DETAILED DISTURBANCE HISTORY MAPPING OF THE MONTANE, JASPER NATIONAL PARK 1997 - 1998

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1999

DISCLAIMER

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ACKNOWLEDGMENTS

First, I would like to acknowledge the Foothills Model Forest and its Partners for initiating and funding this project. Gratitude is notably extended to David Andison, Bandaloop Landscape - Ecosystem Services, and Al Westhaver, Jasper National Park, both members of the Foothills Model Forest Activity Team, for their assistance and direction throughout the course of this study.

I would like to thank Lori Daniels for providing dendrochronological expertise, ongoing sampling advice, and field crew training during the 1997 season. The field sampling and equipment manual that Lori provided to the project proved an invaluable tool. I also wish to thank Mike Norton for his good work during the first season of data collection. Mike tested sampling methods during the summer of 1997 and made recommendations on methodologies for future data collection. His field assistants were Mike Liedtke and Ryan Tew. Randy Heppell assisted with data collection during the 1998 sampling season.

Acknowledgments are extended to Dr. Ian Campbell from the Northern Forestry Centre in Edmonton for providing the Palaeoecology and Dendrochronology Laboratory as well as personal to process wood samples. The 1997 data was processed by a number of people, notably Thierry Varem-Sanders and Farrah Gilchrist. Rob Lucas processed and dated all 1998 samples with Thierry's assistance for technical advice and training.

Lastly, I am grateful to Jasper National Park and the Environmental Training Centre for providing both 1997 and 1998 crews with field equipment. Helen Purves from Jasper National Park was also instrumental in providing the necessary digital layers for this study.

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1 INTRODUCTION

In the mountains, stand replacing fires are by far the main regulators of large scale forest patterns. But, contributors to smaller scale patterns such as partially lethal or non-lethal fires, insect kills, windthrow and flooding events, result in a more complex vegetation mosaic or "multi-aged" forest stands. This higher level of vegetation complexity is often seen in Montane ecoregions. These regions, located at lower elevations, are warmer, hence the fire season is longer and fires can burn "hotter" and for longer periods of time and, these regions tend to be more accessible. It is well known that easy land access tends to result in highly travelled corridors or settled land, which in turn provides additional sources of forest disturbance including man-caused fires, and tree cutting regardless of its purpose. The Montane ecoregion of Jasper National Park presents such characteristics and the Athabasca River Valley, east of Jasper Town site, is highly representative of the Montane for the reasons stated above in addition to its unique cultural history as a trans continental fur trade route.

The detailed mapping of historical disturbances of the Montane is a Foothills Model Forest project that was initiated to understand the more intricate level(s) of disturbance patterns (fire and others) common to these low-lying mountain areas. The main objective of this detailed study is to better define, and with greater accuracy, the disturbance types and intervals. As a secondary goal, the sampling design and methods used to collect age data for this project will be used to develop effective, defendable sampling methodologies for areas of mixed fire/disturbance regime(s).

This technical report presents methods and results of detailed stand origin information that was collected in 1997 and 1998 for two regions of the Montane ecoregion of Jasper National Park. As shown in Figure 1, the chosen sampling region in 1997 was the land falling between the Snaring River and Corral Creek, while the land between Colin Range and Cinquefoil Creek was sampled in 1998. The choice of study units in 1997 was based on the fact that this land was part of the *Culture, Ecology and Restoration Study* and was not covered by Tande's fire history study (Tandy 1979), while in 1998, the sampling area was decided based on these criteria: 1) use of a different facing slope to test for a different fire regime and 2) Colin and Jacques Ranges are regions where prescribed burns are planned in the near future (any additional information from this study will help in the design of the fire management for these prescribed burn units).

Figure 1 Study areas sampled in 1997 and 1998 within the Montane ecoregion of Jasper National Park.

The main body of this report is in the form of fire history summaries, tables of stand origin dates, and lists of fire/disturbance evidence. Disturbances other than fire that were encountered are described, as well as some fire regime and fire behaviour parameters. Lastly, as a separate chapter, recommendations on sampling methodologies and future sampling sites are made.

A more complete analysis of disturbance types and frequencies in relation to forest stand dynamics, terrain, vegetation type and other variables, is described in a separate Foothills Model Forest report (Andison *et. al.* In prep.).

2 METHODS

2.1 General

The disturbance regime of the Montane ecoregion of Jasper National Park is largely defined by fire, and the fire regime itself is governed by a full range of fire intensities and severities resulting in low to high stand disturbances. Surface fires are usually non-lethal to trees and their stand disturbance effect is considered to be low. Historical evidence of surface fires can only be found on trees baring fire scars. These low intensity fires are very hard to discern and mapping their extent is quasi impossible. The other two categories of fire, which are partially lethal or fully lethal to forested stands, are much easier to detect. Partially lethal fires will leave many surviving trees and such disturbance effect will be translated by multi-aged forest stands and the presence of fire scars and releases in the ring growth pattern of surviving trees. Fires that were fully lethal are the easiest to depict as the stand will be evenly-aged and fire scars will be found on the outskirts of the burn area or pockets of remnants within the burn area.

Sampling for reconstructing past fire events in the mountains and boreal forest has normally been done using the Time-Since-Fire-Mapping method (Johnson and Gutsell 1994). However, since this project consists of reconstructing all historical disturbance events (tree cutting, insect kills, windthrow and flooding) at a more detailed scale, the sampling design of the Time-Since-Fire mapping method was adapted to specifically suit the conditions expected in the Park and to ensure that all disturbances could be accounted for. The original design was drafted by Dr. Andison, and improvements and suggestions made by a wide variety of people, most notably Mike Norton, Lori Daniels, Ian Campbell and Marie-Pierre Rogeau. The final methods were an attempt to combine speed with detail.

The grid design of sampling used during the first field season is common practice where multiple, lower intensity disturbances are expected (Arno, *et al.*, 1993 for example). The choice of grid spacing was based on both spatial forest coverage and level of detail requirements. The point-quarter method, which was also used during both sampling seasons, is an accepted mensurational standard, and allowed other tree measurements to be taken. The use of strata reflected our lack of confidence in the ability of tree size to indicate relative age. While time-consuming, the strata effectively removed any bias that might have occurred.

In summary, the 1997 sampling methods consisted of a large number of sample plots taken at close intervals and numerous tree samples in all tree size cohorts. These methods were then adjusted in 1998, based on the 1997 field recommendations, to become a combination of the Time-Since-Fire-Mapping and Detailed Sampling methods. Basically, the Time-Since-Fire-Mapping method was adjusted so that the mapping was done at a larger map scale (finer resolution), and sampling sites were increased by using a combination of transect type and disturbance edges sampling. Some minor differences in the sampling methods are also accounted for the fact that the sampling was not conducted by the same person in 1998. The data analysis, however, was performed by the same person (the author of this report) and the end result, for both field seasons, was a 1:20,000 stand origin map showing dates of historical disturbance events.

Following is a description of the procedures for 1997 and 1998, that were used to do the detailed reconstruction of forest disturbance events that took place in two separate areas of the Montane ecoregion of Jasper National Park. Note that sample preparation and tree aging was done for both datasets by the staff of the Palaeoecology and Dendrochronology Lab of the Canadian Forest Service. This procedure is described as part of the 1998 Field Season, Section 2.3.6. Similarly, tree age analysis and the stand origin mapping process were done identically for the 1997 and 1998 data. These procedures are described as part of the 1998 Field, Sections 2.3.8 and 2.3.9.

