

LANDSCAPE DISTURBANCE PROJECT
STAND ORIGIN MAPPING
1996

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"to develop and recommend an approach to sustainability and integrated resource management through research and technology developed by means of collaborative partnerships".

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1 INTRODUCTION

This report documents the acquisition of stand origin information within the Foothills Model Forest during 1996. The work is part of an ongoing program whose goal is to describe and interpret the pattern of forest age classes caused by wildfire in the Rocky Mountain and Foothills Natural Regions of Alberta. Prior to human settlement, the pattern of forest ages in this ecosystem was influenced predominantly by wildfire; this pattern is now influenced by activities such as fire suppression, prescribed fire, and clearcut harvesting. An improved understanding of the distribution and size of stand ages on the landscape, would guide land managers to plan for future age class distributions similar to the one found before fire suppression. By maintaining a natural forest succession, such approach would reduce the risk of decreasing biodiversity and vegetation mosaic, specific to the ecosystem.

Considerable stand origin mapping had already been done in this area prior to the start of this project. During the early 1960's, a stand origin map was produced for approximately 8,000 km² east of the Front Range by Jack Wright and co-workers of St. Regis Pulp and Power Ltd. The methods were similar to those described in this study, but detailed field records are no longer available (Wright, pers. comm). This stand origin map formed the basis of an analysis of fire frequency by Van Wagner (1978). An additional 2,000 km² of stand origin information was added during the late 1980's (Currie, pers. comm.). The combined map covers the current extent of the Forest Management Agreement (FMA) area of Weldwood of Canada Ltd. (Hinton Division). In Jasper National Park, stand origin mapping was also completed from 1986-1992 (Kubian, 1993) and covers approximately 10,000 km². This map incorporated previous fire history work completed by Gerald Tande (1979).

Three types of Agaps≡ in the FMF, as shown in Figure 1, were identified and are described as follows:

1) Administrative gaps

These gaps occur where no fire history work has been done such as the Town of Hinton, also referred as FMU E9, W.A. Switzer Provincial Park, FMU E3 (coal mines), and the Provincial Corridor between Jasper National Park and the Weldwood FMA area, which is referred as FMUs E4, E5 and E11. The Provincial Corridor alone covers an area of 2,000 km², while the remaining gaps cover a region of x km².

2) Old age gaps

These stands are distributed throughout the Weldwood FMA area and account for approximately 19% (2,300 km²) of the FMA area. Previous work, during 1960-62 by St. Regis Pulp and Power, included these areas, but existing maps show all stands older than 150 years combined as one age class. For the purpose of this research, it is critical to know the stand age distribution as far back in time as possible using tree ages, in order to extend the Atail≡ of the age class distribution. Therefore, fire history field work was redone for selected areas containing stands older than 150 years.

Figure 1. Locations in the Foothills Model Forest for which no stand origin data is available through fire history methods. These Agaps are categorised in three groups: 1) administrative gaps, 2) old age gaps and, 3) non-merchantable forest gaps.

3) Non merchantable forest gaps

These are patches of undated forest throughout the Weldwood FMA area. They usually correspond to open wetlands, meadows and muskegs that were considered non-merchantable.

These gaps represent an area of 1,200 km², accounting for approximately 12% of the Weldwood FMA area. For the purpose of this research, unproductive areas that are forested can provide vital information on stand age distribution over the landscape.

All locations selected for stand origin mapping during 1996 are east of the Front Range, and included areas for which: 1) no stand origin information was available and, 2) older forest were currently combined into a single age class referred to as "pre-1808". The locations of stand origin mapping work in 1996 are as follows:

- ' W.A. Switzer Provincial Park (no stand origin information available);
- ' Forest Management Unit (FMU) E9 / Town of Hinton (no stand origin information available);
- ' Berland River Area (contains older age classes);
- ' Camp One Area (contains older age classes);
- ' Warden Creek Area (contains older age classes);
- ' FMU E4, Brule Lake Area (no stand origin information).

This report presents the methods used to reconstruct past fire events and the results from field work in 1996 in each of these six areas. The main body is in the form of stand origin summaries, tables of stand origin dates, and lists of fire evidence. Frequency tables and graphs showing the distribution of tree ages, fire scars and releases grouped in ten year classes, are presented in Appendices B and C, respectively. Field notes for each sample plot are presented in Appendices D (site information) and E (tree information), while stand origin maps are found in Appendix F.

An analysis of the frequency, size, and spatial arrangement of past wildfires, which uses both newly acquired and previously existing stand origin information, is described in a separate report (Andison, in prep.). The results of a stand age verification exercise in Jasper National Park are also described in a separate report (Mercer, in prep.).

2 METHODS

2.1 General

The fire regime of the study area appears to be dominated by high intensity stand replacing fires. Identifying the extent of low intensity surface fires, which also occur in the study area, would require a sampling strategy that is very time consuming due to the high number of sample plots required. For this reason, only stand replacing fires were mapped. The method used to reconstruct past fire events is called Time-Since-Fire Mapping (Johnson and Gutsell 1994). A time-since-fire map represents a mosaic of forest stand ages that are known or believed to have originated from stand replacing fires. Since not all stands sampled had supporting evidence of an exact fire date, it is more appropriate to call the maps produced for this project: AStand Origin Maps≡.

Following is a description of the procedure used to reconstruct past fire events in the Foothills Model Forest.

2.2 Photo Interpretation

Air photos were used to identify stand boundaries, which were defined by a change in texture and tone on the image (Heinselman 1973, Johnson *et. al.* 1990). Due to the good quality of air photos used, little aerial or ground reconnaissance was necessary to complement the air photo interpretation.

Three series of black and white air photos were available for most of the FMF. One set dated from 1949 at a scale of 1:40,000, another dated from 1955 at a scale of 1:31,680 and the third one was from 1993 at a scale of 1:15,000. The 1949 series was the preferred choice for boundary identification and delineation. This scale allowed for easy transfer of fire boundaries onto 1:50,000 topographic maps. The scale was also large enough to cover a large surface area without compromising the ability to detect fire boundaries. In that regard, the oldest photos were also preferred because historic fires can be better identified. Photos from the 1955 series were washed out, which made the identification of fire boundaries difficult. The 1993 series was used primarily to identify accessibility to sampling sites located in harvested areas.

The stand boundaries identified on the air photos were transferred to 1:50,000 topographical maps (labelled as AMaster copies≡). These maps, used in conjunction with the 1993 air photos, served to locate the sampling sites and were used in the field to refine the exact location of stand boundaries when necessary.

2.3 Sampling location

Gathering information to reconstruct the fire history of a forested stand is best done by aging patches of remnant trees within, or on, the edges of a burn, and by sampling trees that germinated following the last fire (Arno and Sneek 1977).

Sample plots were located on each side of stand boundaries identified on the air photo. The number of sampling sites increased as the size of the stands increased, so that multiple burn histories within stands could be detected. When a stand appeared to be heterogeneous on the air photos, but no definite fire boundaries were visible, additional plots were taken.

2.4 Tree selection

Trees were sampled after doing a stand assessment, which consisted of walking through the forest in the vicinity of the plot location in search of survivors that could carry a fire scar or a release. A release is a sudden and significant increase in the ring growth pattern¹ due to a lack of competition for light and nutrients. Trees that show a release are frequently the survivors living on edges or within a burn. Unlike fire scars, a release can only be seen from a tree cross-section.

Sample trees were selected from survivors that might carry evidence of fire, and also from trees that had regenerated after the fire (Arno *et. al.* 1993). The most common size trees were sampled; these were not necessarily the largest trees. An average of four trees per stand were collected; eight trees when the sampling site fell on a fire boundary.

In stands containing several tree species, tree samples were taken from dominant and subdominant species. Most frequently, the dominant species were the lodgepole pine (*Pinus contorta* Loudon), the white spruce (*Picea glauca* (Moench) Voss) and the black spruce (*Picea mariana* (Mill.) BSP). At higher elevation, the mixed Engelmann spruce (*Picea engelmannii* Parry)/subalpine-fir (*Abies lasiocarpa* [Hook.] Nutt.)² stand could also be found. In this case, the spruce was chosen over the fir, because the latter is considered to be a late seral species and is usually younger than the spruce (Aplet *et. al.* 1988, pers. obs.). In mixed stands of conifers and deciduous tree species such as aspen (*Populus tremuloides* Michx) and poplar (*Populus* L.), conifers were sampled because their annual growth rings are much easier to count, and their life expectancy is generally longer. It should be noted that in the stand origin summaries, found in chapter 3, tree species are simply referred to as pine or spruce stands.

¹ The release should be sustained for a minimum of 10 years to be considered as fire related (pers. obs.)

² Moss 1992 serves as the reference for all tree names used in this report.

