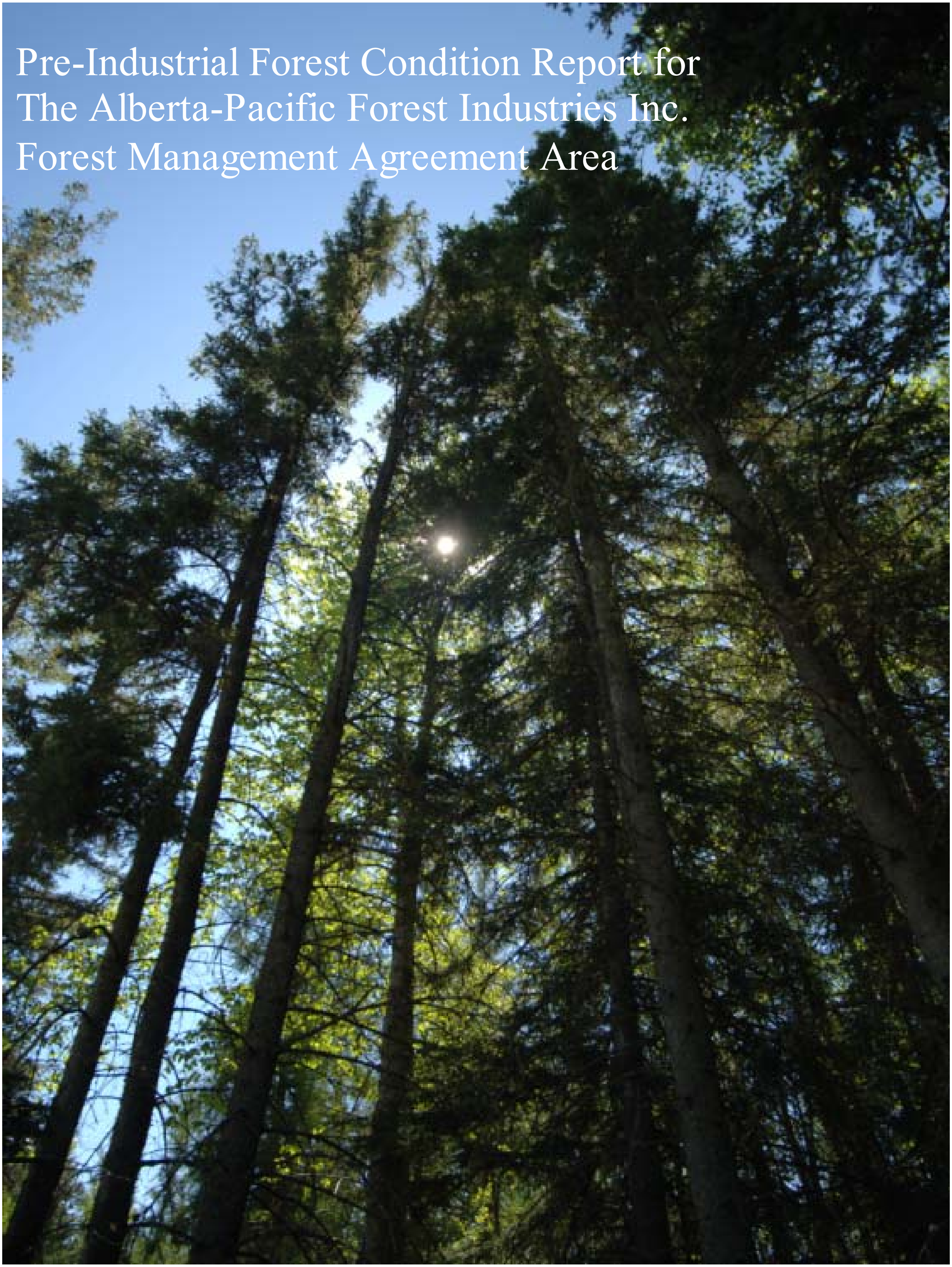
Pre-Industrial Forest Condition Report for The Alberta-Pacific Forest Industries Inc. Forest Management Agreement Area



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1.0 Introduction

Alberta-Pacific Forest Industries Inc. (Al-Pac) received forest certification under the auspices of the Forest Stewardship Council (FSC) in September 2005. A condition of Al-Pac's FSC certification was an assessment of the pre-industrial forest condition pertaining to the landbase in question. The pre-industrial forest condition can be used as a basis for setting management objectives related to the future forest. The National Boreal Standard (FSC) defines pre-industrial forest as "A native forest, which has not been subjected to large-scale harvesting or other forms of human management. A forest area such as existed prior to human settlement occupied by the forest."

Generally, the Al-Pac FMA (Forest Management Agreement) area has a much shorter history of industrial development than many forests in eastern Canada, and therefore a relatively small human footprint at the current time. Currently, the total area cleared or harvested for forestry, oil and gas, transportation and other human landuses shown within Al-Pac's current vegetation inventory is approximately144,000 ha or 2.2% of the approximate 6.5 million hectare FMA area.

Nevertheless, all industrial feature polygons within the vegetation inventory (current to 2006) were removed to produce a snapshot of the current forest cover without industrial impacts. This produced a Non-Industrial Forest Condition (NIFC), which represents forest landscape conditions prior to human activity and settlement, consistent with FSC requirements. However, since boreal forests are inherently dynamic systems and shaped by natural disturbances that fluctuate within a historical range of variability, the snapshot presented here represents one possible forest condition. Variability from this snapshot exists.

In partial fulfilment and compliance with FSC standards, this document serves to describe the pre-industrial forest conditions within the Al-Pac FMA area in compliance with condition 6.1 and indicator 6.1.5 of the FSC standards (FSC 2004).

2.0 Description of Forest Management Area

The FMA was originally awarded to a joint venture of Crestbrook Forest Industries Limited, M.C. Forest Investment Incorporated and Kanzaki Paper Canada Incorporated on August 30, 1991 (O.C. 556/91) pursuant to Section 16(1) of the Forests Act. The agreement was revised May 6, 1998 (O.C. 193/98). In May of 1998, Alberta-Pacific Forest Industries Inc. became the duly authorized operator of the "Alberta-Pacific Project." Alberta-Pacific Forest Industries Inc. is the agent of Al-Pac Forest Products Inc. and in that capacity executes the FMA on their behalf

The FMA establishes the basic timber rights and management responsibilities for Alberta-Pacific over the agreement area in north-eastern Alberta. This area will continue to supply the majority of the deciduous and coniferous fibre requirements of the Company's bleached kraft pulp mill and a substantial portion of the conifer fibre supply for the Quota Holders and participants in the Commercial Timber Permit (CTP) and Miscellaneous Timber Use (MTU) programs of Alberta Sustainable Resource Development.

2.1 Natural Features

The outer boundary of the FMA area encompasses a gross area of almost seven million hectares. East to west, it spans roughly 300 kilometres from the Saskatchewan border west to Lesser Slave Lake. South to north, the FMA area extends from the agricultural White Area around Athabasca and Lac La Biche to the Birch Mountains, a distance of about 340 kilometres (Figure 2.1). Within the FMA area outer boundary there are a number of excluded areas that are referred to as "doughnut holes" making up about 1.1 million hectares.