2.2 1997 FIELD SEASON By Mike Norton, M.Sc[1].

2.2.1 General Sampling Strategy

The first summer of field data collection was designed as a pilot project to develop and refine methods of data collection and analysis. The approach taken was to target a single contiguous study

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[1]For further information, Mike can be reached at: Mike.Norton@env.gov.ab.ca, or 780-422-4764

area to keep things as simple as possible, other approaches to answer specific questions were left for the future. Assuming ecologically different areas are distributed continuously and more or less randomly, this approach still allowed covering a variety of vegetation types.

Whether or not the ultimate goal of the detailed disturbance history project is to sample the entire montane region has not been decided, but obviously the first year's approach does not preclude this. The development of a model from the pilot data for testing in subsequent years is possible.

In the face of uncertainty about the disturbance history of the region being studied, the decision was made to err on the side of caution, that is, to oversample. A grid system of plot layout was used to guide sampling, with plot spacing chosen to ensure that no changes in disturbance history of a mappable size could be missed. A maximum distance between plots was set: 200 m in complex areas and 400 m in even-aged, homogeneous areas. Analysis combined with field observations will dictate how sampling could be altered in the future.

2.2.2. Locating Plots

The sampling grid was directed by air photo interpretation. The basic decision-rule for locating a plot was at any change in forest structure, or following the 200/400 m distance rule mentioned above. Aerial photographs were obtained for the study area (1981 1:10000 and 1949 1:40000 sets were used; JNP now has 1997 1:20000 available) and were coarsely interpreted for major changes in forest structure and the separation between clearly even-aged areas and all other areas. Gridlines were planned to intersect polygons thus defined. In practice, an additional rule of "mappable size" had to be instituted to deal with small patches of different structure; only patches which would be mappable at 1:10000 warranted an additional plot. Most of these areas were likely a result of very small patches of tree death or small-scale topographical variation.

Whenever possible, plots were located on either side of recognizable forest stand boundaries. Plots were placed far enough from the boundary to avoid transitional forest structures (typically 30-50 m). The best approach for determining plot locations was to walk an entire transect keeping note of changes in forest structure not visible on air photos, then to work back collecting data.

In steep areas where a true grid system could not be followed, a goal of total coverage with appropriate plot spacing was used. At a minimum, all polygons visible on air photos were visited, with multiple plots being placed into non-homogeneous areas.

2.2.3. Sampling the Plot

Once a plot center had been marked, a standardized sampling and description methodology began. This included a qualitative site description, a quantitative point-quarter sampling of tree layers, and the collection of cores and cross-sections. Each of these will be described in detail. The first step was to conduct an informal stand assessment to look for evidence of disturbance and confirm the location of the plot as an appropriate one (*i.e.* representative of a larger area).

2.2.3.1 Site Description

The rationale behind the site description was primarily to allow the correlation of disturbance history information to predefined vegetation types. The Ecological Land Classification defines 79 vegetation types and provides full descriptions of each, as well as a rough key. Each plot was identified with an ELC vegetation type. Very often the vegetation type descriptions had to be used in concert with the key to allow a determination, and many intermediate stands were found where two or three vegetation types had to be listed. To allow some cross-checking or verification, qualitative descriptions of five vegetative strata were recorded. For each stratum, the dominant species were recorded (1-6 species depending on the diversity and cover), as well as a cover class for the layer as a whole. Cover classes followed those used by the Alberta Vegetation Inventory standards:

A	0-30%
B	31-50%

C	51-70%
D	71-100%

The following strata were described:

Canopy
Subcanopy
Shrub (includes *Juniperus communis* and *Shepherdia canadensis* and tree species <2 m in height)
Forb/grass/low shrub (the cutoff between shrub and low shrub was at roughly 0.5 m)
Moss

While the terms *canopy* and *subcanopy* are only vaguely defined, they can still have value in helping to describe a plot. The working definition was by physical stature: the canopy was the tallest layer of trees, a subcanopy was not present at every site and referred to those trees which were taller than roughly 2 m, but shorter than the canopy. Some stands had a range in heights of the dominant trees, but a canopy/subcanopy distinction was not appropriate; these were designated as "complex" stands (again following AVI standards) and only a canopy was described.

Tree species were recorded using standard 2-letter forestry codes; all other species were recorded using a 4-letter contraction of their latin names (the first two letters of each of the genus name and specific epithet). A master list of these codes and their translations was maintained. Tree species which were present at a plot but with very low cover (<10%) were recorded in parentheses; these trees were generally not cored. Trembling aspen, balsam poplar, and white birch often fell into this category, at some plots white spruce or lodgepole pine did as well.

Additional quantitative data were recorded at each plot, including the following:

Slope (to the nearest 5%, measured with a clinometer)
Aspect (to the nearest eighth of the compass: N, NE, E, SE etc.)
Canopy height (to the nearest meter, measured with a clinometer)
Subcanopy height (to the nearest meter, measured with a clinometer)

Direct evidence of past disturbance was recorded. The most commonly encountered disturbance agents were (in order of frequency of occurrence):

fire
logging (or more accurately, tree cutting)
insect
windthrow
seasonal flooding

Evidence of fire was found at many plots, including scarring of trees, burned stumps or logs, and charcoal on the bark of Douglas fir trees. Evidence of past tree cutting was also quite common in the lower-lying regions of the Athabasca River valley, in the form of old, obviously sawn-off stumps. Such evidence was recorded into one of three qualitative classes: sparse, moderate intensive. Other disturbance sign was described.

2.2.3.2 Point-Quarter

A basic point-quarter description of each plot was done to allow a more quantitative picture of the tree strata to be calculated. The protocol used was the same as that found in many ecological methodology texts. The key rule is that *each age cohort of each tree species* was included in the tally. In each of four quadrants (NW, NE, SE, SW) the distance from the plot centre to a given tree and the tree's diameter at breast height (dbh) was recorded. A maximum radius of 20 m was used; if no tree of a given cohort is found within 20 m, none is recorded for that quadrant. Only live trees were recorded. Very occasionally a tree which did not clearly fall into one of the identifiable cohorts was omitted.

2.2.3.3 Pulling Cores

There is truly an art to obtaining high quality cores. As a starting point, the booklet *Increment Core Sampling Techniques for High Quality Cores* is excellent. Many other tricks are learned (the hard way) in the field. Two crucial aspects of a good core are a lack of "zig-zagging" in the outer 2" from a wobbly start, and coming within a couple of years of the pith.

The rule for selecting which trees to core was similar to that used for the point-quarter: cores were taken from 3 trees from each age cohort of each species. Trees present with regular frequency but very low cover were often omitted (*e.g.* trembling aspen), but large veteran Douglas fir were always cored regardless of the number present. For canopy trees, the oldest individuals were always targeted. For subcanopy trees, individuals were selected to represent the range of ages.

A quick count of rings was done when possible to ensure that the cohorts which appeared to be present based on height and diameter characteristics did in fact hold true based on tree ages. Often a few cores had to be pulled and counted to confirm the age distribution before even continuing with the stand description and point-quarter.

Cores were pulled as low to the ground as possible, while still keeping the borer horizontal. This was typically about 20-40 cm above the ground, but may have been higher depending on terrain, condition of the tree, the number of cores it took to hit centre, etc. Special care must taken during the first 2" to keep the borer steady to avoid pulling a core which zig-zags.

Trees down to roughly 5 cm dbh could be sampled with an increment borer. Trees smaller than this were felled with a hand-saw and a cross-section disk taken. The disk was labelled directly with a permanent marker on the top side (this procedure was not followed during the first portion of the field season).