If the ages of the sampled trees differed by more than 20 years (as determined by a field count), up to three additional samples were collected in an attempt to more accurately estimate the date that the stand originated.

2.5 Field notes

While assessing the stand, the following information was recorded for each sampling site:

- date and sampling team
- plot number, UTM coordinates, descriptive location
- aspect, slope, elevation
- human disturbance such as logging or facilities
- dominant + subdominant tree species
- fire evidence such as charcoal, burnt snags or stumps, scars
- visual observation of the amount of deadfall (few, moderate, much)
- visual observation of the duff layer (low, moderate, thick)³
- main understory species
- number of trees sampled with species names and presence of fire related scars or releases

Note: a sample Field Sheet is provided in Appendix A.

The sample numbering scheme was as follows: year - study area - plot number. Each study area was designated by a code. W.A. Switzer Provincial was referred as >SP=, FMU E9 as >E9', FMU E4 as >E4', the Berland Area as >B=, and Camp One Area and Warden Creek Area were designated as >A=, which stands for the Athabasca watershed.

2.6 Tree samples

2.6.1 General

Tree samples consisted largely of tree cross-sections (Acookies \cong) but sometimes cores were taken when it was impossible to use a chainsaw. However, preference was given to cutting cross-sections as they are more accurate in tree aging (McBride 1983). All tree samples, including cross-sections and cores, are housed at the Environmental Training Centre, Hinton.

2.6.2 Cutting

Cross-sections were taken as close to the ground as possible to reduce the potential error due to a growth time-lag and to avoid missing growth rings (Zackrisson 1981, McBride 1983). However, no correction factor was applied for germination and growth time-lag, because

³ A description of the amount of deadfall and duff layer can serve in the identification of the fuel type.

field experience indicates that trees do not grow at the same rate due to several factors including genetic diversity and site.

Normally full cross-sections were not taken because of weight and space restrictions during transport to the laboratory. In addition, a dissecting scope used to count growth rings frequently cannot reach the pith of full cross-sections. Therefore the cross section was usually cut in half along the pith. For trees showing a release, the cross-section was taken from the side facing the burned area. As this side of the tree is favoured, due to reduced competition for space and light exposure, the release pattern is usually more significant.

2.6.3 Coring

Cores were taken at about 30 cm (12 inches) above the ground (Arno and Sneek 1977), or as low as possible for the reasons stated above. No cores were taken from scarred trees or from potential fire survivors which might show a release in the ring width pattern, because such cores are unreliable in those circumstances (McBride 1983).

2.7 Sample preparation

2.7.1 General

Preparation of cross-sections and cores, and procedures for counting rings followed the methods of Arno and Sneek (1977).

2.7.2 Cross-sections

The plot number and tree species were marked on each tree sample in the field with a waterproof pen. These samples were air dried for several days, and then sanded with an 80 grit paper on a belt sander until the surface was smooth and easily readable. A dissecting scope (10X) was used for ring counting and light oil was spread on the wood to enhance the visibility of the rings. A carving knife was used to plane areas of very constricted rings. A tick was marked on the sample at every 10th ring.

2.7.3 Cores

Core samples were stored in plastic straws and labelled while in the field. In the lab, they were mounted on boards with glue, and allowed to dry for several days. These samples were sanded by hand, but otherwise the ring counting method was similar to that described for cross-section samples.

2.8 Tree aging

The aging of trees and scars followed methods of Arno and Sneek (1977). Multiple radii were counted on cross-sections when it appeared that scars or releases did not closely match the post fire generation ages. This was done to account for false or missing rings (Zackrisson 1981). Releases were searched for when a tree sample had been taken directly along an

obvious fire boundary or if the sampled tree was a remnant surrounded by younger post-fire regeneration trees.

2.9 Database

Field information, tree ages and fire years established from scars and releases were stored in a digital spreadsheet program for easy access and ease of data manipulation.

2.10 Analysis (Preliminary mapping)

A sheet of mylar was overlaid on the topographical map (Master copy) showing the location of stand boundaries. The boundaries were drawn on the mylar and all tree ages and scar or release ages (fire years) related to each plot were marked.

Data were interpreted and stand ages were assigned using standard criteria. Following are the criteria used.

(H) - based on a known date from historical records such as fire reports, dated photographs, old newspapers, etc.;

(S) - based on fire scars and post fire regeneration tree samples;

(R) - based on releases and post fire regeneration tree samples;

(O/5) - based on the oldest tree, 5 year class ;

(O) - based on the oldest tree, actual tree date;

(M/5) - based on the modal tree age, 5 year class;

(M) - based on the modal tree age, actual tree date;

(2nd O) or **(3rd O)** - based on the second or third oldest tree;

(E) - even-age stand;

(U) - uneven-age stand.

In the case of multi-aged stands where trees differed in age by more than 20 years, either the oldest tree or the modal tree age was chosen to represent the stand age. In each case the stand date was rounded to the older five-year-age-class rather than giving the actual tree date; i.e. if the oldest or modal tree was 1712, the year 1710 was assigned to it. If the oldest or modal tree happened to be on the five-year-age-class, the actual tree date was used.

The second or third oldest tree was used when the oldest tree(s) was not representative of the stand. This occurred when a long time period existed between the oldest tree(s) and the other ones. In the table of results for each study unit, the year of the oldest tree(s) is posted in brackets;

During this procedure, some of the stand boundaries initially observed on the air photo were readjusted by adding or deleting one or more boundaries. This happened most frequently when two adjoining stands were old and no textural difference in the forest cover could be identified to outline the extent of the stand in question. The other common case was when two burns dating less than 20 year apart shared a common fire boundary. In each situation, additional photo interpretation was done to subjectively trace the fire boundaries by using natural fuel breaks such as water bodies, rock outcrops, ridges and gullies.

2.11 Final Mapping

The final mapping procedure was to overlay a transparent acetate on the preliminary map in order to reproduce the stand boundaries and the stand origin dates. A non-permanent marker was used to allow boundary modification that may result from future research or new fires. This map was produced in a format ready for digitizing.

3 RESULTS

3.1 General

Results of the fire history work during 1996 are presented by study area. In the summary, each stand age identified in the unit is presented, and discussed if the stand was multi-aged as a result of succession or multiple lower intensity fires, or if stand boundaries were subjectively defined.

A summary table called AStand origin date statistics follows each stand origin summary and explains how the stand origin dates were assigned based on the established criteria (section 2.10). Each stand age received a unique stand identification number (stand id). However, when similar aged stands were thought to be from a different fire event, a separate stand id was given. The third column of the table represents the range of all tree ages found within the stand; the fourth column lists the criteria used to assign the stand date, while the fifth column reports the number of plots sampled. The last column shows the number of representative trees in comparison to the total number of trees sampled within that stand. The number of representative trees represents all trees within, and in the vicinity of the stand, that support the age of the stand. The age of a representative tree is never more than 20 years younger than the stand origin date.

Occasionally, the number of representative trees is greater than the number of trees sampled in the stand. This is because some of the trees sampled in surrounding stands were used to support the date of the stand in question. This occurred when ages of neighbouring trees were very close to the stand origin date of interest, or when those trees showed a scar or a release testifying to the fire in question. Basically, the larger the ratio $A_{\text{representative}}/\text{total}$, the more accurate the stand origin date. For example, if a stand has 15 representative trees out of a total of 20 trees sampled ($15 / 20$), the stand age would be considered accurate.

The second table entitled AField statistics, fire scars and releases list provides the basic field statistics for the unit by listing the total number of plots, sampled trees, scarred trees and trees showing a release. The dates of all scars and releases found are also enumerated.

In Appendix B, a frequency table for tree ages, scars and releases collected in each unit are presented. The same type of data is shown as distribution plots in Appendix C.

3.2 W.A. SWITZER PROVINCIAL PARK

Stand origin summary

Switzer Provincial Park was one of the Agaps where stand origin information had not been collected previously. Reconstruction of past fire events for this area was done using aerial photography from 1955 at a scale to 1:31,680. Overall, the Park presented a very patchy landscape due to several fires of moderate intensities in the past 125 years. Prior to this time, very few things can be said about historical fires, since the oldest tree detected in the area was from 1809.

The patchiness of this landscape is probably attributed to the fact that most fires in the Park have re-burned over the same areas. This assumption is supported by the presence of patches of even-aged stands in the surrounding area, and multi-aged stands containing a range of tree ages corresponding to fire scars or release dates found.

Note: The following information should be read in conjunction with Table 1 and with the stand origin map for this study area found in Appendix F.

The Provincial Park is on the western edge of a large burn which occurred in 1936 (stand id 1). The 1936 fire encroached into the Park north of Graveyard Lake and up to and around Gregg Lake. Prior to the 1936 fire event, a circa 1915 fire burned over most of the Park. However, its boundaries are not definite because this fire appeared to have burned at different intensities over the landscape. Evidence of a large fire around 1892, which burned extensive areas north of Hinton (identified as 1894 in FMU E9), burned over most of Switzer Provincial Park as well.