These doughnut holes are not part of the official FMA are, and are defined as Non-J areas ("J" refers to "Joint Venture" harvesting program, therefore "non-J" refers to areas not available to the program) of the N.E. Boreal Forest Region. These Non-J areas represent approximately 1.1 million hectares and are primarily composed of non-productive forest land (within the netdown this refers primarily to treed muskeg). These areas were deleted from the legal FMA area at the time of signing since they contain limited productive forest. As such, Al-Pac does not have to pay the Alberta government holding and protection charges for these lands. While based on forest productivity, the doughnut-hole boundaries are mainly administrative, in that they follow township boundaries and are loosely based on AVI delineation of forest types. From an ecosystem management perspective, these areas contribute to biodiversity and wildlife objectives, and thus have been utilized throughout the forest management plan to meet non-timber objectives and strategies. As well, for any natural disturbance analysis, these areas must be utilized, for fire does not recognize administrative boundaries.

2.2 Ecological Setting

The FMA area is within the Boreal Forest Region described by Hosie (1979) and the Boreal Eco-province described by Strong and Leggat (1992). Two natural regions (out of six within the province) described by Alberta Environmental Protection (1994) are represented within the FMA area (Figure 2.1). The Boreal Forest Natural Region encompasses over 98% of the FMA area. Within this region, natural subregions represented within the FMA area are the Central Mixedwood (84%) and the Boreal Highlands (15%) with possible inclusions (< 1%) of Sub-Arctic (Birch Mountains) and Dry Mixedwood (Wandering River-Lac La Biche area). The remainder of the FMA area is represented by the Lower Foothills Subregion (< 2%), which is within the Foothills Natural Region.

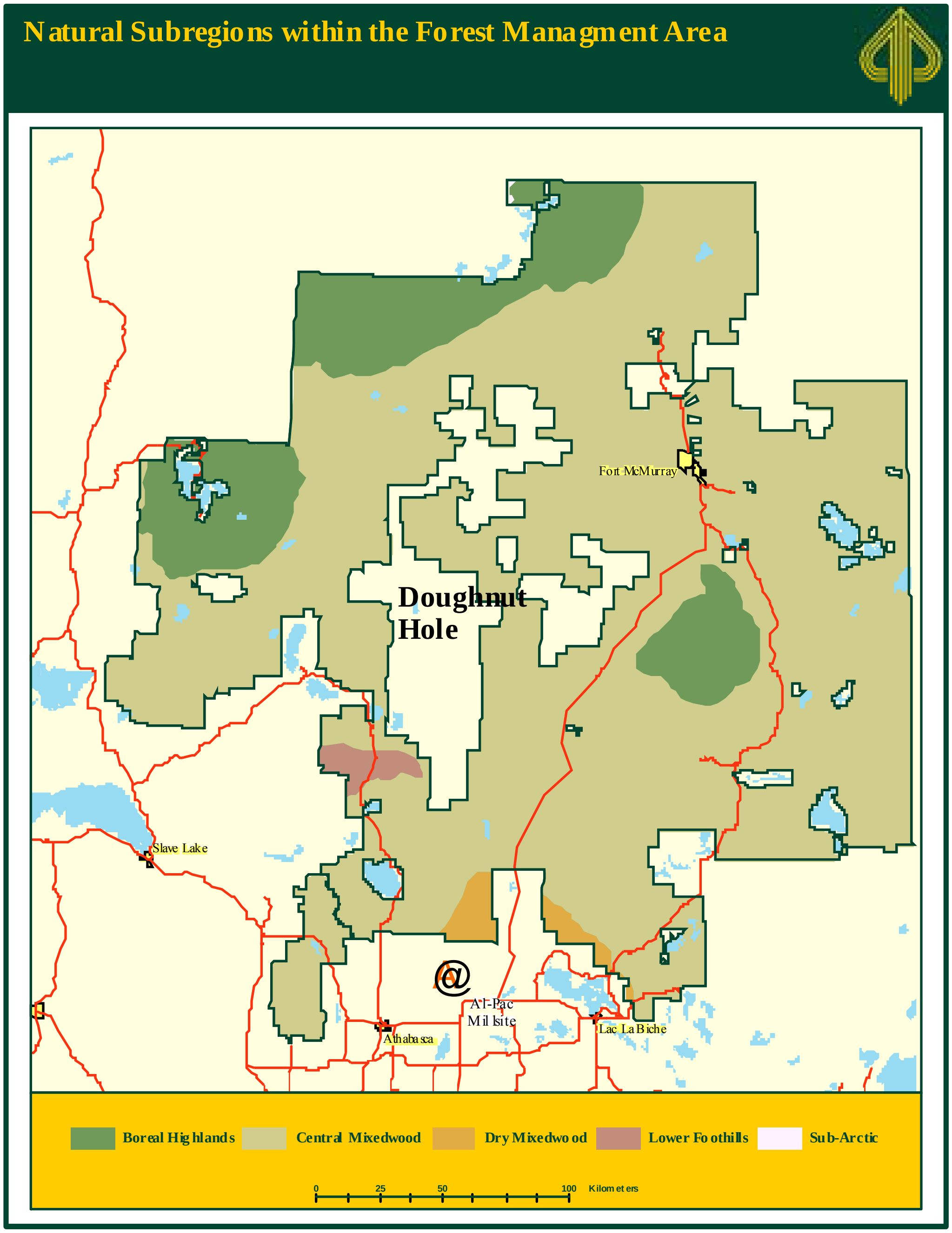

Figure 2.1. Natural subregions within ALPAC's Forest Management Area, northern Alberta.

2.3 Physical and Geological Features

As part of the Boreal Plains, the topography of the FMA area is characterized by large expanses of relatively flat terrain, interrupted by several hill complexes and river valleys (Figure 2.2). The general topography is a result of soils deposition caused by the action of melting and retreating ice sheets. Elevation ranges from about 400 m where the Athabasca River flows northward out of the FMA area, to over 900 m in the Pelican Mountains. Other relatively high areas are the Birch Mountains, Trout Mountain, Stony Mountain and the Thickwood Hills. The major river drainages in the FMA area are the Athabasca and Clearwater Rivers in the central and eastern portions of the FMA area, and the Wabasca River in the northwest corner of the FMA area.

Geologically, Devonian strata of limestone, dolomite, shale and evaporite underlie the FMA area. Bedrock outcroppings occur only in the deep river valleys. The most notable Cretaceous feature is the McMurray formation consisting of oil-saturated sandstone and shale, commonly known as the Athabasca Oil Sands. Figure 2.4 shows the extent of the Athabasca Oil Sands formation as well as the location of conventional oil and gas fields.

Surficial material ranges from fine and impermeable material, where water movement is horizontal, to coarse, where water movement is vertical. Impermeable clay layers force water to flow horizontally and result in the development of large peatland and wetland complexes. Other deposits (landforms) contain glacial-till moraines or clay-rich unsorted material consisting of sand, clay, gravel, and rock where horizontal water movement can also be expected. Glacial rivers deposited coarse material of sands and gravels where vertical water movement is dominant. These deposits are of varying thickness up to 200 m deep. Surface geological features are primarily made up of glacial drift of varying thickness up to 200 m. This surface material was left as a result of the melting of the Wisconsin ice sheet. Glaciation landform features such as glacial fluting, ice disintegration hummocks and potholes, eskers, glaciofluvial and glacial lake deltas are all represented within the FMA area.