Cores were stored in plastic drinking straws (those from McDonalds really do work best) which had been pre-numbered at the office and stapled closed at one end. Extra straws or half-straws were attached as needed for longer cores. The end is stapled (NOT taped) shut with a single staple; this allows the core to breath and helps prevent mildewing during storage.

Cores and small cross-sections were stored in a refridgerator immediately upon return to the office. Bundling the cores by 25's helped keep track of them.

2.2.3.4 Sampling Scars

Both fire- and insect-caused scars were sampled from lodgepole pine and Douglas fir by taking a cross-section of a felled tree. Scars were sampled at every plot where they occurred; multi-scarred trees were sampled preferentially. In areas where only a single scarred tree could be found, that scar was generally not sampled unless it was a surviving veteran. A photograph was taken of the scarred trunk before felling, and sample height and dbh were recorded.

The dendro lab analysis can be performed on any scar on which a path of solid wood can be traced from pith to bark; the path need not be straight. Because scars are dated from the bark back, a rotten tree centre is not a fatal flaw in a cross-section.

2.3 1998 FIELD SEASON

2.3.1 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). The 1949 black and white air photo series at a scale of 1:40,000 was used to identify historical fire events, while a 1997, 1:20,000 orthophoto was used to delineate disturbance events of much smaller size that could not be identified on the 1949 photos. The orthophoto was also used for navigation in the field. The 1949 series was, however, the preferred choice for boundary identification and delineation as historical disturbances could be much better detected.

The stand boundaries identified on the 1949 air photos were transferred freehand onto a mylar overlay of the 1:20,000 orthophoto, while the mapping of smaller size disturbances was done directly onto the mylar.

2.3.2 Sampling location

Gathering information to reconstruct historical forest disturbance events is best done by aging patches of remnant trees within, or on the edges of the disturbance, and by sampling trees that germinated following the last disturbance (Arno and Sneck 1977).

Obvious disturbance boundaries were located first, and plots were aligned in a transect like fashion, linking enough plots for one day's worth of field work. Transects were laid out in a vertical manner from higher to lower elevations (or from the furthest point from the highway, back to the highway). While walking between sites, if something conspicuous appeared that had not been mapped, a plot would be added at this site. As it turned out, by using the 1997 orthophoto at a scale of 1:20,000, all forest structural difference resulting from a form of disturbance could be determined a priori. Lastly, when plots were more than 500 m apart, check plots were added along the transect to ensure that no disturbance would be missed.

2.3.3 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 pattern[2] due to a lack of competition for light and nutrients. Trees that show a release are frequently the survivors living on edges or within the disturbance. 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 disturbance event (Arno *et. al.* 1993). In homogeneous looking stands, 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. If ages of the sampled trees differed by more than 20 years (as determined by a field count), additional samples were collected in an attempt to more accurately estimate the date that the stand originated and to identify the occurrence of multiple disturbance events.

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

In stands containing several tree species, tree samples were taken from dominant and subdominant species. Most frequently, the dominant species were lodgepole pine (*Pinus contorta* Loudon)[3], white spruce (*Picea glauca* (Moench) Voss) and Douglas fir (*Pseudotsuga menziesii* (Mirb.) Franco) trees. 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.

2.3.4 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)[4]
- main understory species
- number of trees sampled with species names and presence of fire related scars or releases
- tree diameter and height of main cohort(s) using the point quarter sampling method (as described in Section 2.2.3.2)

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[3] Moss 1994 serves as the reference for all tree names used in this report.

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

2.3.5 Tree samples

2.3.5.1 General

Tree samples consisted largely of tree cores for the 1997 database, while tree cross-sections accounted for 90% of the 1998 database. In 1998 cores were taken only when it was impossible to use a chainsaw. As a general rule, 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.

2.3.5.2 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 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, keeping the section with the cleanest ring definition. For trees showing a release, the cross-section was taken from the side facing the disturbed 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.

2.3.5.3 Coring

Cores were taken at about 30 cm (12 inches) above the ground (Arno and Sneck 1977), or as low as possible for the reasons stated above. No core was 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).

2.3.6 Sample preparation and tree aging (1997 and 1998 data)

2.3.6.1 General

Preparation of cross-sections and cores, and procedures for counting rings followed methods used for X-ray densitometry in the case of the 1997 data, while the 1998 data were prepared for direct scanning analysis. A detailed account of these methods can be found in the manual "Dendroscan: A tree-ring width and density measurement system" (Varem-Sanders and Campbell,1996). Following is a summary of the procedures used as provided in part by Rob Lucas, Canadian Forest Service.

2.3.6.2 Methods

Tree cross-sections were reduced to segments or 'sticks' containing material from the bark through to the pith. Care was taken to ensure fire scars, if any, were displayed in these segments. Core samples were mounted in slotted boards. All samples were oven dried at 65ºC and then sequentially sanded with 80, 120, 220, 400 and 600 grit sandpaper to ensure that all rings were clearly visible and all fine scratches were removed.

For the densitometry analysis, a table saw was used to thin slice samples, resins, salts and glue were extracted using solvents and subsequently press-dried at 70° C between two metal plates. Samples were then x-rayed and positive enlargements were developed. These enlargements were scanned and read by Dendroscan in a similar way as for the direct scanning process described below.

For the scanning process, polished samples were scanned on an AGFA DuoScan flatbed scanner at either 1000 or 2000 dpi. Higher resolution was used for samples containing finer rings to ensure the image was clear enough to allow accurate analysis. All images were stored in .tif format. Image files were then edited using Adobe Photoshop 5.0 software to add a pure black path line perpendicular to the rings. Any scars were also marked with a dark (not pure black) line at this time.

Edited .tif files were then imported into DendroScan software and converted to .isc format for analysis. DendroScan was used to analyze the pixel colour along a digital path defined by the pure black lines added previously in Photoshop. Ring boundaries were automatically identified by DendroScan from peaks in the 'gray intensity' of pixels sampled along the digital path. Samples were cross-dated using specific marker rings on several samples as reference points and, the .isc files were edited to remove mis-marked rings or add any rings which were missed by DendroScan. The .isc files then contained the correct age of the trees, as well as information on the date of any fire scars.

2.3.7 Database (1997 and 1998 data)

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

2.3.8 Analysis (Preliminary mapping) (1997 and 1998 data)

Dates of stand origin and disturbance evidence were marked at each plot location, on a printed copy of the orthophoto.

Data were interpreted and stand ages were assigned to the polygons that were outlined on the sheet of mylar during the "photo interpretation" process (Section 2.3.1). Stand ages were determined by using the following set of criteria. Criteria used to age each stand are listed in the table of results of each study unit (Chapter 3).

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

(S) - based on fire scars <u>and</u> post fire regeneration tree samples;

(R) - based on releases <u>and</u> 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;

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

(E) - even-age stand;

(U) - uneven-age stand.

In the case of multi-aged stands attributed to natural forest succession, 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. For multi-aged stands resulting from multiple disturbance events, the polygon was assigned multiple dates using the set of criteria.

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 air photo interpretation was done, coupled with tree age information, to subjectively trace the fire boundaries by using natural fuel breaks such as water bodies, rock outcrops, ridges and gullies.

2.3.9 Final Mapping (1997 and 1998 data)

The final mapping procedure was to use another mylar sheet to overlay the one used for the preliminary mapping, in order to reproduce the stand boundaries and the stand origin dates. This map was produced in a format ready for digitizing.