Small patches of remnants bordering the Park were dated as 1886, 1874 and 1809; suggesting the presence of previous fires throughout the Park.

Table 1. Stand origin date statistics for W. A. Switzer Provincial Park*.

| Stand Origin | Stand id | Range of ages | Criteria | # plots | # trees (representative / total) |
|---------------------|-----------------|----------------------|-----------------|----------------|---|
| 1936 | 1 | 1939 - 1947 | S, E | 3 | 15 / 11 |
| 1936 | 2 | 1945 - 1950 | Stand id 1, U | 1 | 2 / 4 |
| 1915 | 3 | 1914 - 1936 | S, R, U | 3 | 21 / 10 |
| 1892 | 4 | 1892 - 1907 | O, E | 2 | 24 / 10 |
| 1886 | 5 | 1886 - 1891 | O, E | 1 | 11 / 4 |
| 1874 | 6 | 1872 - 1884 | O, E, U | 3 | 13 / 15 |

* For explanation of how to read this table, please refer to sections 2.10 and 3.1.

Table 2. Field statistics, list of fire scars and releases for W.A. Switzer Provincial Park.

| SWITZER | Scars | Releases |
|------------------------|---------------------------------|-----------------|
| 22 plots | 1894, 1898x3, 1900x3, 1901x2, | 1915 |
| 90 trees | 1902, 1904, 1905, 1906, 1907, | |
| 23 trees with one scar | 1909, 1913, 1914, 1915, 1916x3, | |
| 3 trees with two scars | 1917, 1918, 1920, 1921, 1922, | |
| | 1930x2, 1932, 1935, 1936x3 | |

3.3 FMU E9

Stand origin summary

Stand origin information had not previously been collected for FMU E9, which surrounds and contains the Town of Hinton. Air photo interpretation for this unit was done using 1955 black and white air photos at a scale of 1:31,680.

Based on the stand origin information collected, this study area is dominated by a stand replacing fire regime. Prior to the era of fire suppression, this area experienced a stand replacing fire every 10 to 20 years on average during the period of 1876 to 1936. However, it was not uncommon for the region to have lower intensity fires that only partially destroyed forest stands. This latter type of fire behaviour yielded a patchy landscape where distinct burn areas are more difficult to define. Numerous fire scars were found throughout the study unit, especially on the edges of stand replacing fires, but also within stands. Several scars dating fire events in the early 1900's provided evidence of low intensity burns (surface fires) as no post fire regenerated trees were associated to this/these fire(s). Evidence of surface fires appear throughout the study area north of the Athabasca River, and east of the Town of Hinton along Highway 16. It should be noted that by the nature of the methods used to reconstruct these past fire events, only the stand replacing (high intensity) fires were mapped.

Note: The following information should be read in conjunction with Table 3 and with the stand origin map for this study area found in Appendix F.

North of the Athabasca River and west of Hinton, two recent fires from 1936 and 1915 burned in the area of Rat Lake. The fire boundary between these two fires is arbitrary as it was difficult to distinguish the true extent of the 1936 fire based on air photos. The 1936 fire also seems to have been of a lower intensity as it left scattered remnants from 1894 throughout. The extent of the 1915 burn north and west of the Athabasca Ranch is poorly defined due to a patchy landscape composed of aspen clones and mixed stands of deciduous and coniferous species. East and south of Cold Creek (outside the study unit) the boundary between the 1915 and 1936 fires is also not clearly defined. However, even-aged tree samples collected for this area support the existence of these two fires.

A fairly recent fire, dated as 1925 from pith data, was identified at the headwaters of Hardisty and Cache Percotte Creeks. This fire encroaches into the E9 study unit from the south and its true extent is unknown.

The Northeast corner of E9 shows a fire which occurred around 1904. Several scars dating from 1900 to 1910 were found in this area but the one plot taken within this stand shows very late post fire regeneration. It may represent a later burn dating from around 1925, but

additional plots would be needed to support this assumption.

Around 1894, an intense fire replaced stands south of the Athabasca River and west of Hardisty Creek. Evidence of the same fire is also found north of the River, more precisely around Rat Lake, along Orchard Creek and north of the microwave tower. This stand age was based on several scars ranging from 1893 to 1899 and on even-aged trees found throughout that stand.

The most extensive fire in the study unit was likely the one that occurred in the 1870's. Based mainly on pith data and a few releases, this fire was dated as 1876. Although this stand appears to be a patchy landscape due to the presence of scattered aspen trees or aspen clones, it is largely even-aged. Evidence of the 1876 burn can still be found throughout the study area, an indication that this fire likely killed the majority of the trees within the unit. Very few trees dating prior to this fire were found in the area.

On both sides of the Athabasca River near Old Entrance, small patches of forest have survived fires since 1740.

Poorly drained sites, such as muskegs, have shown the ability to survive to several stand replacing fires. Along Highway 40 South near Cold Creek (outside FMU E9) two muskegs have escaped burning since 1620 and 1710, respectively. However, another muskeg 1 km west of Cache Percotte Creek dated from 1935.

No fire evidence prior to the 1876 burn was found in the study unit. However, even-aged tree samples from the 1860's were collected north of E9 about 3 km east of Fish Creek. Therefore, it is likely that areas within FMU E9 burned in the 1860's as well.

Table 3. Stand origin date statistics for FMU E9*.

| Stand Origin | Stand id | Range of ages | Criteria | # plots | # trees (representative / total) |
|--------------|----------|---------------|-------------------------------|---------|-------------------------------------|
| 1936 | 7 | 1935-1952 | S, E | 6 | 27 / 21 |
| 1935 | 8 | 1939-1942 | 2 nd O/5, E (1904) | 1 | 3 / 4 |
| 1925 | 9 | 1928-1945 | O/5, E, U | 1 | 3 / 5 |
| 1915 | 10 | 1917-1933 | S, E, U | 2 | 16 / 12 |
| 1904 | 11 | 1928 -1934 | S | 1 | 12 / 3 |
| 1894 | 12 | 1893-1907 | S, R, E | 10 | 75 / 29 |
| 1876 | 13 | 1874-1892 | S, R, E | 21 | 95 / 68 |
| 1740 | 14 | 1741-1761 | O/5, U | 1 | 2 / 4 |
| 1710 | 15 | 1713-1754 | O/5, U | 1 | 1 / 2 |
| 1620 | 16 | 1622-1628 | O/5, E | 1 | 2 / 2 |

* For explanation of how to read this table, please refer to sections 2.10 and 3.1.

Table 4. Field statistics, list of fire scars and releases for FMU E9.

| E9 | Scars | Releases |
|---------------------------|---------------------------------|-------------------------------|
| 58 plots | 1876, 1880x2, 1891, 1893x5, | 1852, 1871, 1877, 1888, 1893, |
| 287 trees | 1894x5, 1895x3, 1896x7, 1897x2, | 1900, 1901, 1908 |
| 31 trees with one scar | 1898, 1899, 1900x4, 1901, | |
| 13 trees with two scars | 1903x2, 1904x4, 1905x2, 1906x2, | |
| 16 trees with one release | 1907x3, 1908x2, 1909x2, 1910x7, | |
| 1 tree with 2 releases | 1911x2, 1912, 1913x2, 1914, | |
| | 1915x3, 1916, 1919, 1920x2, | |
| | 1928, 1934, 1935, 1936 | |

3.4 BERLAND AREA

Stand origin summary

The Berland study area covers an area of almost 500 km², and contains large old patches identified as 150⁺ years on the original stand origin map. The identification of fire boundaries was done using the 1949 black and white aerial photography series at a scale of 1:40,000. Air photo analysis revealed a far more complex landscape than one would have expected from an old age stand. Multiple fire boundaries were identified, which greatly increased the required sampling intensity.

The boundaries of the area are as follows. Big Creek, to its junction with the Berland River, constitutes the northern boundary of the study area. The western and southern edges correspond to the boundary between the FMA area and Willmore Wilderness Park. The eastern boundary follows the Berland River a short distance from the north, then the range boundary separating Range 1 from Range 2.

Sixty-one stands with different ages were identified, among which only three dated from the past 100 years. Several older stands, particularly those from the 1700's along Highway 40, were multi-aged. In general, few stands showed evidence of lighter intensity burns such as scars, releases, or mixed ages from even-age trees within the same stand. This unevenness in ages was usually caused by forest succession.

Note: The following information should be read in conjunction with Table 5 and with the stand origin map for this study area found in Appendix F.