Ancient glacial lake beaches have left extensive areas of fine sands that have been windblown in the eastern part of the FMA area. Groundwater discharge that originates from deep geological formations is often high in dissolved salt content. Water may also be contaminated with organics from the Athabasca Oilsands formation.

Cold water mineral springs along the Clearwater River have salt content in the order of 3,000 to 20,000 parts per million, consisting of predominantly sodium chloride. These springs have a hydrogen sulphide smell and surface calcareous deposits. Salt springs along the Athabasca River and sulphate springs in the western part of the FMA area have also been identified and documented by the Alberta Research Council's hydrogeological surveys and reports.

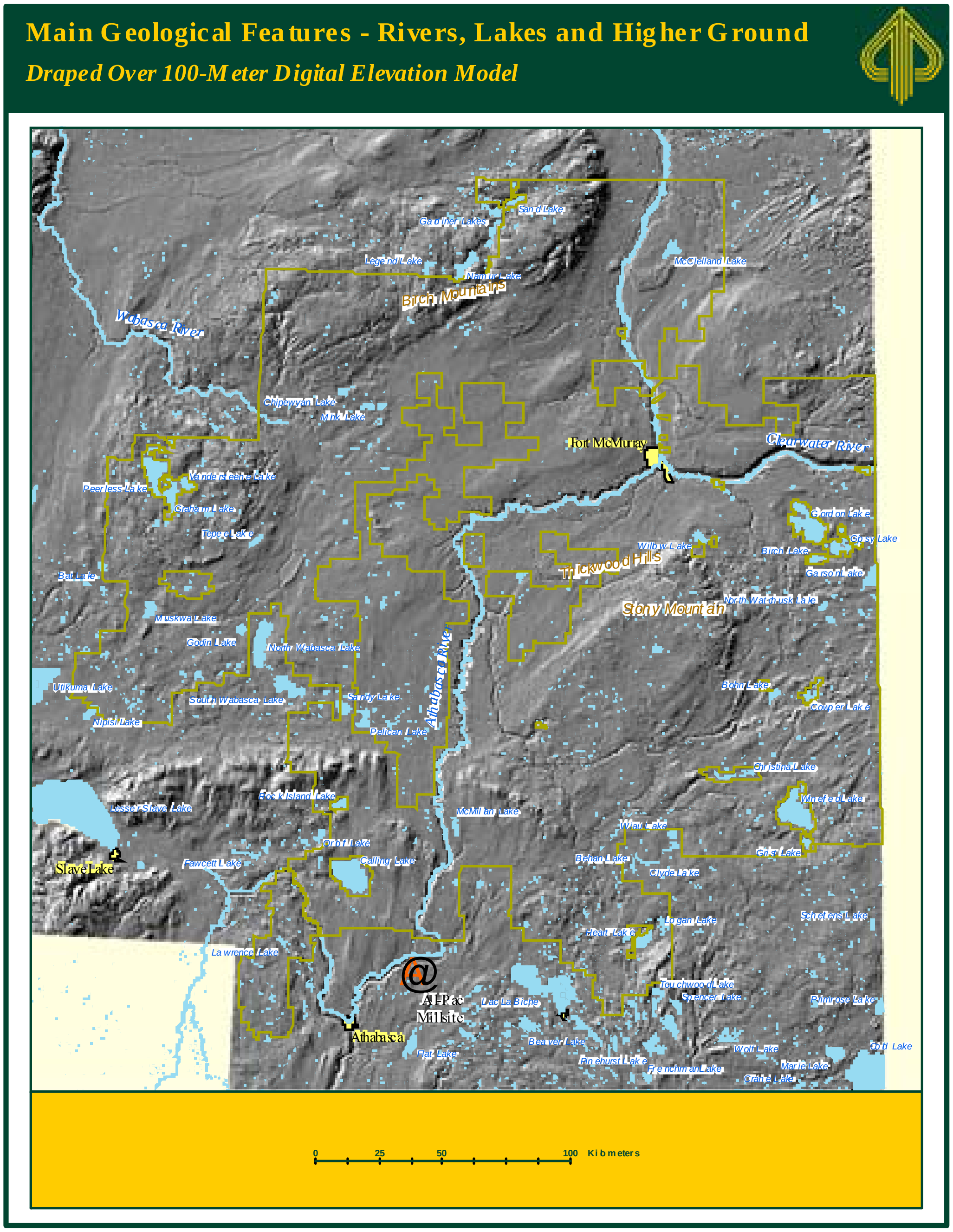

Figure 2.2. An orthorgraphic overview of the Al-Pac Forest Management Agreement area illustrating its main geological features.

2.4 Human Landuse and Industrial Activity

A variety of human land use features are embedded in the forested landscape of the FMA area. The activities associated with this "human footprint" demonstrate the economic and cultural reliance that people have on the natural resources of northeastern Alberta. Many of the industrial sectors and human settlements are likely to continue to increase in population size and footprint size. Thus, the footprint with respect to human features on the landscape is clearly dynamic. We present here the current situation of human features on the landscape up to 2003 – the most current analysis of human use in the FMA area (Table 2.1).

Table 2.1. Human Land Use Deletions from the FMA area [1]

Type of Human Landuse	Length (kilometres)	Area (hectares)	Notes
Town/City/Rural Residences		2,363	
Agriculture		1,802	
Wellsites (# - 19,289)		15,516	1
Industrial Plants		5,929	
Seismic Lines	72,368	41,082	2
Pipelines	8,906	22,258	3
Roads – Major (primarily highways)	1,533	19,237	4
Roads (LOC)	39,209	31,367	5
Railways	226	450	
Power Lines	560	2,800	
Total		**134,561**	

Notes: 1. Based on average wellsites of 90m x 90m; 2. Based on 5-m wide seismic lines (this is very conservative as many historic lines were 5 to 8 m wide); 3. Based on average pipeline right-of-way width of 20 m; 4. Major roads widths used were 40 m; 5. Road widths used were 8 m and includes, pipeline agreement roads, License of Occupation (LOC) roads, and wellsite access roads.

In addition to features accounted for in Table 2.1, unaccounted features include those that are not considered permanent (or long-term) deletions from the FMA area. For example, some seismic lines, in-block roads and landings, and cutblocks are temporary disturbances that regenerate to forest on various growth trajectories. Seismic lines have various regenerative trajectories depending on their subsequent re-use by industrial or non-industrial human users (Lee and Boutin, in press). From a forestry perspective, conventional 5 to 8-m wide seismic lines are typically out of phase with the surrounding forest. New technology in the seismic industry may provide opportunities to reduce the impact of seismic lines from both a forestry and ecological perspective

[1] These metrics are from a dynamic landscape. Disturbances are continually happening throughout the FMA area landscape. Linear features such as roads and pipelines were buffered to remove the possibility of double-counting features. As such, the numbers above can generally be viewed as a conservative estimate of today's footprint. The oilsands areas are excluded from this table, as they are dealt with separately. The doughnut holes are excluded from this table, as they are not within the Al-Pac FMA area.