3 RESULTS

3.1 General

Results of the fire history work are presented in two sections corresponding to the 1997 and 1998 field seasons, with each section subdivided into study units. For each study unit, a fire history summary is provided describing the location, extent and number of fires encountered. Notes are also occasionally made with regard to the nature of the stands, such as: stand density, species composition and signs of disturbance.

A summary table called "Stand origin date statistics" follows each fire history summary and explains how the stand origin dates were assigned based on the established criteria (section 2.3.8). Each stand age received a unique stand identification number (stand id). However, when similar aged stands were thought to be from a different disturbance 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 "representative/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 "Field 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.

Following the fire history summary section of individual study units, are two additional sections. The first one deals with other types of disturbances encountered, while the last section briefly describes fire regime parameters such as: fire-return-intervals and the mean-fire-return-interval, and fire behaviour components including: dates and locations of surface fires, fire spread directions and charcoal height found on live trees.

3.2 1997 FIELD DATA

It is important to note that the data set used for the stand origin mapping is incomplete. Out of the 852 trees that were cored, 290 samples were undatable due to a poor scanned image or due to the fact that part of a core, or the entire core, was damaged by the saw used in the lab. Although not accurate, some of these dates were salvaged by using field counts. Also, the quality of the fire scar dates entered in Dendroscan was questionable. Dates believed to be from the same disturbance event varied by about 5 years and some releases even preceded scar dates by a few years, which is impossible. To further confuse the issue, a great number of trees displayed late post-disturbance recruitment dates. This made it even more difficult to ascertain disturbance dates. This problem is believed to be largely due to the fact that samples from cores are taken higher above the ground than cross-sections taken with a chain-saw. As an example, one tree was both cored and cut to extract two samples. The core sample dated from 1852 while the cross-section dated from 1826. Another drawback from using cores was that potential releases in the ring growth pattern and internal fire scars were missed.

3.2.1 SNARING RIVER to CORRAL CREEK

This study unit encompasses the land between the Snaring River, Corral Creek, the Athabasca River and an arbitrary boundary ranging from a distance of 1500 to 2000 metres off the Athabasca River. It represents roughly 15 km^2 of montane terrain characterised by gentle, southeast prevailing slopes.

Fire history summary

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 A.

The forest mosaic between the Snaring River and Moberly Flats is much more complex than that found north of Moberly Flats. This is also where a large number of scattered Douglas fir trees and Douglas fir patches were found. The resilience of these trees to fire, coupled with the flat nature of the greater part of this terrain, accounts for this age complexity. To ease the reading of the disturbance history summary, the study unit was parted in two sections.

1) Between the Snaring River and Moberly Flats

The most recent fire dates from 1932 (id 26) which partially burned over a small portion of the 1889 fire (id 22).

The 1889 fire (id 22) burned at different intensities, from partial crown removal to full stand replacement. This resulted in a patchy mosaic of homogeneous pine stands and mixed stands composed of Douglas fir, white spruce and lodgepole pine trees. Evidence was found that the 1889 fire burned over fires from 1847 (id 16, 18, 19, 20, 23, 24, 31), 1825 (id 12, 16, 18, 20, 30) and 1798 (id 18, 20, 21, 24, 27, 31). These fires form a complex mosaic where fires occurred in different combinations and different numbers. Only 2 patches (id 20), largely composed of Douglas fir trees, had evidence of all four fires. One other patch of similar vegetation composition (id 12) had multiple fire evidence but these dated from 1847, 1825, 1798, 1750 and 1655. It is also in this stand (id 12) that the oldest tree sampled was collected (1655). Note that boundaries of stand id 31 were arbitrarily defined.

A fire bordering an unnamed creek on the slopes of Chetamon Mountain occurred in 1832 (id 13). This fire burned over the 1798 fire and perhaps over a forest dating from 1720 (id. 11). Within the 1832/1798 stand (id 14), an older patch of trees dating from 1780 (id 15) was found. This older patch was subject to windthrow damage in 1977.

A small multi-aged stand (id 25) dating from 1790/1830 was found between the Celestine Lake

Road and the railway, while another small pocket of multi-aged forest dating from 1795/1835 (id 28) was found about 300 metres from the Snaring River and roughly 4 km away from the Athabasca River. Boundaries of the latter stand are arbitrary.

2) Moberly Flats to Corral Creek

In 1898, a fire (id 1, 8) burned just to the north of Moberly Flats and up to Corral Creek. This fire burned over the 1861 fire (id 7, 8), which had burned the land between Cobblestone Creek, Corral Creek and the Athabasca River. Note that these two fires likely extended beyond Corral Creek but that land was not sampled as part of this detailed disturbance sampling project. The 1861 fire burned over stands dating from 1750 (id 9), 1735 (id 10) and 1710 (id 29). All of these older stands were found at least one kilometre away from the Celestine Lake Road, on steeper terrain.

Table 1 Stand origin date statistics for Snaring River to Corral Creek.*

Stand Origin	Stand id	Range of ages	Criteria	# plots	# trees (representative / total)
1932	26	1931 - 1942	S, R, E	3	8 / 7
1898	1237	1892 - 1932	S, R, E, U	13	32 / 43
1889	2.02122e+11	1889 - 1927	S, R, E, U	28	84 / 114
1861	78	1871 - 1900	S, R, E, U	13	44 / 53
1847	1.61819e+13	1846 - 1890	S, R, E, U	21	57 / 78
1845	6	1846 - 1878	O/5, U	1	1 / 2
1835	5	1839 - 1879	O/5, U	1	1 / 2
1835 / 1795	28	1843 - 1864	S, R, U	2	1 / 4
1832	1314	1841 - 1868	S, R, E, U	5	12 / 15
1830 / 1790	25	1830 - 1854	O, E, U	2	2 / 4
1825	1216182030	1825 - 1848	S, R, E, U	12	32 / 27
1798	1.82021e+11	1795 - 1843	S, R, E, U	18	19 / 39
1795 / 1835	28	1795 - 1834	O, E, U	2	4 / 6
1790 / 1830	25	1794 - 1853	O/5, U	1	1 / 1
1780	15	1783 - 1788	O/5, E	1	2 / 2
1775	17	1777 - 1821	O/5, E, U	2	3 / 5

Stand Origin	Stand id	Range of ages	Criteria	# plots	# trees (representative / total)
1755	2	1758 - 1792	O/5, U	1	1 / 2
1750	912	1699 - 1800	M/5, E, U	10	11 / 21
1735	3	1737	O/5	1	1 / 1
1735	10	1738	O/5	1	1 / 1
1720	11	1724 - 1766	O/5, E, U	1	2 / 5
1710	29	1712 - 1721	O/5, U	1	3 / 3
1700	4	1700 - 1722	O, E	1	2 / 3
1655	12	1657 - 1736	O,5, U	2	1 / 3

* For explanation of how to read this table, please refer to sections 2.3.8 and 3.1.

Table 2 Field statistics, list of fire scars and releases for Snaring River to Corral Creek.