The most recent burn is referred as the Smith Creek burn, which dates from 1956 (Delisle and Hall 1987). In 1910, a burn coming from Willmore Wilderness Park extended to the south part of the Little Berland River. This fire was wind driven and spotted to the northwest by Moon Creek, and about six kilometres away near Hightower Creek. Some of the plots sampled in this burn showed late post-fire regenerated trees dating between the 1920's and 1930's, which could suggest a second burn. However, no fire scars or releases were found to support this. The third most recent burn dates back to 1909 and is located around the Berland River Trail.

Two stands dating from 1885 are present in this study area. A small patch (id 70) was found east of the Berland River, north of Hightower Creek, while the other one (id 34) was located near Cabin Creek. No fire evidence such as scars or releases was found on site, but even-aged trees and surficial charcoal confirm the presence of a stand replacing fire.

The 1870 stand consists of a strip of spruce forest along the south side of Hendrickson Creek.

This stand (id 33) is located within an 1834 burn.

Patches of multi-aged stands (id 31) along the shore of the Berland River south of Pasture Creek were dated from 1850. Another stand (id 74), bisected by Highway 40 just south of the Cabin Creek airfield, was also dated as 1850. The boundaries of this stand are arbitrary and were delineated by creeks, meadows and ridge lines. Sampling plots were frequently multi-aged, likely due to succession. However, plot 96-B-1212 showed evidence that this 1850 fire left survivors from the 1760 burn (id 44).

One small stand dating from the 1840's was located in the Hightower Creek area.

In 1834 an extensive fire burned in the area north of the Berland River, running from the western boundary of the FMA area (the extent could be further to the west but no sampling or air photo interpretation was done outside the FMA area) to the headwaters of Pasture Creek. This fire left several remnant patches dating from 1635 to 1795. In this stand, plot 96-B-274 contained trees showing releases dating a stand replacing disturbance from 1924 or 1925. This possible fire was not mapped because no post fire regeneration trees were found in the area and no fire boundaries could be identified on the air photos.

A small stand (id 27) dating from circa 1815 is located along the shore of Big Creek. The date was based on the oldest tree collected in a multi-aged forest, and is approximate. A small strip of trees (id 67) along Pinto Creek was also dated as 1815.

A strip of spruce dominated forest along the Little Berland River and scattered small patches in the neighbouring area were dated as 1810. The larger patch sharing a boundary with the 1775 stand (id 65) was not sampled.

Five locations in the study area had evidence of fire in the early 1800's. 1) Evidence of an 1800 fire was supported by the discovery of small patches of remnants (id 36) along the Berland River. 2) A portion of an early 1800 fire (id 51) encroached on the FMA area from Willmore Wilderness Park. The boundaries common to the 1700 stand (id 52) are arbitrary. Due to the old age of these two stands, boundaries were no longer visible on the air photos. Rather, topography was used as a guideline for boundary delineation. 3) An 1800 stand is also located between Moon Creek and Highway 40. Common boundaries between the 1760 (id 44) and 1715 (id 79) stands are arbitrary for reasons similar to those stated above. 4) Patches of muskegs (id 60) in the Hightower Creek area were dated from the early 1800's as well. 5) Lastly, more patches of muskegs (id 61), located south of Hightower Creek, were assigned a date of 1800 although they have not been sampled.

Several patches (id 18) dating around 1795 were found along Big Creek. Some of these stands are multi-aged, perhaps due to succession or to the presence of more recent and lower intensity disturbances. Some older trees dating from 1745, 1768 and 1771 are still present in part of the stands, suggesting that the 1795 fire was not as intense. Another possible explanation for the presence of older trees was that most sample plots were located adjacent

to meadows and muskegs where a helicopter could land⁴. Wetter areas can often favour the survival of trees during fire events.

A small even-aged stand (id 30) located along the shore of the Berland River in the Smith Creek burn also escaped fire since 1795.

One stand dating from 1785 can be found along the Berland River, east of Highway 40.

Three regions of the study area show fire evidence from around 1775. Some patches (id 24) were found along the shore of the Berland River. Within these patches, some trees dated from the early 1800's. However, it is unknown if those trees have regenerated after a fire or if they are simply the product of succession. Another small stand (id 65) along Highway 40, between Pinto Creek and the Little Berland River, was dated as 1775. This stand is multi-aged, probably due to forest succession. Lastly, a small patch of trees (id 78) close to the headwaters of Fox Creek was also dated as 1775.

Patches of even-aged pine dated as 1770 border the 1760 stand (id 25). These patches are possibly part of the 1760 burn in which stand establishment was delayed.

A small 1765 stand can be found in the 1910 burn. The accuracy of this date is relatively low considering that only two trees were collected, and their ages were 1768 and 1796.

Four stands dating from 1760 were mapped in the study area. 1) In the Pasture Creek area an extensive stand (id 25), mainly composed of pine with scattered patches of spruce dispersed throughout, was dated as 1760. Releases with dates from 1757, 1772, and 1777 added to the level of confidence in the assignment of a date to this stand. 2) Scattered patches (id 43) from 1760 are also located between Moon Creek and the Berland River. Only one patch was sampled, and it was multi-aged. The level of confidence for the date assigned is therefore low. However, a nearby stand (id 44) also dating as 1760 had two plots that were almost even-aged, which increased the level of confidence in the date of the stand. 3) In the Moon Creek area another stand (id 44) from 1760 can be found. Although the date of this stand is fairly accurate, the northeast boundary common to the 1850 stand (id 74) is arbitrary. Sample plot 96-B-320 showed evidence that on this site the 1760 burn was of a lower intensity. Within the stand, trees with similar ages from 1732 to 1738 suggested that a previous burn occurred around 1730. Also in this sampling site, trees with releases dating from 1825, 1830, 1830, 1832 and 1839 indicated that another low intensity disturbance occurred. 4) A large stand (id 72) on the east side of the Little Berland River, from Hightower Creek to the northern boundary of Willmore Wilderness Park, dated from 1760 as well. Several plots were multi-aged which made it difficult to assign an age. The northern boundary by Hightower Creek was defined arbitrarily due to the old age of the stands in the area which inhibited the identification of burn lines on the air photos. Only two plots (96-B-1239, 96-B-1249) showed evidence from releases (1928, 1926, 1901, 1899, 1863, 1861, 1849, 1846) of passive crown fire activity. These plots are about three kilometres apart and

⁴ For most of this study area, sampling plots were accessed by helicopter.

no other plots were sampled between these sampling sites to identify any post fire regeneration trees dating from the 1840's to the 1930's. Otherwise, the multi-aged component of the 1760 stand (id 72) is largely associated with succession.

A 1755 strip of spruce forest was found along the bottom of a side tributary of Moon Creek.

A remnant patch of spruce from 1750 along Cabin Creek has survived the 1834 and 1909 fires.

About two kilometres east of the Willmore Wilderness Park boundary, an even-aged stand dating from 1745 was found.

Patches from 1740 were found in two locations. Three patches (id 41) interspersed by the 1909 burn and now by cutblocks, were found along the east side of Willmore Wilderness Park boundary. Six more patches (id 63) dating from 1740 as well, were found by the Little Berland River on each side of Highway 40.

Evidence of disturbances in 1735 were found in four different locations in the study area. 1) Along Moon Creek (id 40). 2) As a small clump of spruce surrounding a meadow along Willmore Wilderness Park (id 39). Trees selected for this stand may not be representative as they were the only trees left after logging. 3) Seven patches (id 47) dating from 1735 were found between Fox and Moon Creeks. Only one patch was sampled as the other ones were not accessible by helicopter. 4) A 1735 stand (id 53) was also found between the Berland River and Moon Creek. The boundary along Moon Creek dividing the 1700 (id 52) and 1735 (id 53) stands is arbitrary.

A multi-aged 1730 stand was found near the junction of the Berland and Little Berland Rivers. The uneven ages of this stand are likely attributed to succession.

Northeast of the Big Berland Cabin there were three small patches of pine (id 22) dating from 1725. One of these patches showed old logging evidence dating from around 1955 (based on a release). There is also a patch of muskeg (id 62), located east of Highway 40 and about 0.5 km east of the Little Berland River, that dated from 1725.

Five locations in the study area showed evidence of a disturbance in the early 1720's. 1) There was a small 1720 stand (id 55) between Moon and Fox Creeks, 2) one along Fox Creek (id 57) and 3) one patch of spruce (id 58) along Moon Creek. 4) A small stand (id 73) from 1720 was also found along Highway 40 just south of the Little Berland River. The boundary adjacent to the 1760 stand (id 72) is arbitrary. 5) Lastly, a fairly large 1720 stand (id 75) was found east of the Little Berland River and north of Hightower Creek. The boundary common to the 1760 stand (id 72) is arbitrary. Most of the multi-aged plots collected were located in the northeast corner of the stand.

