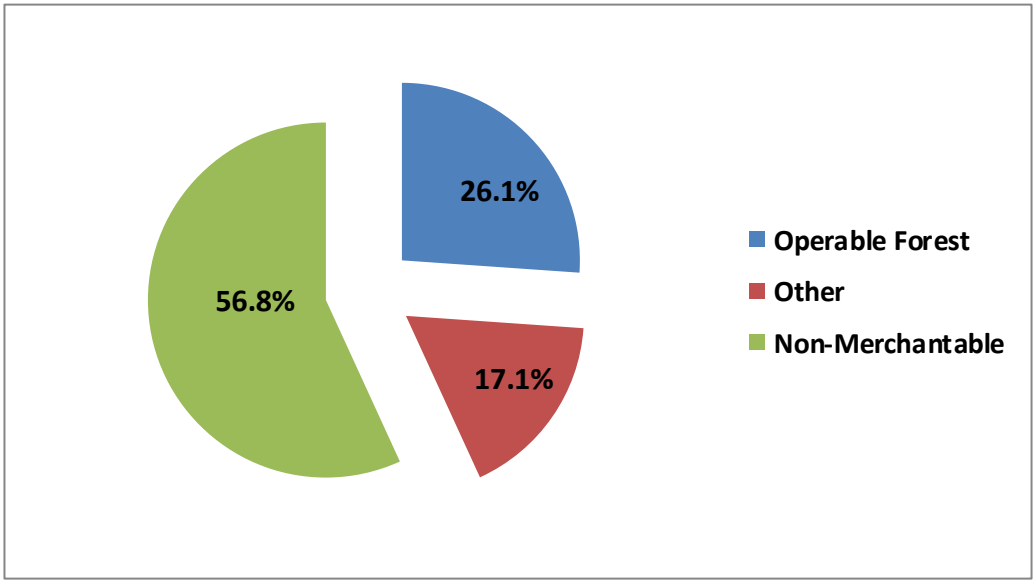


The 2006 Al-Pac land base was almost the same as in 2000, but Quota Holders obtained some conifer supply through inclusion of previously excluded bog and muskeg areas for purposes of their allowable cut calculation.

2015

By 2015, the FMA land base had changed considerably. A new FMU, S14, added 365,000 hectares. The government's Lower Athabasca Regional Plan (LARP) excluded forestry operations in various areas, and the major expansion of energy sector activities and related infrastructure reduced operable forest throughout the FMA area. Reductions due to LARP and anthropogenic footprint totaled about 1.2 million acres. Meanwhile, the previously excluded 1.1 million hectares of mostly non-merchantable bog and muskeg complexes were made part of the legal FMA area. The result is a gross area of about 7.3 million hectares.

Figure 4: Gross FMA Land Base 2015 (SAVI Inventory): 7.3 million hectares in 12 FMUs



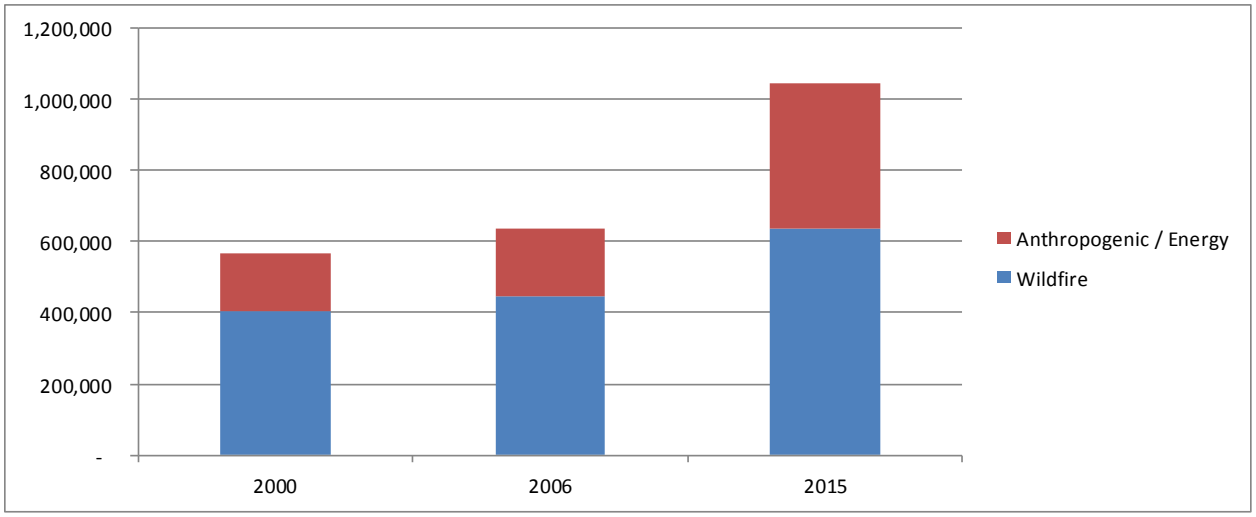
The SAVI inventory was completed by 2012. Although the legal FMA area increased by about 25 per cent from 2006 to 2015, Al-Pac's operable forest land actually declined by about 9 per cent.