Statistics	Scars	Releases
125 plots 949 trees (90% cores) (290 trees lost in lab prep.) 38 trees with one scar 15 trees with two scars 1 tree with three scars 1 tree with four scars 37 trees with one release 5 trees with two releases 1 tree with four releases	1957, 1942, 1941, 1912, 1906, 1904x2, 1903, 1901, 1898, 1896, 1895, 1894x4, 1893x4, 1892x3, 1891x2, 1890x2, 1889x7, 1888, 1887, 1884, 1882, 1872, 1869, 1866, 1864, 1863, 1862x2, 1861, 1852, 1851, 1848x2, 1847, 1846x2, 1844, 1842, 1839, 1838, 1832, 1830, 1829, 1828x2, 1827x2, 1826, 1825, 1799, 1784, 1773, 1730, 1725	1980, 1977, 1954, 1953, 1950, 1943, 1942, 1941x3, 1940, 1935x2, 1908, 1906, 1903x2, 1901, 1900, 1899x2, 1897, 1896, 1895x3, 1894x2, 1893x2, 1892x4, 1891, 1890x3, 1889x5, 1874, 1868, 1867, 1864, 1863x3, 1862x2, 1847, 1846x2, 1844, 1839x2, 1837, 1832, 1831, 1828x2, 1825, 1798, 1784, 1776, 1756, 1732, 1727

3.2.2 Other disturbances than fire

This section presents other forms of stand disturbance events than fire. These events are either man-caused, usually involving tree cutting for any type of usage, or natural events such as insect kills, windthrow and flooding.

a) Tree cutting

Old cut stumps were found at 52% of the sites. The highest concentration of cutting was found between Moberly Flats and Corral Creek, along the Celestine Lake Road and in proximity to the

Snaring River. Field notes however, do not specify the intensity of logging and if these actions were part of salvage cutting associated with late 1800 fires. This extensive tree cutting may have affected forest succession, but based on samples collected, it appears that the impact of such a disturbance would have been over-ruled by fire effects. This historical logging is so old, that its evidence was actually not visible on the oldest air photos.

b) Insect kills

The following sampling sites had some trees baring evidence of insect damage: 1, 3, 17, 23, 25, 26, 28, 33, 37, 38, 40, 41, 47, 62, 86, 94, 102 and, 106. However, only two sites had scars believed to be from beetle kills. These scars were accompanied by releases but had no post-disturbance regeneration trees following the scar date. This is the only clue that lead to the conclusion that such scars were formed as a result of beetle damage rather than fire. As shown on Figure 2, sampling sites 26 and 40 were affected by insect infestations in 1957 (release in 1953?) and 1901, respectively.

c) Windthrow

Five sampling sites showed blowdown evidence, four of which could be dated from releases and post-disturbance recruitment trees. Site 38 showed evidence of a recent blowdown but it could not be dated. Site 53 had a release dating a windthrow event from 1943 and, based on field notes and tree ages, it is believed that site 49, which is only 200 m away, was also affected by this event. Site 86 dated a major windthrow in 1977, while site 100 was partially affected (50 to 70% of canopy removal) by windthrow in 1976 (due to inaccuracies in the age data, it is likely that sites 86 and 100 were affected by the same windthrow event which occurred either in 1976 or 1977). Figure 2 shows areas that were wind damaged.

d) Flooding

It does not appear that flash flood events significantly impacted the stand age structure of these forests. Most tree ages at flood sites could actually be associated with fire events. However, the oldest trees sampled were found in the flood plain of Cobblestone Creek and, it is likely that the nature of these flood sites (sites 55 and 62) contributed to the survival of trees to fire.

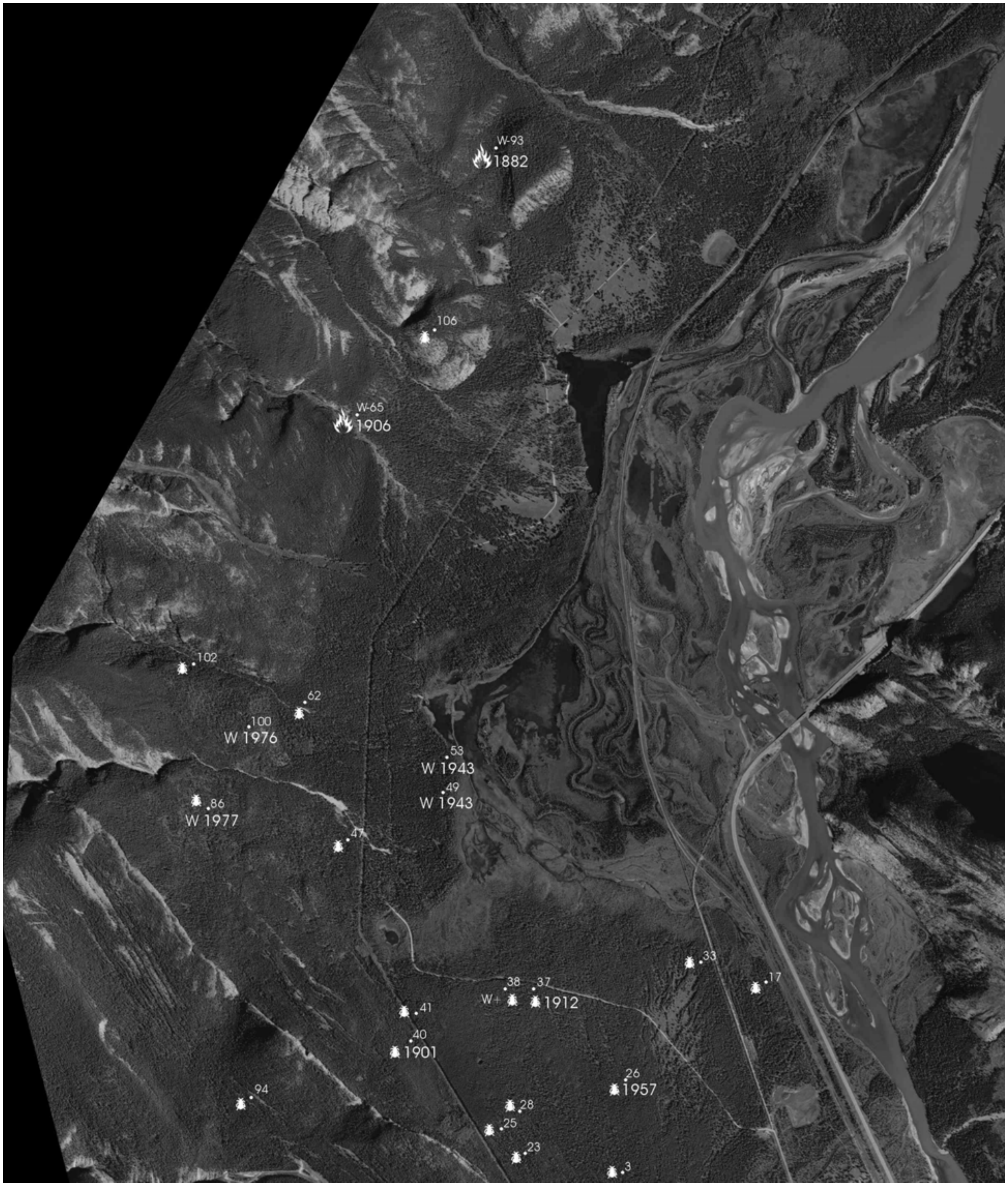

Figure 2 Sites of known disturbances, other than fire, for the area between the Snaring River and Corral Creek. **W** = wind damage, [beetle symbol] = beetle kills, [flame symbol] = surface fires.

Other sampling sites affected by flash flood events were those located on the flood plain and alluvial fan of an unnamed creek just north of Cobblestone Creek, at the base of Esplanade Mountain. None of the forest growing at these sites (69-70-71-74-75-76) appeared to have been affected by flooding.

3.2.3 Fire regime and fire behaviour

a) Fire regime descriptors

Snaring River to Moberly Flats:

FRIs[5]: 5 to 43 years between 1720 and 1932

MFRI: 28 years since 1720

Only one stand was found prior to 1720 and it dates back to 1655. This gives a FRI of 65 years which is likely false given that a lot of the old fire evidence has been erased by subsequent fires.