A patch of remnants (id 38) dating from 1715, located between Moon Creek and the Berland River, has escaped the 1909 and 1885 (id 34) fires. Another small stand (id 79), off the Little Berland River and west of Highway 40, has been assigned a date of 1715. The boundary of

this stand, common with the 1800 one (id 77), is arbitrary.

Some patches of remnants (id 37) dating from 1705 were located along the shoreline of the Berland River within the 1909 burn. Small stands of spruce remnants (id 20), also dating from 1705, were found north of Hendrickson Creek as well.

Two 1700 stands were identified in the study area. One (id 29), is an open spruce stand located about two kilometres south of Pasture Creek, while the other (id 52) is by Moon Creek in proximity to Willmore Wilderness Park. Some boundaries of the later stand are arbitrary. In this case, Moon Creek was used to separate the 1700 stand (id 52) from the 1735 one (id 53).

On the west side of Moon Creek, two small patches dating from 1695 were identified. The stands were rather multi-aged and the date assigned was based on the oldest tree found. Therefore, this date may not be very accurate.

Some patches of muskegs along the east side of Willmore Wilderness Park dated from 1685.

A strip of spruce forest located on the flats of Moon Creek was assigned a date of 1682. This date was based on one fire scar, which was found south at the headwaters of Moon Creek.

Two small stands dating from 1665 were found along a tributary of Moon Creek.

Close to the headwaters of Hightower Creek, a small stand dating from 1655 was detected. This stand was uneven-aged. Based on scar and release evidence from 1778 and 1835, as well as tree ages, it appears that two passive crown fires swept through the area since 1655.

A very small pine stand dated as 1640 was discovered northeast of the Big Berland Cabin. The extent of the stand was based on the 1949 air photos. However, from field work assessment, the stand boundary is no longer visible. Surrounding stands dating from 1725 (id 22) and 1705 (id 20), made it difficult to dissociate the boundaries of the 1640 stand.

Patches of spruce dominated remnants (id 19) located between Big and Hendrickson Creeks were dated from 1635. These stands were multi-aged, likely due to succession. The oldest tree collected was chosen to represent the age of the stand. Another 1635 stand (id 56) was also found at the headwaters of Fox Creek by Willmore Wilderness Park boundary.

Lastly, the oldest stand found in the Berland Area dated back to 1610. It was discovered as a small patch along the shore of Big Creek. This stand was multi-aged, and its date was based on the oldest tree found, which was 1612.

Table 5. Stand origin date statistics for the Berland Area *

| Stand Origin | Stand id | Range of ages | Criteria | # plots | # trees (representative / total) |
|--------------|----------|---------------|-------------------------------------|---------|-------------------------------------|
| 1956 | 28 | 1958 - 1965 | H, R, S, E | 4 | 20 / 12 |
| 1910 | 59 | 1911 - 1938 | S, R, E, U | 11 | 40 / 42 |
| 1909 | 35 | 1911 - 1936 | R, S, E | 9 | 61 / 47 |
| 1885 | 70 | 1889 - 1922 | O/5, E | 1 | 3 / 4 |
| 1885 | 34 | 1804 - 1908 | 3 rd O/5, E (1804, 1828) | 5 | 19 / 21 |
| 1870 | 21 | 1874 - 1894 | O/5, E, U | 1 | 2 / 3 |
| 1850 | 74 | 1766 - 1884 | M/5, E, U | 3 | 5 / 12 |
| 1850 | 31 | 1779 - 1857 | M/5, E, U | 1 | 2 / 4 |
| 1840 | 76 | 1840 - 1855 | O, E | 1 | 4 / 4 |
| 1834 | 33 | 1804 - 1892 | R, S, E | 23 | 120 / 106 |
| 1815 | 27 | 1817 - 1872 | O/5, U, E | 1 | 1 / 4 |
| 1815 | 67 | 1817 - 1822 | O/5, E | 1 | 2 / 2 |
| 1810 | 64 | 1811 - 1825 | O/5, E | 1 | 4 / 4 |
| 1800 | 60 | 1802 - 1887 | O/5, E, U | 2 | 3 / 6 |
| 1800 | 77 | 1750 - 1877 | M/5, E, U | 5 | 7 / 17 |
| 1800 | 36 | 1800 - 1826 | O, E | 1 | 3 / 4 |
| 1800 | 51 | 1724 - 1862 | M, U, E | 3 | 3 / 13 |
| 1800 | 61 | | based on # 60 | | |
| 1795 | 18 | 1745 - 1876 | M/5, E, U | 6 | 18 / 27 |
| 1795 | 30 | 1795 - 1809 | O, E | 1 | 4 / 4 |
| 1785 | 69 | 1786 - 1820 | O/5, E, U | 2 | 6 / 8 |
| 1775 | 78 | 1744 - 1836 | M/5, U, E | 1 | 2 / 5 |
| 1775 | 65 | 1779 - 1880 | O/5, E, U | 1 | 2 / 4 |

| Stand Origin | Stand id | Range of ages | Criteria | # plots | # trees (representative / total) | |
|--------------|----------|---------------|-------------|--|-------------------------------------|---------|
| | 1775 | 24 | 1775 - 1811 | O, E, U | 3 | 7 / 12 |
| | 1770 | 26 | 1762 - 1788 | 2 nd O, E | 3 | 11 / 12 |
| | 1765 | 66 | 1768 - 1796 | O/5, U | 1 | 1 / 2 |
| | 1760 | 72 | 1761 - 1902 | O/5, E, U | 8 | 23 / 32 |
| | 1760 | 25 | 1752 - 1889 | 2 nd O/5, R, E, U (1752) | 9 | 17 / 52 |
| | 1760 | 44 | 1760 - 1810 | O, E, U | 4 | 11 / 17 |
| | 1760 | 43 | 1760 - 1842 | O, U | 1 | 1 / 5 |
| | 1755 | 49 | 1757 - 1797 | O/5, E, U | 1 | 3 / 4 |
| | 1750 | 32 | 1753 - 1764 | O/5, E | 2 | 5 / 5 |
| | 1745 | 42 | 1748 - 1751 | O/5, E | 1 | 4 / 4 |
| | 1740 | 63 | 1731 - 1857 | 2 nd O/5, U (1731) | 3 | 5 / 13 |
| | 1740 | 41 | 1743 - 1793 | O/5, E | 1 | 3 / 4 |
| | 1735 | 47 | 1738 - 1859 | O/5, E, U | 1 | 2 / 4 |
| | 1735 | 53 | 1736 - 1768 | O/5, E | 2 | 5 / 6 |
| | 1735 | 39 | 1739 - 1790 | O/5, E, U | 1 | 2 / 4 |
| | 1735 | 40 | 1738 - 1768 | O/5, U | 1 | 1 / 3 |
| | 1730 | 71 | 1733 - 1849 | O/5, E, U | 1 | 2 / 4 |
| | 1725 | 62 | 1725 - 1862 | O, U | 1 | 1 / 4 |
| | 1725 | 22 | 1725 - 1821 | O/5, U | 3 | 3 / 7 |
| | 1720 | 73 | 1682 - 1857 | M/5, U | 2 | 2 / 7 |
| | 1720 | 75 | 1665 - 1885 | 2 nd O/5, E, U (1665) | 9 | 16 / 35 |
| | 1720 | 58 | 1688 - 1730 | 2 nd O/5, E | 1 | 3 / 4 |
| | 1720 | 55 | 1747 - 1802 | M/5, E, U | 1 | 2 / 4 |
| | 1720 | 57 | 1690 - 1750 | M, E, U | 1 | 2 / 4 |
| | 1715 | 79 | 1716 - 1792 | O/5, U, E | 1 | 2 / 5 |
| | 1715 | 38 | 1703 - 1869 | M/5, E, U | 2 | 5 / 8 |
| | 1705 | 37 | 1707 - 1899 | O/5, U | 2 | 2 / 10 |
| | 1705 | 20 | 1705 - 1820 | S, O, E, U | 3 | 7 / 10 |

| Stand Origin | Stand id | Range of ages | Criteria | # plots | # trees (representative / total) |
|--------------|----------|---------------|-------------------------------------|---------|-------------------------------------|
| 1700 | 29 | 1683 - 1730 | 2 nd 0/5, E, U (1683) | 1 | 2 / 4 |
| 1700 | 52 | 1672 - 1848 | M/5, U, E | 5 | 6 / 20 |
| 1695 | 45 | 1696 - 1797 | O/5, E, U | 1 | 2 / 5 |
| 1685 | 48 | 1689 - 1740 | O/5, E, U | 1 | 2 / 3 |
| 1682 | 46 | 1684 - 1704 | O/5, E, U | 1 | 4 / 5 |
| 1665 | 54 | 1665 - 1746 | O, E, U | 1 | 2 / 4 |
| 1655 | 68 | 1658 - 1838 | O/5, U | 1 | 1 / 3 |
| 1640 | 23 | 1640 | O/5 | 1 | 1 / 4 |
| 1635 | 56 | 1775 - 1833 | M/5, E, U | 1 | 2 / 4 |
| 1635 | 19 | 1639 - 1776 | O/5, U | 4 | 4 / 11 |
| 1610 | 17 | 1612 - 1712 | O/5, M | 1 | 1 / 3 |

* For explanation of how to read this table, please refer to sections 2.10 and 3.1.