2.4.1 Human Settlement

The current population within the FMA area is greater than 85,000. However, over 80% of this population currently resides in the rapidly growing city of Fort McMurray. Fort McMurray's growth is a recent phenomenon. Not until 1967 was there a paved all-season highway linking the city with southern reaches of the province. Fort McMurray's current population expansion is driven primarily by the rapid growth of the oil and gas industry in northern Alberta (Table 2.2). The FMA area is bounded on the south by agricultural settlement and the major towns of Athabasca, Boyle, and Lac La Biche. The City of Fort McMurray falls within the outside boundary of the FMA area, as do a number of communities and Indian reserves, including Janvier, Conklin, Sandy Lake, Heart Lake, Gregoire Lake, Fort MacKay, Peerless Lake, Trout Lake, Calling Lake and Chipewyan Lake. Just outside the FMA area are the Beaver Lake, Namur Lake, and Wabasca reserves and the settlements of Red Earth, Plamondon, Wandering River, Smith, Atmore, Grassland, Buffalo Lake and Kikino (Figure 2.3).

For communities in and around the FMA area, the forest resources within the FMA area are a vital source of employment supported by the forest industry, trapping, guiding, hunting, tourism and fishing. The southern part of the FMA area lies within a three-hour drive from major population centres in and around Edmonton, a city of approximately 1 million people. Several lakeside summer villages are established along the southern edge of the FMA area.

Lakeland Park and Recreation Area and the Cold Lake Air Weapons Range (CLAWR) are on the southeastern edge of the FMA area. Lakeland Park and Recreation Area offers tourism and recreation opportunities and represents a large reserve area with minimal harvesting. Cold Lake Air Weapons Range includes a military base and oil field operations that provides economic benefits to the area. There are no commercial forestry operations within the CLAWR – it therefore contributes to ecological values because of its restricted use.

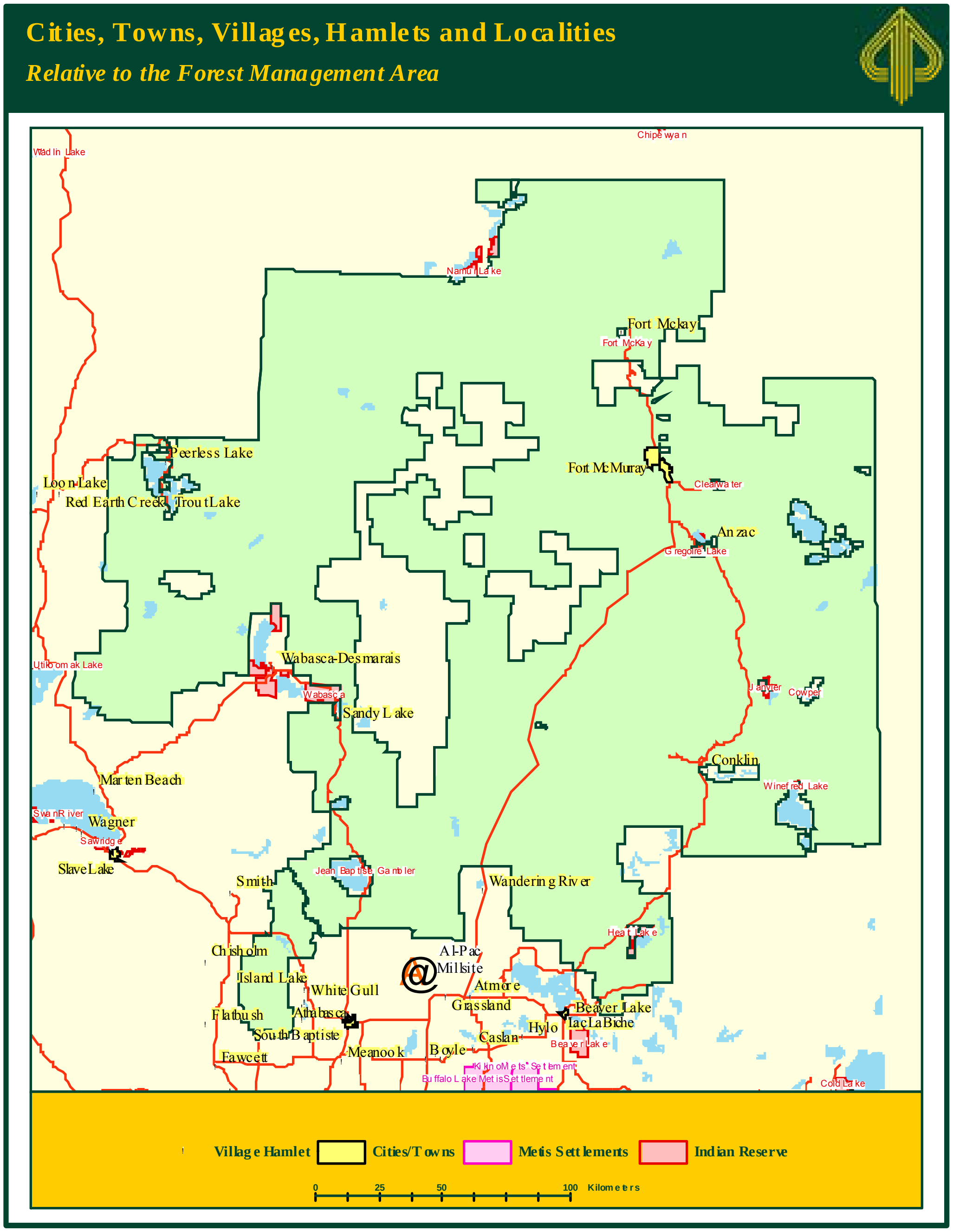

Figure 2.3. Communities and human population centres within the Al-Pac Forest Management area.

Table 2.2. Chronology of events for the city of Fort McMurray and area from 1948 to the present (source: www.fortmcmurry.com)

Year	Event
1948	Bitumount plant commences operation in summer of 1948. Due to accidents, fires and low river levels it was never successful. It closed Sept. 30, 1949.
1957	The Stoney Mountain RCAF radar station became operational as part of the Mid Canada early warning line. It disbanded in 1964.
1965	The Grant McEwan bridge opened providing access across the Athabasca River for the Great Canadian Oil Sands project.
1966	The Fort McMurray General Hospital was built with 34 beds. It was expanded twice in the 1970's to provide 54 beds and additional pediatric, emergency, laboratory and surgical care.
1967	Highway 63 (an all-weather, gravel road to the south) was completed.
1967	Great Canadian Oil Sands plant officially opens.
1974	Syncrude Canada Ltd. begins construction which took four years to complete. Canadian Bechtel Co. handled most of the construction. The plant was initially licensed to produce 125,000 barrels of oil per day.
1978	September 15, 1978 official opening of the Syncrude Canada Ltd. plant at Mildred Lake north of Fort McMurray.
1980	Fort McMurray Regional Hospital opened with 150 beds.
1996	Regional Municipality of Wood Buffalo celebrates first anniversary of amalgamation by unveiling new logo.
1996	June, 1996 Prime Minister Chretian visits the City and announces $25 billion worth of tax breaks for the oil sands industry. Building starts are up and housing prices have increased 20.4% over December 1995.
1999	Shell Canada and two partners announce the Albian Sands project.
Present	Projections for future growth are inextricably tied to the oil and gas processing plants, and the commodity they produce. Approximately $21 billion worth of projects are under construction or on the drawing board from existing plants and companies new to the region. Syncrude opened the North Mine last year and are currently working on the Aurora Mine project; Suncor's Steepbank Mine went into production with project Millenium not far behind. Mobil Oil's Kearl oilsands project is on hold. In addition, other players like Japan Canada Oil, CS Resources, and Doyer either have construction underway, are looking at growth, or are getting planning started.