Moberly Flats to Corral Creek:

FRIs: 5 to 80 years between 1700 and 1898

MFRI: 22 years since 1700

Overall, between 1700 and 1932, 0.04 fire occurred every year between the Snaring River and Corral Creek. Based on a mean fire size assumed to be of 2000 ha (Rogeau 1996), the yearly burned area would have equal 80 ha. Taken to a larger temporal scale, on average 800 ha of land burned every 10 years.

b) Fire spread direction

Compass direction of fire scarred trees were not determined during the 1997 field season.

c) Surface fires

Some fire scars were found that could not be coupled with a release in the ring growth pattern, nor with post-fire-regeneration trees. Very few of these events were recorded and their extent is unknown. Location and dates of those believed to be surface fires, are mapped on Figure 2.

[5]FRI: fire-return-intervals, MFRI: mean-fire-return-interval

d) Bark charcoal height

Not recorded during the 1997 field season.

3.3 1998 FIELD DATA

3.3.1 COLIN RANGE to JACQUES RANGE

This study unit encompasses the land between Morro Peak, Jacques Range, Highway 16 and an arbitrary boundary ranging from a distance of 1500 to 2000 metres off the highway. It roughly represents 12 km^2 of montane terrain of prevailing northwest facing slopes.

Fire history summary

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 B.

Just east of Morro Peak, above the Cold Sulphur Spring, the oldest stand was found. It dates back to 1485 (stand id 1) and is strictly composed of Douglas fir (Fd) trees of all sizes and ages. Charcoal was found on the bark of most trees but no fire scar or release formation occurred. These trees have a constant and significant growth rate in comparison with spruce or pine trees, and this characteristic makes it difficult to depict traces of disturbances. Beetle damage was present on the majority of the trees.

On the slope facing the Athabasca River, between Morro Peak and Jacques Valley, pockets of Fd and white spruce (Sw) trees were dated from 1785 (stand id 2), 1775 (stand id 3) and 1755 (stand id 4). Although short distances apart, these three stands appear to be from three separate disturbance events as trees were evenly aged within each stand. These pockets of remnants escaped two fires that occurred in 1904 and 1912 (stand id 5). Substantial fire scar and release evidence were found to date these two fire events that occurred only 8 years apart. This would explain the thicket of regrowth and small diameter burnt snags dispersed throughout the stand. Due to the short interval between these two fires it was not possible to distinguish where the 1904 burn escaped from the 1912 fire. Based on the samples taken, it appears that the 1912 fire re-burned the majority of the

1904 fire.

At the top of the saddle and dipping down into the Morro Creek basin (behind Morro Peak), two patches consisting of a mixture of remnant lodgepole pine (Pl), Sw and Fd trees dated from 1745 (stand id 7 & 8). One of the patch (stand id 7) showed evidence of an 1832 fire. These patches also escaped the 1904 and 1912 fires (stand id 5, 9 & 10), which burned the greater part of this valley. Closer to valley bottom, towards Morro Creek, evidence was found that in 1914 (stand id 9) another fire burned over the 1904 one. Boundaries between the 1904 and 1914 fire are undetectable. Across Morro Creek, patches of the 1904 fire could be detected by air photo interpretation. Unfortunately no stand could be visited on this side of the valley due to its remoteness and inaccessibility.

As a general note, patches of remnant trees, for this particular area, were commonly found on crests of small rocky ridges (topographic ribs). These were also the only places where fire scars could be found and, it was not uncommon to find double-scarred trees as well. Interestingly, scars often faced opposite directions, even for the same burning event.

On the Jacques Range slopes, on a steep bank above Jacques Creek, numerous single and double scars were found. Of the four sampled trees of plot 27, all scars were facing different compass orientation (NNE, SSE, N and E). No release in the ring growth pattern or post-fire regeneration trees were associated with the two scarring events which dated from 1890 and 1901. These evidence point to slow moving surface fires at this specific site.

A strip of Pl/Fd remnants following the banks of Jacques Creek was found to be unevenly aged, suggesting two burn histories: 1870 and 1850 (stand id 16). However, no fire evidence was found to corroborate these dates. Pockets of evenly aged trees dating from 1850 (stand id 14) were found across the creek, but chances are that the 1850 disturbance event could be as old as 1840, therefore matching the 1840 burning event (stand id 15) also located on the other side of the creek.

The southwest facing slopes of Jacques Range were burned by two recent fires: 1904 and 1915 (stand id 18). Numerous fire scars and releases were found for the 1904 fire, which is the same fire that burned the Morro Peak area. No fire evidence was found for the 1915 fire (stand id 21) in the

Jacques Creek valley but evidence was found on the other side of Jacques Range, in the Edna-Talbot Lake area. Due to the short fire return interval between the 1904 and 1915 fire, exact boundary delineation was sometimes difficult.

The forest growing on the alluvial fan of Jacques Creek dated from 1870 (stand id 12). Although the fan was covered with wood and rock debris from flash flood events, it does appear that this forest regenerated from fire. Evidence of a circa 1870 fire was found in a closed forest stand, about three kilometres upstream. On the outskirt of the alluvial fan, two stands were dated from the 1912 fire event (stand id 13), even though post-fire regeneration was delayed by about 10 years (which is not abnormal on poor growing sites). These stands are also located in the flats of the creek outlet but flooding disturbance has not been seen for a very long period of time (moss and humus layer formation over creek bed rocks).

Table 3 Stand origin date statistics for Colin Range to Jacques Range.*

Stand Origin	Stand id	Range of ages	Criteria	# plots	# trees (representative / total)
1915	21	1917 - 1935	O/5, E	2	9 / 9
1914 / 1904	9	1913 - 1932	S, R, E	2	8 / 6
1912	13	1922 - 1940	S, E	3	7 / 9
1912 / 1904	5	1909 - 1931	S, R, E	10	55 / 35
1912 / <u>1805</u>	11	1808 - 1912	O/5, E	1	2 / 3
1870	12	1870 - 1883	O, E	2	6 / 6
<u>1870</u> / 1850	16	1873 - 1880	O/5, E	1	3 / 3
1850	14	1850 - 1866	O, E	3	9 / 11
1840	15	1842 - 1848	O/5, E	1	4 / 4
<u>1832</u> / 1745	7	1841 - 1861	S, R, E	3	9 / 16
1785	2	1789 - 1794	O/5, E	1	4 / 4
1775	3	1776 - 1798	O/5, E	1	3 / 3
1770	6	1771 - 1853	O/5, E, U	1	2 / 3
1755	4	1757 - 1772	O/5, E	1	4 / 4
1745	8	1748 - 1778	O/5, E	3	10 / 11

Stand Origin	Stand id	Range of ages	Criteria	# plots	# trees (representative / total)
1485	1	1485 - 1792	O/U	1	1 / 4

* For explanation of how to read this table, please refer to sections 2.3.8 and 3.1.

Table 4 Field statistics, list of fire scars and releases for Colin Range and Jacques Range.