Table 6. Field statistics, list of fire scars and releases for the Berland Area.

| Statistics | Scars | Releases |
|-------------------------------|-----------------------------------|------------------------------------|
| 177 plots | 1961x3, 1960, 1959x2, 1958x3, | 1975, 1969, 1965, 1964x4, 1962x2, |
| 745 trees | 1955x2, 1953, 1950, 1949, 1948, | 1961x4, 1959x2, 1958, 1957, 1944, |
| 73 trees with one scar | 1947, 1938, 1937, 1934, 1933, | 1935, 1932, 1931x2, 1930, 1929x2, |
| 6 trees with a double scar | 1926, 1923, 1914x2, 1913x2, | 1926, 1925x4, 1924x4, 1919, |
| 134 trees with a release | 1911x2, 1910, 1909, 1907x3, 1906, | 1917x2, 1915, 1914x5, 1913, |
| 6 trees with a double release | 1901, 1899, 1897, 1893x2, 1889, | 1912x2, 1911x4, 1909x4, 1907x2, |
| | 1883, 1881, 1879, 1875, 1872, | 1906, 1902x2, 1901, 1899, 1898, |
| | 1870, 1854, 1849, 1845, 1841, | 1897, 1896, 1893x2, 1884, 1877, |
| | 1840, 1839x3, 1837, 1835, 1834x2, | 1867, 1863x2, 1861, 1854, 1852, |
| | 1832, 1819, 1818, 1808, 1802, | 1849x2, 1848x2, 1847, 1846, 1845, |
| | 1800, 1793, 1788, 1730, 1682 | 1843x3, 1842x2, 1840, 1839x3, |
| | | 1838, 1837, 1835, 1832, 1830x2, |
| | | 1829x2, 1828, 1827, 1826, 1824, |
| | | 1817, 1813, 1809x2, 1798, 1792x2, |
| | | 1791, 1788, 1778, 1772, 1757, 1724 |

3.5 CAMP ONE AREA

Stand origin summary

This study area is bordered to the west by Brule Lake; the Athabasca River constitutes the northern boundary, while the eastern side shares a common boundary with FMU E9, and Highway 16 forms the southern boundary. Most of this study area is composed of old forest that is identified as a 150⁺ year age class on the original stand origin map. Based on the 1949 black and white air photos at a scale of 1:40,000, the area appeared to be fairly homogeneous, and the diversity of age classes for this area is relatively low.

It should be noted that the majority of the forest in this area was harvested in the 1950's and 1960's.

Note: The following information should be read in conjunction with Table 7 and with the stand origin map for this study area found in Appendix F.

The most recent burn in this area is a spotted fire from 1936 that jumped across the Athabasca River. This fire was identified as stand id 7 in FMU E9.

A 1926 burn extends from Jasper National Park in a thin corridor along Highway 16.

In 1915 there was a burn of a considerable size, also along Highway 16. This fire extended well into FMU E9, and for this reason, sampling was done mostly in FMU E9.

Small patches of spruce dominated remnants dating from 1870 were detected within the 1926 burn.

A small stand along the shore of Brule Lake was identified as 1860 based on the presence of even-aged trees. However, the delineation of the stand is somewhat arbitrary.

The 1800 stand is very patchy due to numerous muskegs, ponds and small lakes scattered throughout. The forest was found to be multi-aged, which could be attributed to the quality of trees collected. Most of the stand had been harvested, leaving behind only scattered smaller trees and small clumps of trees bordering wet sites.

Although the 1760 stand showed a homogeneous texture on the air photos, it was multi-aged. This could also be attributed to the quality of some of the trees sampled, which were taken in

patches of remnants in cutblocks or along the edges of cutblocks.

The boundary of the 1625 stand arbitrarily follows a patch of muskeg. This muskeg was distinguished as a different stand as it was composed of old trees of even ages.

Table 7. Stand origin date statistics for Camp One Area^{*}.

| Stand Origin | Stand id | Range of ages | Criteria | # plots | # trees (representative / total) |
|--------------|----------|---------------|---------------------|---------|-------------------------------------|
| 1936 | 82 | 1952 - 1955 | Stand id 7 (E9), E | 1 | 3 / 3 |
| 1926 | 85 | 1930 - 1940 | R, E | 1 | 5 / 4 |
| 1915 | 10 | 1917 - 1919 | Stand id 10 (E9), E | 1 | 3 / 3 |
| 1870 | 86 | 1871 - 1877 | O/5, E | 1 | 5 / 5 |
| 1860 | 81 | 1860 - 1871 | O, E | 1 | 4 / 4 |
| 1800 | 83 | 1672 - 1894 | M/5, E, U | 8 | 7 / 27 |
| 1760 | 80 | 1590 - 1840 | M/5, E, U | 13 | 15 / 47 |
| 1625 | 84 | 1628 - 1655 | O/5, E | 1 | 4 / 4 |

^{*} For explanation of how to read this table, please refer to sections 2.10 and 3.1.

Table 8. Field statistics, list of fire scars and releases for Camp One Area.

| Statistics | Scars | Releases |
|----------------------------|------------------|-----------------------------------|
| 32 plots | 1957, 1959, 1960 | 1796, 1817, 1847, 1850, 1853, |
| 115 trees | | 1891x2, 1892, 1912, 1914x2, 1926, |
| 3 trees with one scar | | 1927, 1940, 1942, 1944x2, 1954, |
| 27 trees with a release | | 1956, 1957x2, 1958x2, 1959x2, |
| 3 trees with two releases | | 1960x3, 1961x3, 1962x2, 1968, |
| 1 tree with three releases | | 1973, 1974 |

3.6 WARDEN CREEK AREA

Stand origin summary

A fairly large area of old forest located south of Highway 16 was identified on the original stand origin map, of which approximately half was sampled in 1996. The boundaries of the sample area are as follows. The west side borders FMUs E4 and E5. The southern boundary corresponds to the line dividing Township 48 from Township 49, while the northern boundary corresponds to the top edge of the 1:50,000 topographic map 83 F/4. Lastly, the eastern boundary partly follows the line separating Range 24 from Range 25, then follows the edges of stand origin polygons. Any polygons within the study area that had an unknown stand origin date were assigned a question mark with a stand id of zero. Most of this study area has been logged, but sufficient numbers of unlogged patches of forest allowed field crews to obtain Agood≅ tree samples.

Note: The following information should be read in conjunction with Table 9 and with the stand origin map for this study area found in Appendix F.

An extensive burn, dated as 1890, was located in the Warden Creek Area. Based on releases found on the edges of this burn, it appears that this fire overlapped another fire from circa 1824 to 1829. Also in the same burn, two low intensity fires encroached on the eastern side around 1916 to 1925 and around 1934 to 1942.

Small remnant patches dating from 1820 were found at the headwaters of Warden Creek.

Regrowth from a large fire in 1780 still covers the slopes of Folding Mountain.

Several remnant patches were found in the 1890 burn. Some dated from 1765 and 1760, while others dated from 1735. The 1765 stands were located on the western edge of the 1890 burn, while the 1760 ones were found along Warden Creek. Stands dating from 1735 were detected east of Warden Creek.

Finally, three pockets of remnants dating from 1705, also within the 1890 burn, were discovered along Warden Creek.

Table 9. Stand origin dates statistics for Warden Creek Area*.

| Stand Origin | Stand id | Range of ages | Criteria | # plots | # trees (representative / total) |
|---------------------|-----------------|----------------------|-------------------------------|----------------|---|
| 1890 | 87 | 1885 - 1919 | R, E | 12 | 49 / 48 |
| 1820 | 89 | 1773 - 1869 | M/5, E, U | 2 | 5 / 9 |
| 1780 | 93 | 1782 - 1867 | O/5, E, U | 2 | 5 / 8 |
| 1765 | 88 | 1706 - 1780 | 2 nd O/5, E (1706) | 1 | 3 / 4 |
| 1760 | 90 | 1762 - 1793 | O/5, U | 1 | 1 / 3 |
| 1735 | 91 | 1738 - 1764 | O/5, E, U | 1 | 2 / 4 |
| 1705 | 92 | 1707 - 1862 | O/5, E, U | 1 | 2 / 3 |

* For explanation of how to read this table, please refer to sections 2.10 and 3.1.