2.4.2 First Nations

People of Aboriginal ancestry use the land for hunting, fishing, trapping, harvesting and gathering, as well as for spiritual and cultural activities. Traditional Land Use and Occupancy Studies (TLUOS) document how Aboriginal people rely on the land for hunting, fishing, gathering plants, trapping and generally living and traveling in the forest (Robinson et. al., 1994). Alberta-Pacific has supported several TLUOS studies within the FMA area (e.g., Wabasca-Desmarais, Anzac-Janvier, and Conklin).

2.4.3 Oil and Gas Industry

The oil and gas industry is the dominant industrial activity within the FMA area in terms of area disturbed and economic impact (Figure 2.4). Since the first oil and gas developments in 1962, the industry currently creates a very large number of jobs and business opportunities relating to oilsands bitumen extraction, natural gas and crude oil exploration, resource development and pipeline work (Table 2.1). Oilsands extraction is concentrated near Fort McMurray. Oilsands project areas are not included in the table as they are not part of the FMA area. Steam-assisted gravity drainage (SAGD) heavy oil operations are currently a relatively small component of the energy sector in northeastern Alberta, but are expected to become a major contributor to industrial activity in the future. Approximately 70,000 kilometres of seismic lines criss-cross virtually all of the FMA area (Table 2.1), with seismic line densities ranging from .002 km/km^2 to 17.9 km/km^2. As well, oil and gas industry-related roads, wellsites and pipelines are common in most areas.

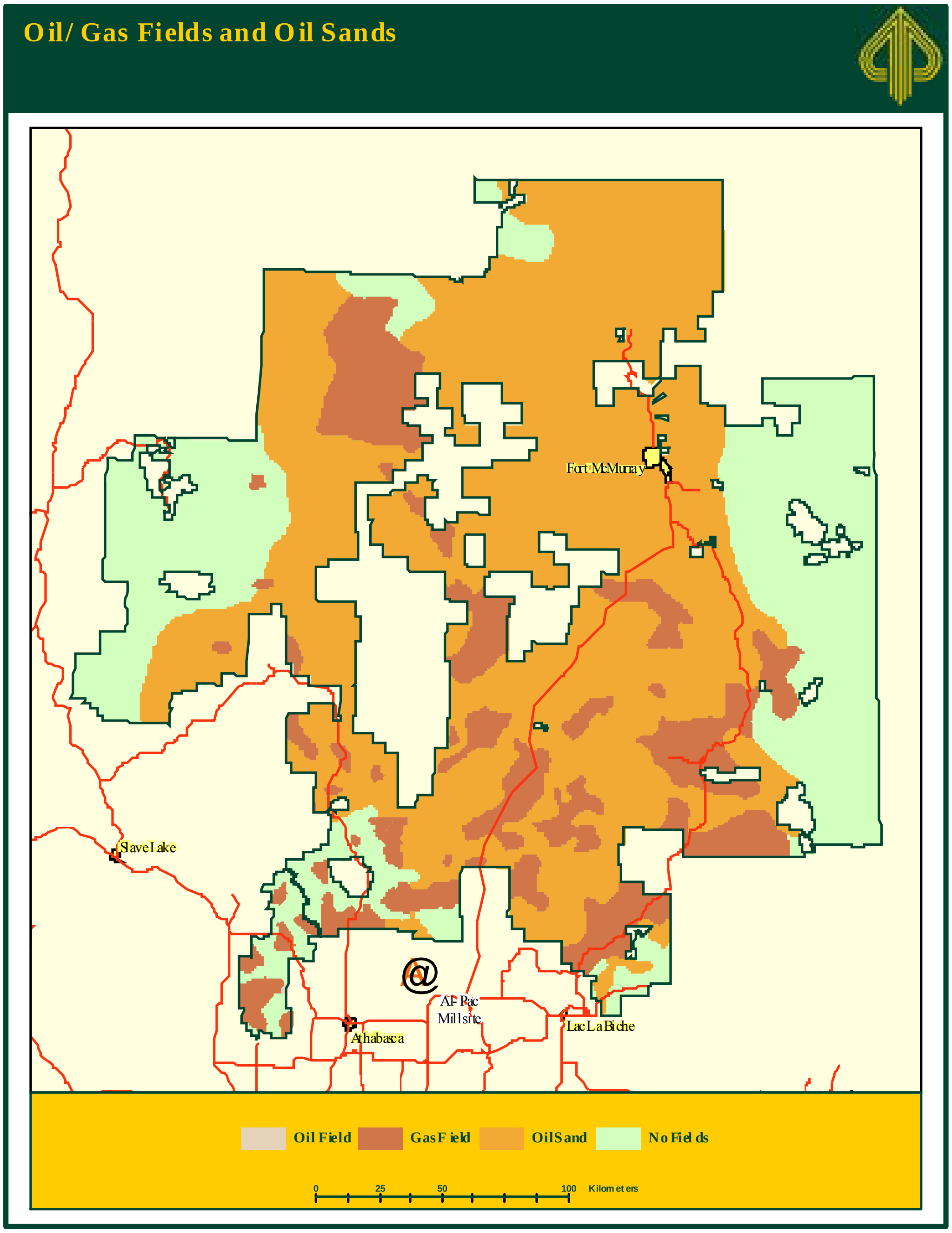

Figure 2.4. Oil and gas fields, and oil sands within the Al-Pac Forest Management Agreement area.

2.4.4 Forest Industry

Coniferous and deciduous harvesting from within this FMA area is well established, with long-term timber quotas being held by eight companies and individuals, and supporting several sawmills and one panel board plant (Table 2.3).

Table 2.3. Chronology of forest industry events related to the Al-Pac FMA from 1826 to present.