Statistics	Scars	Releases
32 plots 123 trees (13% cores) 22 trees with one scar 6 trees with two scars 25 trees with one release 3 trees with 2 releases	1914x4, 1912, 1905, 1904x15, 1901x4, 1890x2, 1846, 1833, 1832x2, 1831, 1829, 1798	1930, 1914x2, 1912x2, 1910x2, 1909x2, 1906x2, 1905, 1904x13, 1902, 1864, 1846, 1836, 1833, 1829x2

3.3.2 JACQUES RANGE to CINQUEFOIL CREEK

This unit covers the land between Jacques Range, Cinquefoil Creek, which empties out into Talbot Lake, Highway 16 and an arbitrary boundary ranging from a distance of 1500 to 2000 metres off the highway. It roughly represents 9 km^2 of montane terrain. Figure 3 outlines the boundary of the study unit and shows locations of sampling sites.

Fire history summary

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 B.

The same 1904 fire (stand id 10) from the Morro Peak area burned the slopes of Cinquefoil Mountain and stopped (or started) about 500 metres past Edna Lake. Part of this burn area was also subsequently re-burned by the 1915 fire (stand id 21). The 1915 fire also burned over fires from 1896 (stand id 22), 1862 (stand id 24) and 1833 (stand id 26), while the 1904 fire burned over fires from 1862 (stand id 23) and 1820 (stand id 19). Lastly, evidence was found that the 1896 fire had burned over the 1862 one (stand id 30). Surviving all these burns, two small pockets of remnants dating from 1815 (stand id 25 and 27) were found by Talbot Lake. All post 1833 stands were substantiated by fire evidence such as scars and releases.

It was in the more open areas such as muskeg and grassy meadows, between Edna and Talbot Lakes, that pockets of old Sw remnant trees with scattered Pl trees were found. These pockets dated as far back as 1833 (stand id 26) and 1815 (stand id 25). It is in stand 25 that a remnant pine tree from 1815 bared evidence of 4 distinct fires: 1882-1862-1848 and 1833. Two, and possibly three, of which accounted for stand replacing fire events (1833, 1862 and possibly 1882).

The oldest stands found in this study unit were along lake shorelines. On the east shore of Edna Lake, a 1535 (stand id 17) Sw stand was found, while the southwest shoreline of Talbot Lake was composed of forest stands dating from 1815 (stand id 27), 1795 (stand id 29) and 1635 (stand id 28). With the exception of the 1815 stand, these stands were located in wet lands.

Table 5 Stand origin date statistics for Jacques Range to Cinquefoil Creek.*

Stand Origin	Stand id	Range of ages	Criteria	# plots	# trees (representative / total)
1915	21	1917 - 1937	S, R, E	6	18 / 10
1915 / 1795	29	1797 - 1958	2nd O/5, E, U (1669)	1	2 / 4
1904	10	1904 - 1918	S, R, E	7	23 / 21
1904 / 1882 / 1815	25	1882	S	1	2 / 1
1896	22	1901 - 1903	S, E	2	6 / 5
1862	23	1861 - 1899	S, E, U	3	5 / 6
1845	20	1848 - 1854	O/5, E	1	4 /3
1833	26	1835 - 1865	S, E	2	7 / 7
1820	19	1824 - 1860	O/5, E, U	3	11 / 4
1815	27	1819 - 1831	O/5, E	1	5 / 3
1635	28	1637 - 1785	O/5, U	1	1 / 4
1535	17	1537 - 1677	O/5, U	1	1 / 4

* For explanation of how to read this table, please refer to sections 2.3.8 and 3.1.

Table 6 Field statistics, list of fire scars and releases for Jacques Range to Cinquefoil Creek.

Statistics	Scars	Releases
23 plots 83 trees (7% cores) 8 trees with one scar 1 trees with 4 scars 15 trees with one release	1920, 1915x4, 1905x2, 1896, 1882, 1862, 1848, 1833	1974, 1941, 1920, 1915, 1913, 1908, 1905, 1891, 1888, 1824, 1805

3.3.3 Other disturbances than fire

This section presents other forms of stand disturbance events than fire. These events are either man-caused, usually involving tree cutting for any form of usage, or natural events such as beetle kills, windthrow and flooding.

a) Tree cutting

Old cut stumps covered with charcoal, most likely from the 1904 - 1912 fires, were found at less than 700 metre away from Highway 16 (plot 12).

Old cut stumps, burnt by the 1904 - 1912 fires, were also found 100 metres away from Highway 16 at plot 15.

b) Insect kills

As a general rule, all Douglas fir forest bared evidence of beetle damage. The oldest stands have been thinned out by beetle kills rather than by fire. Beetle damage could also be found on older pine trees, killing individual trees.

Although it has been discussed that beetle damage can create catfaces very similar to fire scars (Gara *et. al.* 1984, Mitchell *et. al.* 1983), all scars could be associated with stand replacing fire events, even those with beetle damage.

c) Windthrow

Between plots 17 and 18, numerous Douglas fir tree stumps were observed with charcoal on them. The stumps were rotten and dry, and the nature of the break, high on the stump and jagged, suggest wind damage.

d) Flooding

The forest growing on the alluvial fan of Jacques Creek could not be associated with a flooding event but rather with fire. A similar conclusion was made for the Cinquefoil Creek alluvial fan.

3.3.4 Fire regime and fire behaviour

a) Fire regime descriptors

Colin Range to Jacques Range Unit:

FRIs[6]: 1 to 34 years since 1745

MFRI: 13.08 years since 1745

Only one stand was found prior to 1745 and it dates back to 1485. Giving a FRI of 260 years. This FRI is likely false as evidence of oldest burns have been erased by subsequent fires.

Jacques Range to Cinquefoil Creek:

FRIs: 5 to 20 years since 1815

MFRI: 13.33 years since 1815

The MFRI has been estimated to be 130 years prior to 1815, but again only two stands older than 1815 could be found.

Overall, between 1745 and 1915, 0.08 fire occurred every year between Morro Peak and Talbot Lake. Based on a mean fire size assumed to be of 2000 ha (Rogeau 1996), the yearly burned area would have equal 160 ha. Taken to a larger temporal scale, on average1600 ha of land burned every 10 years.

b) Fire spread direction

Compass direction of fire scars were used to determine the direction of fire spread. Fire scars form

[6]FRI: fire-return-intervals, MFRI: mean-fire-return-interval

on the opposite side of the tree from where flames are licking the bark (Gutsell and Johnson 1996). Basically, the fire scar orientation points to the direction of the fire spread. Figure 3 and 4 display pointing arrows with their associated fire dates to indicate the direction of burning.

c) Surface fires

Some fire scars were found that could not be coupled with a release in the ring growth pattern, nor with post-fire-regeneration trees. Very few of these events were recorded and their extent is unknown. Location and dates of those believed to be surface fires, are mapped on Figure 3 and 4.

d) Bark charcoal height

Bark scorched height provides an estimate of the surface fire intensity for that specific site. Douglas fir trees were the only trees that recorded charcoal on their bark. Occasionally scarred pine trees record charcoal on the catface portion of the tree.

The 1485 Douglas fir stand above the Cold Sulphur Spring recorded charcoal on the majority of the trees. Charcoal was up to 3' above ground on most trees, but the largest tree of the stand recorded charcoal up to 12' high on the downhill side.

At sampling site 18, up on a ridge at about 1200 metre from the highway, charcoal was recorded 2 ½' up on the southeast facing bark of Douglas fir trees.