The full SAVI inventory was completed in 2012, and data collection began in 2014 for a new inventory known as AVI-II. This 12-year program includes four-band, high-resolution, leaf-off digital imagery that identifies understorey growth as well as canopy species. The technology now permits resolution down to 30 centimetres. The results will be combined with LiDAR imagery and other data to produce a comprehensive picture of the evolving landscape.

Wildfire and Anthropogenic Impacts

In addition to legal boundary changes, wildfires and human activities (mainly energy sector and infrastructure) had major impacts on the land base. Burned landscapes are not considered operable areas until a new inventory redefines the vegetation complex. Anthropogenic footprint is also deemed non-operable until sites are reclaimed, vegetation re-established, and a new inventory completed.

Figure 5. Major Natural and Anthropogenic Landscape Changes (hectares; entire FMA area)



In the FMA area, wildfire is the principal natural disturbance on the landscape—far greater than other natural disturbances such as those caused by insects, disease, and wind. The fire regime includes many small burns and a few very large ones. Recent large wildfires include Chisholm in 2001, House River in 2002, and Richardson in 2012.

Anthropogenic disturbance primarily reflects the major expansion of oil sands activity, related infrastructure, and major transportation and utility corridors developed since the late 1990s. The full extent of oil sands disturbance is not shown because most of the surface-mineable oil sands area had been deleted from the FMA area by 2015 for the determination of the AAC, while only the actual surface lease areas were excluded from 2000 and 2006 legal land base.

Composition of the Operable Area

Changes in the forest strata of the operable land area indicate both socio-economic and environmental effects. Some of the variation reflects changes in the legal boundaries and the effect of wildfire and anthropogenic disturbance. However, part of the reduction in mixedwood area is also due to past silvicultural practice following harvests. After a mixedwood stand is harvested, all or part of the area is generally replanted with conifer seedlings to meet Alberta regeneration standards. As a result, the re-growing area is then categorized as pure conifer. Al-Pac's harvests of deciduous stands include "understorey protection" to retain some conifer and thus maintain mixedwood characteristics and increase conifer-dominated mixedwood growing stock within the inventory.

Figure 6. Forest Strata in the Operable Land Base

Age-Class Distribution

The distribution of stand ages and classifications is a crucial indicator of sustainable forest management. Economically, the distribution shows the present and future availability of timber supply for the forest companies. Environmentally, it reflects the approximate availability of the habitat types required by various species of flora and fauna.

In the boreal forest of northeastern Alberta, however, the frequent fire cycles have produced a wide range of natural variation in age-class distribution across the landscape.[*] In recent decades, fire suppression may have increased the amount of older forest stands that previously would have burned. Large-scale harvesting is also comparatively recent, and research is continuing on the ways to maintain optimum distribution of age classes and habitat types over the long term. The impacts of wildfire and anthropogenic disturbance are additional considerations.

The age classes in the FMA are broadly categorized according to age groups (seral stages) and stand types (strata). The seral stages are different for slower-growing species such as white spruce compared to faster-growing species such as aspen.

The four seral stages used in the analysis are:

- **Juvenile** (Establishment) – the establishment or regeneration phase of tree growth (generally years 1-20) - seedlings or suckers. No merchantable volume in this stand type.
- **Immature** – trees or stands that have grown past the regeneration or juvenile stage but are not yet mature. The age period for this class varies by species (generally years 21-60). These trees are still considered non-merchantable. The stand is represented by the rapid growth segment of a yield curve.
- **Mature** – trees or stands that are sufficiently developed to be harvestable and that are at or near rotation age. The age period for this class varies by species (generally years 61-100). These stands represent the peak growth volume segment of a yield curve.
- **Old Forest (Over-mature)** – an aging stand that is past the mature stage. The age period for this class varies by species. Stands have declining growth volume rates and increased individual mortality. These stands demonstrate changes in the upper forest canopy (i.e. gap dynamics) and have an increasing recruitment of snags and downed woody debris. This stage can be identified in yield curves as the point at which gross wood volume remains the same or declines (i.e., volume loss due to death equals or exceeds growth).

The five major strata and age-class differentiations are:

1. Deciduous (primarily aspen poplar, abbreviated as Aw)
2. White Spruce (Sw)

[*] Smith, M.L., D'Eon, R.G. 2006. *Pre-Industrial Forest Condition Report for The Alberta-Pacific Forest Industries Inc. Forest Management Agreement Area.* Alberta-Pacific Forest Industries Inc, Boyle, AB.