Year	Event
1826	Start of commercial forest industry. Change in regulations enabled timber sales of forests which were deemed "not fit and proper" for Navy personnel. This marked the beginning of legal harvesting of timber by private interests on public lands. Important precedents were set in these first timber sales: auction sales - sale to highest bidder; leasing of harvesting rights - lands remaining with the "Crown" or public; renewable leases - tenure could be extended upon conformance to terms of the lease; stumpage - payment of dues to the landowner (Crown) for the rights to harvest timber - based variously on area or volume.
1832	Penalties for human-caused fires first instituted by the Council of Assiniboia
1849	Crown Timber Act - first major Act related to Canada's forests.
1854	Fire legislation enacted - reaction to depletion through fire and agricultural land clearing.
1871	Alberta's first water-powered sawmill built near the Mission at Lac la Biche.
1876	Federal Department of the Interior formed, leading to the establishment of a Crown timber agent in Edmonton in 1882 along with two forest rangers, located in Edmonton and Calgary.
1877	The council of the North West Territories, of which today's Alberta was a part, passed an ordinance for the prevention of forest and prairie fires at its first session.
1880s	Timber cutting rights first sold in Alberta. Sawmills established in Alberta to serve local needs - Lethbridge, Calgary, Red Deer and Edmonton.
1899	Forestry Branch in Department of Interior - Elihu Stewart named first "Chief Forester" for Dominion Forests which were largely located in the North West Territories including Alberta, Saskatchewan and Manitoba.
1900	Canadian Forestry Association – a public support group was established.
1905	Alberta and Saskatchewan established as provinces, and Manitoba expanded north to 60 degrees latitude. Provincial statutes enacted, but forestry remains under Dominion Forest Service for protection and management. Forest protection in settlement areas was a provincial responsibility. Trans-continental railway arrives in Edmonton - two major sawmills: Fraser's and Walter's.
1905	Bill Gordon on his way to the Klondike, decided to stay in Fort McMurray and built the first sawmill. They set up their mill in the area near the Riviera Hotel, close to the Hangingstone River. Their sawyer also came from Edmonton and helped them to harvest logs along the Clearwater River. In the spring the logs would be brought back down the river to the mill in booms in the water.
1915-20	FMU L1 has significant harvesting for the railroad.

1922	Wood Buffalo National Park established.
1930	The Transfer of Resources Act passed responsibility for natural resources, including forest protection, to the provinces. Resulted in the set up of the Alberta Department of Lands & Mines;12,000 sq. mi. in Forest Reserves (31,000 km2); 148,000 sq. mi. in Northern Alberta Forest District which was known as the NAFD (383,000 km 2).
1948	Green Zone established to distinguish between forested land and lands (White Zone) capable of supporting agriculture.
1948	Alberta Forest Service established
1949	Department of Lands & Mines divided into Departments of Lands & Forests; and Mines and Minerals. - start of forest inventories - independently at first, later with support of Canada Forestry Act. Forest Act proclaimed including area base agreements sustained yield management
1950s	Government board reviewed the method of handling timber sales and was able to make no substantial recommendations due to lack of forest inventory information
1950	Bobocel family runs a small portable sawmill in and around Shaw Lake producing 300,000 board feet per year
1952	Fire suppression policy change in Alberta NAFD - from 10-mile rule to attack all fires in northern Alberta.
1955	Construction of the first pulp mill in Hinton signaled the beginning of major forest industry development in Alberta.
1957	First provincial scale forest cover map completed for Alberta. The map includes a forest classification legend with 13 classes.
1960	Imperial mill closes
1960	Bobocel family begin harvesting within Heart Lake Indian reserve
1961	Forests Act revised - authorized Forest Management Agreements, encouraged sustained yield management.
1962	Forest inventories completed - Forest Management Units defined and initial calculations of Allowable Annual Cut (AAC).
1964	Roy Ewashko came to Fort McMurray and started a small portable mill along the Athabasca River north of the Syncrude "Lower Camp". The mill operated in the winter months and could saw approximately 30,000 board feet (about one truckload per day) with it's 30 employees. Northland Forest Products Ltd. now operates a modern sawmill/planer mill complex 20 kms north of Fort McMurray. A full range of dimension lumber is produced from two sawmill lines producing approximately 75 million board feet of softwood dimension lumber per year, and 45,000 oven-dry metric tonnes of conifer woodchips. Northlands are currently a quota holder in the A15 Forest Management Unit.

1966	Quota System authorized in revised Forests Act - changes from competitive bidding to rational allocations and requirements for forest renewal.
1966	Coniferous quotas were sold within the province:

Number of coniferous* quotas earned May 1,1966 by size class (NE Alberta shown)

Forest	< 1 M.M.F.B.M	1 – 3 M.M.F.B.M	3 – 5 M.M.F.B.M	5 + M.M.F.B.M
Slave Lake	19	6	5	4
Lac La Biche	5	3	1	
Athabasca	5	1		

*M.M.F.B.M = Million Foot Board Measure

1970's	Clearcutting becomes common practice in the early 1970s. Until then it was primarily selective harvest of large diameter trees.
1970	Forest Land Use Branch set up in AFS - increased focus on forestland use problems and integrated use for timber, recreation, range, water, petroleum, coal (minerals) and others.
1971	Vanderwell Contractors (1971) Ltd operates a modern sawmill/planer complex located in Mitsue industrial Park, east of Slave Lake. The products are dimensional lumber, chips sold to pulp mills. Vanderwell also installed a bagging plant and pellet plant to utilize the wood waste. Vanderwell is currently a quota holder in the L1, L2, S18 and S22 Forest Management Units.
1971	Number of coniferous quotas effective December 13, 1971 by size class (NE Alberta):

Forest	< 1 M.M.F.B.M	1 – 3 M.M.F.B.M	3 – 5 M.M.F.B.M	5 + M.M.F.B.M
Slave Lake	12	6	10	9
Lac La Biche	4	2	2	1
Athabasca	1	1	1	3

1975	Bobocel family ends harvesting within Heart Lake Indian reserve begins harvesting under the permit system and buying imperial mills quota
1977	Environment Council of Alberta formed (from old Environment Conservation Authority - reduced authority).
1978	Public hearings on impact of forest operations - Dancik report.
1980s	An active community timber program in FMU L1.
1983	Alberta's IA strategy changed fundamentally with the introduction of the "presuppression preparedness system". The probable locations and growth rates of lightning fires are now predicted from daily meteorological forecasts and maps of spatially interpolated fire behaviour indices (Forestry Canada Fire Danger Group 1992). IA crews are then dynamically prepositioned among a network of base camps to minimize expected fire sizes at IA.
1984	St. Jean Lumber (1984) Ltd Manufacturer of Dimension Lumber, Boards, Timbers, Fence Posts and special orders.

1988	Alpac project is developed and initially approved by government
1989	EIA review board appointed for Al-Pac project and hearings conducted
1991	Alberta government approves Al-Pac Forest management agreement (FMA). Construction of mill begins and Al-Pac begins generating AVI for the FMA.
1993	Al-Pac's first harvest begins on the FMA in February, first pulp produced in mid-August. Official opening takes place September 1
1993	Ed Bobocel Lumber Ltd. buys and moves the Imperial mill into Lac La Biche starts Producing dimensional lumber and boards.
1989	Weyhauser acquired Pelican spruce mills at House River and Hangingstone River. Consolidated the operations at Boyle closing the mills at House River and Hangingstone River
1992	Weyhauser close operations at Boyle
1993	Weyhauser operations at Bolye acquired by Millar Western, who modernized and re-opened in 1994, upgrades more than double its capacity to 130 million board feet of spruce, pine and fir dimension lumber per year. Millar Western is currently a quota holder in the L3 and A14 Forest Management Units.
2001	Alberta Vegetation Inventory (AVI) completed for the Al-Pac FMA area

(Sources: History of Forest and Prairie Fire Control Policy in Alberta, Dr. Peter J. Murphy, published by Alberta Environment, 1985, Quota System of Timber Disposal. Timber Management Branch, Alberta Forest service, 1972. Pers Comm George Dribnenki, Ed Bobocel, Ken Yackimec)

2.4.5 Outdoor Recreation and Parks

Eighty-eight guide-outfitters have areas overlapping with the FMA area. As well, the FMA area contains 451 registered traplines. Recreational hunting is prevalent in the fall, and there is a bear hunt in the spring. Large lakes, rivers and streams provide recreational fishing and some commercial fishing opportunities. Recreational fishing, hunting and vacation lodges are found throughout the FMA area. There are also several recreational trails of historic significance on the FMA area, including the Trans Canada Trail that crosses the southwest corner of the FMA area near Smith.