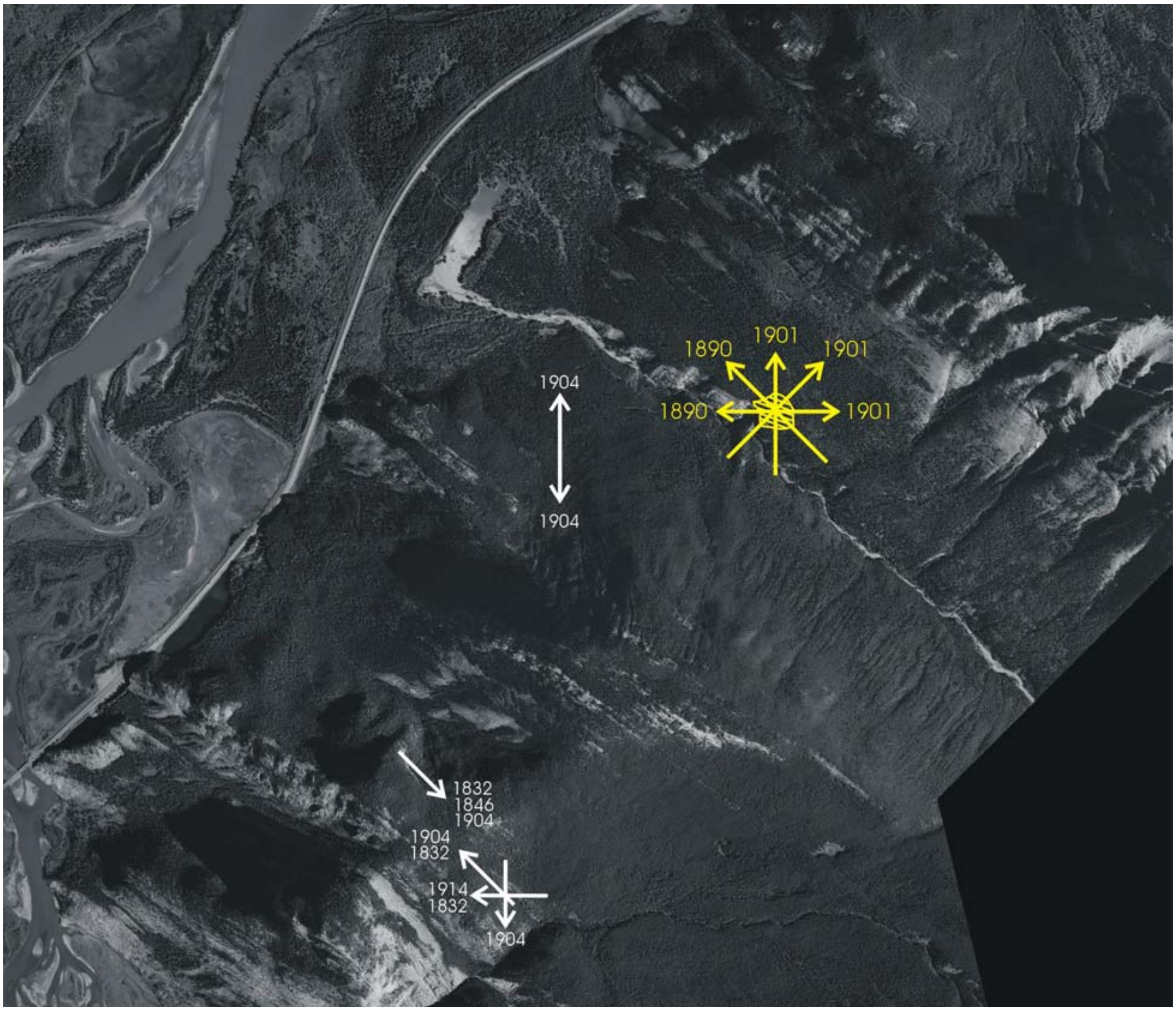

Figure 3 Fire spread direction and location of surface fires for Colin Range to Jacques Range Unit. Direction of burn is shown by pointing arrows, while direction and location of surface fires are shown by a combination of arrows and hatched area. Note that dates of surface fires are displayed in a bigger size font.

Figure 4 Fire spread direction and location of surface fires for the Jacques Range to Cinquefoil Creek Unit. Direction of burn is shown by pointing arrows, while direction and location of surface fires are shown by a combination of arrows and hatched area. Note that dates of surface fires are displayed in a bigger size font.

4 RECOMMENDATIONS

4.1 Future sampling regions

The study units sampled as part of this two year project were located on both sides of the Athabasca River, at the same latitudinal level and within a similar valley orientation (SW-NE). To gain a better understanding of the role that aspect, valley orientation and historical human use level play on mean fire return intervals, it would be important that other montane regions be sampled. Notably, smaller size valleys, which run perpendicular to the main Athabasca Valley, such as the Snake and Fiddle, may present a different disturbance regime. Portions of the Athabasca Valley upstream from Jasper Townsite, as well as some of the land between Yellowhead Pass and the Town of Jasper, should also be sampled on both sides of these rivers (Athabasca and Miette).

4.2 Sampling strategies

< Tree sampling on edges of stands displaying a different structure is the best way to obtain relevant information on historical disturbances;

< Most stand edges can be identified a priori using both old and recent air photos;

< The transect approach should be used only in stands with multiple age-cohorts as determined from field recognition;

< Sampling of all age cohorts cannot be accomplished based on tree diameter and should be avoided to reduce the number of sampled trees and the confusion it brings to stand aging. Most times tree diameter is not a good surrogate of age, and other tree characteristics such as height, tree tops, crown density, branch arrangement and scarring should be used as indicators to determine the likelihood of age heterogeneity within a stand as a result of disturbance;

< Core samples should be avoided as much as possible as these samples are taken higher above the ground than cross-sections. As a result 5 to 30 years can easily be lost depending on the tree species and growing environment (topography, soil composition and drainage). This problem is compounded by the fact that the pith is easily missed when using an increment borer. Lastly, releases in the ring growth pattern following a disturbance, as well as healed over fire scars, often go undetected when using cores.

4.3 Tree and scar dating

X-ray densitometry or scanning of tree samples for accurate tree and disturbance dating is a very costly and time consuming process. I would suggest processing samples in this manner for those samples showing a scar or a release, those with very constricted rings and, trees that appear to be older than 200 years. Otherwise, regular sanding with an 80 grit sand paper, in combination with the use of oil as a ring enhancer and a dissecting scope, could be used on the remainder of the samples. The reason for this suggestion is that it was observed that on young trees with clear rings, field counts were very close, if not identical, to the laboratory tree date.

5 LITERATURE CITED

Andison, D. (In prep.). Detailed disturbance dynamics in the Montane area of the Foothills Model Forest.

Arno, S.F. and K.M. Sneck (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.

Gara, R.I., J.K. Agee, W.R. Littke, and D.R. Geiszler. 1984. Fire wounds and beetle scars. Journal of Forestry 84(4): 47-50.

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.

McBride, J.R. (1983). Analysis of tree rings and fire scars to establish fire history. Tree-Ring Bulletin, 43:51-67.

Mitchell, R.G., R.E. Martin and J. Stuart. 1983. Catfaces on lodgepole pine - fire scars or strip kills by the mountain pine beetle? Journal of Forestry 83(?): 599-600.

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

Rogeau, M.-P. 1996. Understanding age-class distributions in the Southern Canadian Rockies. M.Sc. Dept. of Forest Science, University of Alberta, Alberta. 139 p.

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

Varem-Sanders, T.M.L. and I.D. Campbell. 1996. Dendroscan: a tree-ring width and density measurement system. Natural Resources Canada, Canadian Forest Service, Northern Forestry Centre, Edmonton, Alberta. Special Report 10. 131 p.

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

Stand origin map: Snaring River to Coral Creek

Appendix B
Stand origin map: Colin Range to Cinquefoil Creek