Table 10. Field statistics, list of fire scars and release for Warden Creek Area.

| Statistics | Scars | Releases |
|-------------------------|---------------------------------|-------------------------------------|
| 24 plots | 1828, 1916x2, 1917, 1919, 1922, | 1824, 1829, 1840, 1848, 1879, 1881, |
| 101 trees | 1934, 1935, 1937, 1942, 1967 | 1890, 1892, 1894x2, 1897, 1925x2, |
| 9 trees with one scar | | 1931 |
| 1 tree with two scars | | |
| 14 trees with a release | | |

3.7 FMU E4 - Brule Lake Area

Stand origin summary

A portion of FMU E4 that was accessible by road was sampled during the 1996 field season. Some of the sampling also occurred east of the study area; for this reason the stand origin mapping extended beyond FMU E4.

The study area encompasses lands bounded by the west shore of Brule Lake and north bank of the Athabasca River. The northern boundary follows, for a short way, the boundary of FMU E4, then follows the boundary between Township 50 and 51.

Judging from multiple fire evidence found along the slopes of Boule Range and just east of this mountain range, the region seems to be located in a fire-prone area.

Note: The following information should be read in conjunction with Table 11 and with the stand origin map for this study area found in Appendix F.

The most recent burn in the area is from 1946 (Delisle and Hall 1987) and is referred locally as the ABlack Cat≅ burn. Trees sampled along the edge of the burn at high elevations showed releases from the 1946 fire, and also from disturbances that occurred around 1898, 1926 and 1962. Post fire regeneration trees were found for the 1898 release (plot 96-E4-216).

The fire from 1936 that was identified in FMU E9 as stand id 7 and in W.A Switzer Provincial Park as stand id 2, also occurs in FMU E4. The fire may have ignited along the east slopes of Boule Range, or along the shore of Brule Lake.

The 1915 burn, which was also identified in FMU E9, covers the southeast slopes of Mount Solomon.

On the north shore of the Athabasca River, just east of Brule Lake, a stand dating from 1885 escaped the 1915 and 1936 fires. Most of this stand has been logged, so trees samples may not be representative of the original stand.

Small remnant patches dating from 1820 were found along the border of the 1915 and 1936 burns. Evidence of this fire is also present in the 1795 burn (plot 96-E4-155). However, it

was not mapped since no fire boundaries could be identified between the 1820 and 1795 stands.

A strip of spruce remnants dating from 1795 extends along the shore of Brule Lake and downstream along the north bank of the Athabasca River.

The oldest stand, which dates from 1755, was located at high elevation above the Black Cat burn. The stand appears to be homogeneous over an extensive area along the Boule Range. However, only one plot was taken, and the level of accuracy of the stand date is low.

Table 11. Stand origin date statistics for FMU E4, Brule Lake Area *

| Stand Origin | Stand id | Range of ages | Criteria | # plots | # trees (representative / total) |
|--------------|----------|---------------|------------|---------|-------------------------------------|
| 1946 | 98 | 1954 - 1963 | H, S, R, E | 1 | 6 / 2 |
| 1936 | 7 | 1931 - 1950 | E9, S, E | 3 | 10 / 11 |
| 1915 | 10 | 1925 - 1927 | E9, E | 1 | 4 / 4 |
| 1885 | 94 | 1888 | O/5, E | 1 | 2 / 2 |
| 1820 | 95 | 1796 - 1877 | M/5, E, U | 2 | 6 / 9 |
| 1795 | 96 | 1795 - 1807 | O/5, E | 1 | 4 / 4 |
| 1755 | 97 | 1758 - 1781 | O/5, E, U | 1 | 2 / 3 |

* For explanation of how to read this table, please refer to sections 2.10 and 3.1.

Table 12. Field statistics, list of fire scars and releases for FMU E4, Brule Lake Area.

| Statistics | Scars | Releases |
|---------------------------|-------|-------------------------------------|
| 11 plots | 1942 | 1898, 1926, 1942, 1962, 1963, 1967, |
| 40 trees | | 1970x3, 1977 |
| 1 trees with one scar | | |
| 8 trees with a release | | |
| 2 trees with two releases | | |

4 LITERATURE CITED

- Andison, D.W. In preparation. Landscape patterns caused by wildfires in the Foothills Model Forest (working title).
- Aplet, G.H., R.D Laven,. and F.W. Smith (1988). Patterns of community dynamics in Colorado Engelmann Spruce - Subalpine Fir forests. *Ecology*, 69(2):312-319.
- Arno, S.F. and K.M. Sneek (1977). A method for determining fire history in coniferous forests of the Mountain West. USDA For. Serv. Gen. Tech. Rep. INT-42, 28 p.
- Arno, S.F., E.D. Reinhardt and J.H. Scott (1993). Forest structure and landscape patterns in the Subalpine Lodgepole Pine type: a procedure for quantifying past and present conditions. USDA For. Serv. Gen. Tech. Rep. INT-294, 17 p.
- Delisle, G.P. and R.J. Hall (1997). Forest fire history maps of Alberta, 1931 to 1983. Canadian Forestry Service, Northern Forestry Centre, Edmonton, Alberta. 55 p.
- Heinselmann, M.L. (1973). Fire in the virgin forests of the Boundary Waters Canoe Area, Minnesota. *Quaternary Research*, 3:329-382.
- Johnson, E.A. and S.L. Gutsell (1994). Fire frequency models, methods and interpretations. *Advances in Ecological Research* 25: 239-283.
- Johnson, E.A., G.I. Fryer and M.J. Heathcott (1990). The influence of man and climate on the fire frequency in the interior Wet Belt Forest, British-Columbia. *Journal of Ecology*, 78:403-412.
- Kubian, R. (1993). An assessment of fire history data for Jasper National Park. Contract Report (KJP-930002) to Parks Canada, Jasper National Park. 70 pp.
- McBride, J.R. (1983). Analysis of tree rings and fire scars to establish fire history. *Tree-Ring Bulletin*, 43:51-67.
- Mercer, E.G. In preparation. Verification of stand age information in Jasper National Park

(working title).

Moss, E. H. (1994). *Flora of Alberta*. 2nd. edition. University of Toronto Press. 687 p.

Tande, G.F. 1979. Fire history and vegetation patterns of coniferous forests in Jasper National Park, Alberta. *Can. J. Bot.* 57:1912-1931.

Van Wagner, C.E. 1978. Age class distribution and the forest fire cycle. *Can. J. For. Res.* 8:220-227.

Zackrisson, O. (1981). Forest fire history: ecological significance and dating problems in the North Swedish boreal forest. *USDA For. Serv. Gen. Tech. Rep. RM-81*, 120-125 pp.

APPENDIX A

Field sheet sample

FIRE HISTORY FIELD SHEET

Date: _____

Plot #:

Unit: _____

Watershed:

Location:

UTM: _____

Aspect: _____ Slope: _____ Elevation:

Human disturbance:

FOREST STAND DESCRIPTION:

Comp.:

Duff: _____ Deadfall:

Fire evidence:

Understory:

| <i>Trees</i> | <i>Species</i> | <i>Age</i> | <i>Scars / Releases</i> |
|--------------|----------------|------------|-------------------------|
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Notes:

Field Team:

APPENDIX B

**Frequency tables for tree ages,
scars and releases**

Appendix B.1. Frequency of scars, releases and tree ages, grouped by 10 year age classes for W.A. Switzer Provincial Park.

| Classes | Scars | Releases | Trees |
|----------------|--------------|-----------------|--------------|
| 1800 | 0 | 0 | 1 |
| 1810 | 0 | 0 | 0 |
| 1820 | 0 | 0 | 0 |
| 1830 | 0 | 0 | 3 |
| 1840 | 0 | 0 | 5 |
| 1850 | 0 | 0 | 1 |
| 1860 | 0 | 0 | 3 |
| 1870 | 0 | 0 | 8 |
| 1880 | 0 | 0 | 12 |
| 1890 | 5 | 0 | 12 |
| 1900 | 10 | 0 | 17 |
| 1910 | 5 | 1 | 5 |
| 1920 | 4 | 0 | 5 |
| 1930 | 6 | 0 | 7 |
| 1940 | 0 | 0 | 10 |
| 1950 | 0 | 0 | 1 |
| 1960 | 0 | 0 | 0 |
| 1970 | 0 | 1 | 0 |

Appendix B.2. Frequency of scars, releases and tree ages, grouped by 10 year age classes for FMU E9.