Within the FMA area boundaries there are a number of provincial parks, protected areas and exclusion zones such as major lakes (Table 2.4, Figure 2.5). These areas have been deleted from the FMA area landbase. Linear transportation corridors such as provincial highways, railways, electrical utilities and pipelines also affect the FMA area's landbase.

Table 2.4. Protected Areas in Northeastern Alberta in and around the FMA area

Name	Total Area (ha)
Birch Mountains Wildland Park	130,882
Crow Lake Wildland	1,462
Gipsy Lake Wildland	17,667
Grand Rapids Wildland	25,720
Gregoire Lake Provincial Park	1,401
La Biche River Wildland	16,436
Lakeland Provincial Park and Recreation Area	60,609
Maguerite River Wildland Park	188,435
Otter-Orloff Lakes Wildland	4,225
Poachers' landing Provincial Recreation Area	1,706
Stony Mountain Wildland	12,123
Whitemud Falls Wildland	4,726
Sub total	**465,392**
Wood Buffalo National Park (Alberta Portion)	2,053,597
GRAND TOTAL	**2,618,989**

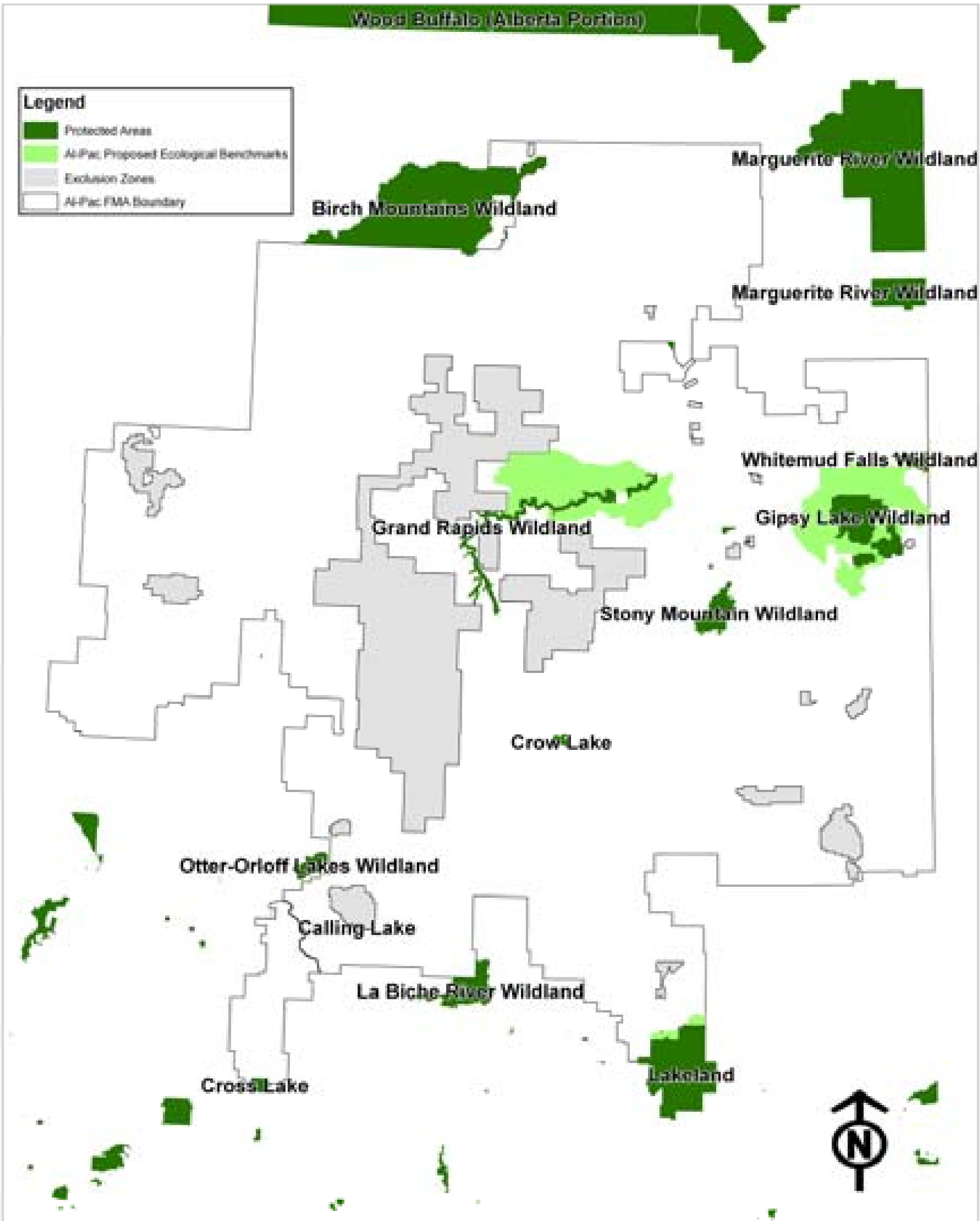

Figure 2.5. Protected areas and exclusion zones in and around the Al-Pac Forest Management Agreement area (exclusion zones are for Al-Pac operations only; other industrial users can operate within exclusion zones; protected areas have some level of government-legislated protection).

3.0 Major Disturbance Factors

Cumming et al. (1996) described the landscape of the boreal forest as having "multi-scaled heterogeneity" created by different processes operating at different temporal and spatial scales. Several disturbance factors contribute to this heterogeneity – specifically fire, insects, pathogens, and wind. However, by far, wildfire is the single most important of these agents in determining broad-scale forest patterns within the boreal forest, and specifically within the Al-Pac FMA area (Armstrong 1998). As a result, the vast majority of time, money, and effort directed towards understanding and managing natural disturbance mechanisms within the Al-Pac FMA area has been directed towards understanding fire and its influence on forest ecology. In turn therefore, more attention is directed towards the topic of fire in the following text of this document.

3.1 Fire

3.1.1 Fire Size Distribution

Wildfires in Alberta range in size from single trees to hundreds of thousands of hectares (Lee et al. 2002). Wildfire size distribution in northern Alberta demonstrates a classic reverse-J or negative exponential distribution – that is, the vast majority of all fires are very small, while only a few are very large (Cumming 2001). However, typically these few large fires make up the majority of burned forest in a given area. Fire data specific to the Al-Pac FMA area is consistent with these trends (Figures 3.1 and 3.2).

Fires two hectares or less account for 79% of all fires recorded in the FMA area from 1961 to 2003. However, as is typically the case, large fires (>1000 ha), while relatively rare, account for 96% of the FMA area burned, and very large fires (between 5,000 and 150,000 ha) are responsible for 83% of the area burned within the FMA area. These figures are very similar to provincial averages reported by Lee et al. (2002). From 1961 to 2003[2], 98% of the area burned in Alberta was due to only 5% of the fires. The largest wildfire recorded in Alberta over the past 40 years was a 409,460-ha fire in 1981. The largest fire recorded within the FMA area was 236,448 ha and occurred in 2002. It is these large fires that play a dominant role in structuring landscape patterns since they account for the vast majority of the area burned within the FMA area.