3. Mixedwood
4. Jack pine (Pj)
5. Black spruce (Sb)

Table 1. Major Strata in the Al-Pac FMA Area (Source: 2006 FMP)

Major Strata	Juvenile	Immature	Mature	Over-Mature / Old
Deciduous	1 – 10 years	11 – 60 years	61 – 100 years	100 + years
Mixedwood	1 – 10 years	11 – 60 years	61 – 100 years	100 + years
White Spruce	1 – 20 years	21 – 70 years	71 – 120 years	120 + years
Black Spruce	1 – 20 years	21 – 70 years	71 – 120 years	120 + years
Jack Pine	1 – 20 years	21 – 60 years	61 – 100 years	100 + years

Comparisons of the distribution of these age classes, at the scale of the FMU and the FMA area, provide valuable insights over longer periods of time, such as the interval from one TSA to the next. Changes in legal boundaries make a complete presentation and analysis too complex for use in this document, but the data are available and can be provided on request. The next FMP will provide age-class metrics for all 12 FMUs.

An Example of Age-Class Distribution Change

The L3 FMU (see Map 1) provides an example of the way that age-class distribution is used as a monitoring indicator. L3 was selected because it is located near the middle of the FMA area and its gross area and boundaries have been relatively stable for the past 25 years.

Map 1. Forest Management Units in the Al-Pac FMA Area

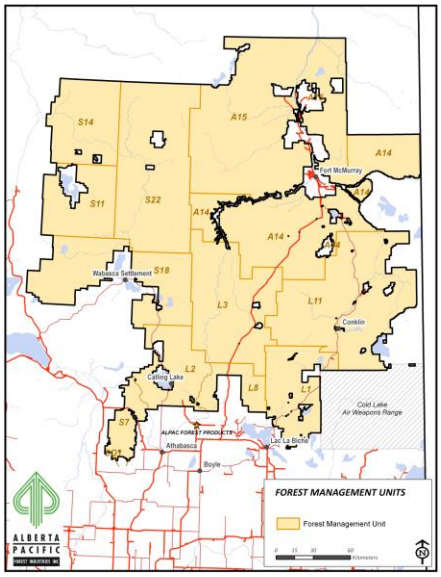
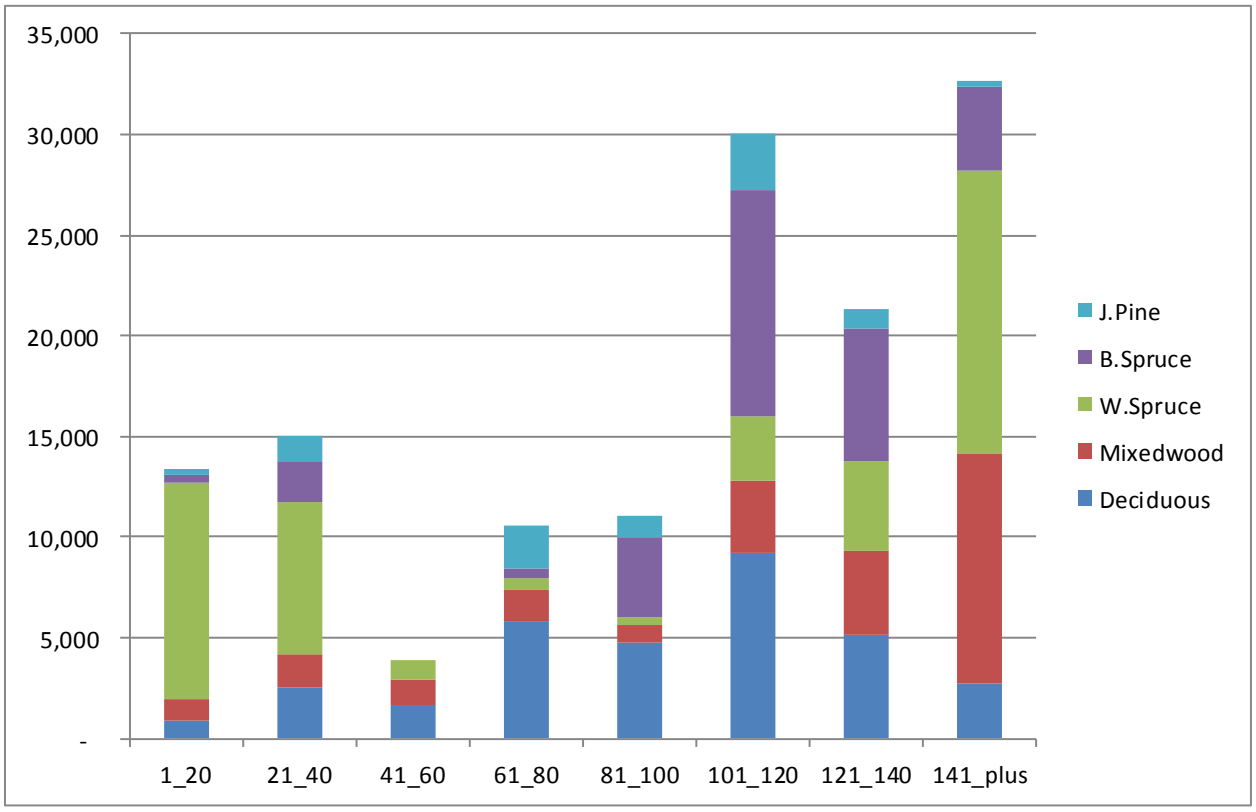
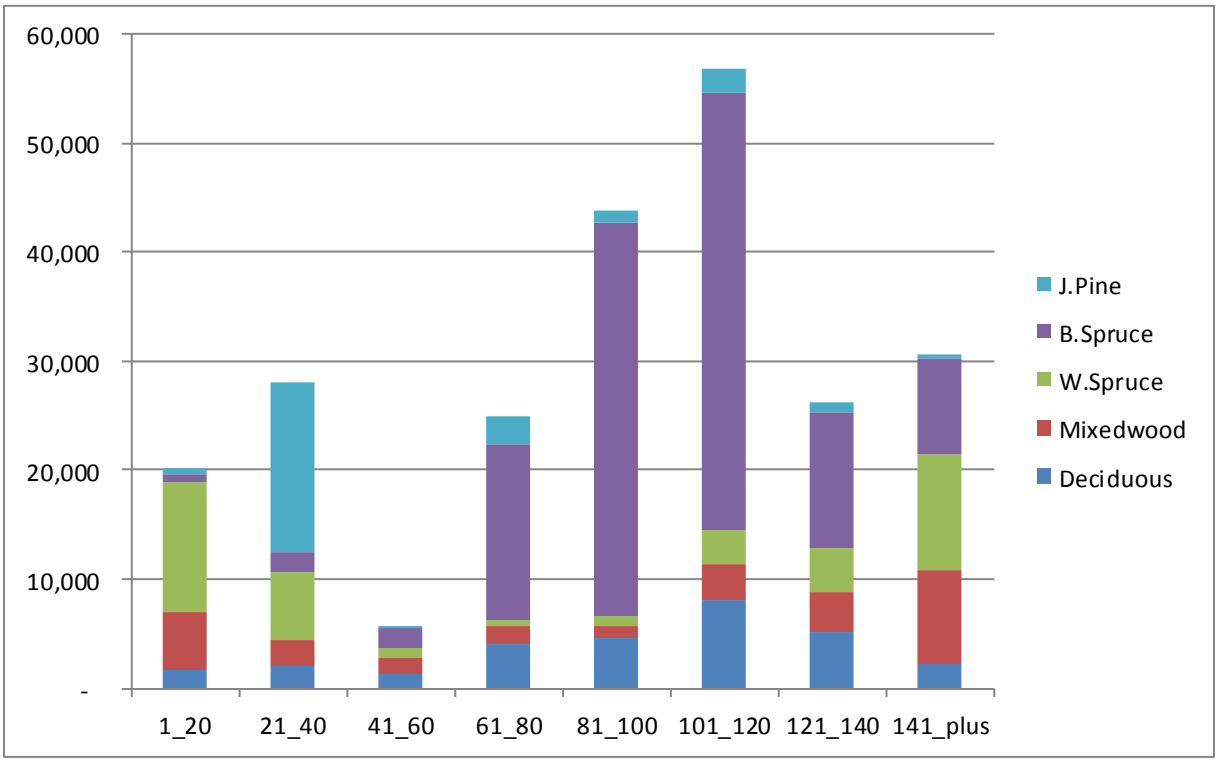


Figure 7. L3 Age-Class Distribution in 2006



The 2006 distribution showed a large amount of juvenile white spruce due to reforestation after harvests in the preceding 20 years. The distribution also showed that large amounts of mature and over-mature timber remained available for harvest—a preponderance of older forest that was unusual in boreal Alberta. In the later stages of succession of the boreal forest, in the absence of wildfire, the forest will have a greater amount of older conifer-dominated mixedwood and white spruce hectares. Older deciduous forests slowly decline as they age, die, or are harvested.

Figure 8. L3 Age-Class Distribution in 2015



The 2015 inventory for L3 showed a decline in the oldest age classes as harvests continued. Juvenile jack pine appeared as an increase due to new inventories restoring older burned landscapes to operable status.

Authors: Robert Bott and David Cheyne, 2016