| Class | Scars | Releases | Trees |
|--------------|--------------|-----------------|--------------|
| 1620 | 0 | 0 | 2 |
| 1630 | 0 | 0 | 0 |
| 1640 | 0 | 0 | 0 |
| 1650 | 0 | 0 | 0 |
| 1660 | 0 | 0 | 0 |
| 1670 | 0 | 0 | 0 |
| 1680 | 0 | 0 | 0 |
| 1690 | 0 | 0 | 0 |
| 1700 | 0 | 0 | 0 |
| 1710 | 0 | 0 | 2 |
| 1720 | 0 | 0 | 0 |
| 1730 | 0 | 0 | 0 |
| 1740 | 0 | 0 | 1 |
| 1750 | 0 | 0 | 1 |
| 1760 | 0 | 0 | 1 |
| 1770 | 0 | 0 | 2 |
| 1780 | 0 | 0 | 2 |
| 1790 | 0 | 0 | 0 |
| 1800 | 0 | 0 | 0 |
| 1810 | 0 | 0 | 1 |
| 1820 | 0 | 0 | 0 |
| 1830 | 0 | 0 | 6 |
| 1840 | 0 | 0 | 3 |
| 1850 | 0 | 1 | 3 |
| 1860 | 0 | 0 | 1 |
| 1870 | 1 | 2 | 45 |
| 1880 | 1 | 2 | 57 |
| 1890 | 27 | 1 | 33 |
| 1900 | 17 | 3 | 33 |
| 1910 | 17 | 0 | 7 |
| 1920 | 2 | 0 | 15 |
| 1930 | 4 | 0 | 37 |
| 1940 | 0 | 3 | 32 |
| 1950 | 0 | 4 | 13 |
| 1960 | 0 | 2 | 1 |

| | | | |
|------|---|---|---|
| 1970 | 0 | 2 | 0 |
|------|---|---|---|

Appendix B.3. Frequency of scars, releases and tree ages, grouped by 10 year age classes the Berland Area.

| Class | Scars | Releases | Trees |
|-------|-------|----------|-------|
| 1600 | 0 | 0 | 0 |
| 1610 | 0 | 0 | 1 |
| 1620 | 0 | 0 | 0 |
| 1630 | 0 | 0 | 4 |
| 1640 | 0 | 0 | 2 |
| 1650 | 0 | 0 | 3 |
| 1660 | 0 | 0 | 3 |
| 1670 | 0 | 0 | 3 |
| 1680 | 1 | 0 | 8 |
| 1690 | 0 | 0 | 3 |
| 1700 | 0 | 0 | 11 |
| 1710 | 0 | 0 | 14 |
| 1720 | 0 | 1 | 31 |
| 1730 | 1 | 0 | 27 |
| 1740 | 0 | 0 | 23 |
| 1750 | 0 | 1 | 23 |
| 1760 | 0 | 1 | 60 |
| 1770 | 0 | 2 | 41 |
| 1780 | 1 | 1 | 30 |
| 1790 | 1 | 3 | 39 |
| 1800 | 2 | 3 | 31 |
| 1810 | 3 | 2 | 23 |
| 1820 | 0 | 6 | 17 |
| 1830 | 8 | 9 | 45 |
| 1840 | 4 | 13 | 79 |
| 1850 | 1 | 2 | 39 |
| 1860 | 0 | 3 | 16 |
| 1870 | 3 | 1 | 13 |
| 1880 | 3 | 1 | 19 |
| 1890 | 4 | 6 | 21 |
| 1900 | 6 | 10 | 8 |
| 1910 | 7 | 16 | 47 |
| 1920 | 2 | 1 | 34 |
| 1930 | 4 | 5 | 13 |
| 1940 | 3 | 1 | 1 |

| | | | |
|------|----|----|---|
| 1950 | 10 | 4 | 3 |
| 1960 | 4 | 12 | 9 |
| 1970 | 0 | 1 | 1 |

Appendix B.4. Frequency of scars, releases and tree ages, grouped by 10 year age classes for the Camp One Area.

| Classes | Scars | Releases | Trees |
|---------|-------|----------|-------|
| 1600 | 0 | 0 | 1 |
| 1610 | 0 | 0 | 0 |
| 1620 | 0 | 0 | 1 |
| 1630 | 0 | 0 | 0 |
| 1640 | 0 | 0 | 1 |
| 1650 | 0 | 0 | 2 |
| 1660 | 0 | 0 | 1 |
| 1670 | 0 | 0 | 2 |
| 1680 | 0 | 0 | 1 |
| 1690 | 0 | 0 | 1 |
| 1700 | 0 | 0 | 1 |
| 1710 | 0 | 0 | 1 |
| 1720 | 0 | 0 | 2 |
| 1730 | 0 | 0 | 2 |
| 1740 | 0 | 0 | 5 |
| 1750 | 0 | 0 | 4 |
| 1760 | 0 | 0 | 8 |
| 1770 | 0 | 0 | 7 |
| 1780 | 0 | 0 | 8 |
| 1790 | 0 | 1 | 3 |
| 1800 | 0 | 0 | 9 |
| 1810 | 0 | 1 | 5 |
| 1820 | 0 | 0 | 5 |
| 1830 | 0 | 0 | 2 |
| 1840 | 0 | 1 | 4 |
| 1850 | 0 | 2 | 5 |
| 1860 | 0 | 0 | 7 |
| 1870 | 0 | 0 | 11 |
| 1880 | 0 | 0 | 5 |
| 1890 | 0 | 3 | 1 |
| 1900 | 0 | 0 | 0 |
| 1910 | 0 | 3 | 3 |
| 1920 | 0 | 2 | 0 |
| 1930 | 0 | 0 | 3 |
| 1940 | 0 | 4 | 1 |

| | | | |
|------|---|---|---|
| 1950 | 2 | 8 | 3 |
| 1960 | 1 | 9 | 0 |
| 1970 | 0 | 2 | 0 |

Appendix B.5. Frequency of scars, releases and tree ages, grouped by 10 year age classes for the Warden Creek Area.

| Classes | Scars | Releases | Trees |
|---------|-------|----------|-------|
| 1670 | 0 | 0 | 1 |
| 1680 | 0 | 0 | 1 |
| 1690 | 0 | 0 | 0 |
| 1700 | 0 | 0 | 3 |
| 1710 | 0 | 0 | 2 |
| 1720 | 0 | 0 | 1 |
| 1730 | 0 | 0 | 1 |
| 1740 | 0 | 0 | 1 |
| 1750 | 0 | 0 | 0 |
| 1760 | 0 | 0 | 5 |
| 1770 | 0 | 0 | 3 |
| 1780 | 0 | 0 | 5 |
| 1790 | 0 | 0 | 4 |
| 1800 | 0 | 0 | 2 |
| 1810 | 0 | 0 | 1 |
| 1820 | 1 | 2 | 3 |
| 1830 | 0 | 0 | 3 |
| 1840 | 0 | 2 | 0 |
| 1850 | 0 | 0 | 0 |
| 1860 | 0 | 0 | 5 |
| 1870 | 0 | 1 | 0 |
| 1880 | 0 | 1 | 6 |
| 1890 | 0 | 5 | 31 |
| 1900 | 0 | 0 | 15 |
| 1910 | 4 | 0 | 5 |
| 1920 | 1 | 2 | 0 |
| 1930 | 3 | 1 | 0 |
| 1940 | 1 | 0 | 0 |
| 1950 | 0 | 0 | 1 |
| 1960 | 1 | 0 | 2 |

Appendix B.6. Frequency of scars, releases and tree ages, grouped by 10 year age classes for FMU E4, Brule Lake Area.

| Classes | Scars | Releases | Trees |
|----------------|--------------|-----------------|--------------|
| 1750 | 0 | 0 | 1 |
| 1760 | 0 | 0 | 1 |
| 1770 | 0 | 0 | 0 |
| 1780 | 0 | 0 | 1 |
| 1790 | 0 | 0 | 3 |
| 1800 | 0 | 0 | 2 |
| 1810 | 0 | 0 | 1 |
| 1820 | 0 | 0 | 6 |
| 1830 | 0 | 0 | 0 |
| 1840 | 0 | 0 | 1 |
| 1850 | 0 | 0 | 0 |
| 1860 | 0 | 0 | 0 |
| 1870 | 0 | 0 | 1 |
| 1880 | 0 | 0 | 3 |
| 1890 | 0 | 1 | 0 |
| 1900 | 0 | 0 | 4 |
| 1910 | 0 | 0 | 0 |
| 1920 | 0 | 1 | 6 |
| 1930 | 0 | 0 | 3 |
| 1940 | 1 | 3 | 5 |
| 1950 | 0 | 0 | 1 |
| 1960 | 0 | 3 | 1 |
| 1970 | 0 | 4 | 0 |

APPENDIX C

**Distribution graphs for tree ages,
scars and releases**

APPENDIX D

Field notes part 1: site information

APPENDIX E

Field notes part 2: tree information

APPENDIX F
Stand origin maps