[2]Fire history and other analyses within this document are based on data up to and including 2003, the most current year of extensive analyses within the FMA for submission of the 2003 Forest Management Plan to the government of Alberta. Updating of data and analyses up to 2005 is underway, but results are not available at this time.

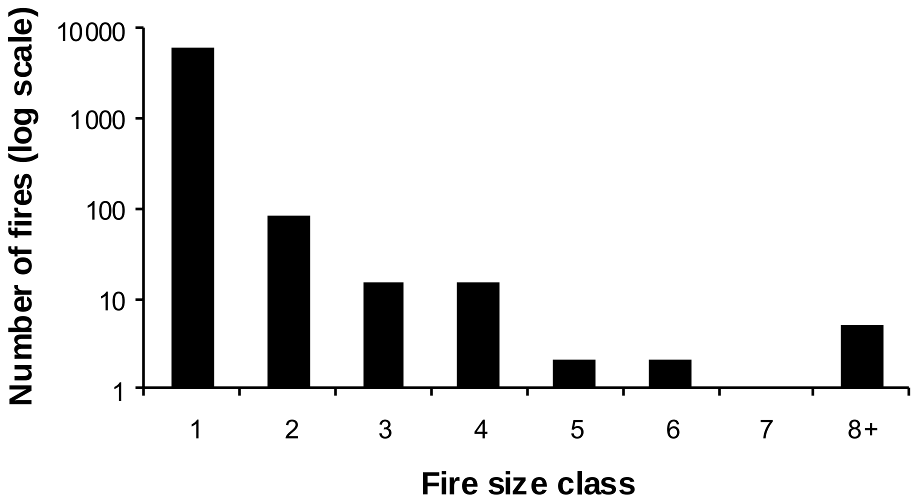

Figure 3.1. Number of fires by fire size class within AL-PAC's FMA from 1961 to 2003 (source: Alberta Forest Service). Classes (ha): 1 = <1,000; 2 = 1,001 – 5,000; 3 = 5,001 – 10,000; 4 = 10,000 – 25,000; 5 = 25,000 – 50,000; 6 = 50,000 – 75,000; 7 = 75,000 – 100,000; 8 = >100,000.

Figure 3.2. Percent of total area burned by fire size class within Al-Pac's FMA area from 1961 to 2003 (source: Alberta Forest Service). Classes (ha): 1 = <1,000; 2 = 1,001 – 5,000; 3 = 5,001 – 10,000; 4 = 10,000 – 25,000; 5 = 25,000 – 50,000; 6 = 50,000 – 75,000; 7 = 75,000 – 100,000; 8 = >100,000.

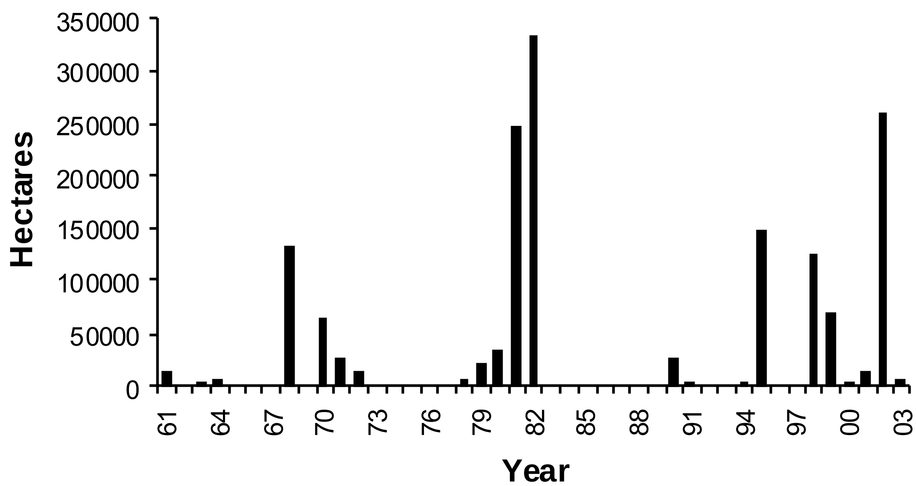

Figure 3.3. Annual total amount of area burned by wildfire within the Al-Pac FMA area between 1961 and 2003. (Source: Alberta Forest Service)

3.1.2 Temporal Fire Patterns

Between 1961 and 2003, an average of 36,119 ha of forest has burned annually within the Al-Pac FMA area (Figure 3.3). However, variability in weather and other forest fire conditions results in large annual variability in the amount of area burned among years. This variability in burned area ranges from a low of 14 ha in 1996, to a high of 332,734 ha in 1982. Thus, describing an "average" year is difficult and must be done with caution. In fact, Armstrong et al. (2001) in discussions of fire patterns in northern Alberta, stated unequivocally that the mean disturbance rate (in relation to fire) for this area is not practically quantifiable because of the extreme variability of annual rates.

Large fires are generally associated with "fire years" in which extreme climatic conditions, including extended periods of drought followed by hot and dry weather, make the forest highly susceptible to burning (Lee et al. 2002). During fire years multiple, extensive fires can occur within the FMA area and surrounding areas. For example, in 1981 six fires occurred in Alberta that each exceeded 100,000 ha. In that same year, there were four fires >10,000 ha within the Al-Pac FMA area alone, and another five fires >50,000 within the FMA area in 1982. These two fire years were then followed by seven years of low fire activity within the FMA area (Figure 3.3). Based on the provincial database of fires greater than 200 ha, an average of 0.4% of the land area in northern Alberta has burned annually since 1961 (i.e., 4 ha burned per year for every 1,000 ha of land). However, because of the impact of fire years, which result in large "spikes" in some years, the rate of burning over time varies tremendously (Figure 3.3). Once again, this variability makes it difficult to characterize an "average" rate of annual burning. Further, studies of charcoal and pollen in lake sediments have demonstrated that burning rates have fluctuated over the centuries, likely in response to long-term climatic changes.

Cumming (2001) investigated burn rates within the Al-Pac FMA area. He calculated that for the 36-yr period between 1961 and 1996, 7.5% of the study area burned, corresponding to an overall annual burn rate of 0.21% (i.e., 0.21% of the area burns annually). This in turn corresponds to a 482-yr fire cycle, which is the amount of time required to burn an area equal in size to the study area. However, differences in the spatial distribution of fire patterns occur (i.e, fires do not burn all forests at equal rates; see section 3.1.3). In contrast, Andison (2003) investigated burn rates within the FMA area and calculated much shorter fire return intervals and reports estimates of 60 to 80 years.

Since the 1950s, fire suppression efforts have steadily increased in terms of dollars spent. By 1971 a policy of total suppression across the entire province was in place. These efforts have not been accompanied by a decreasing trend in the annual area burned (Figures 3.3 and 3.4). While there is some evidence that fire suppression has reduced the number of large fires when climatic conditions are not extreme, suppression does not appear to have been effective in stopping all large fire events. Evidence suggests that the large fires that occur during the extreme fire years account for much of the total area burned over time.

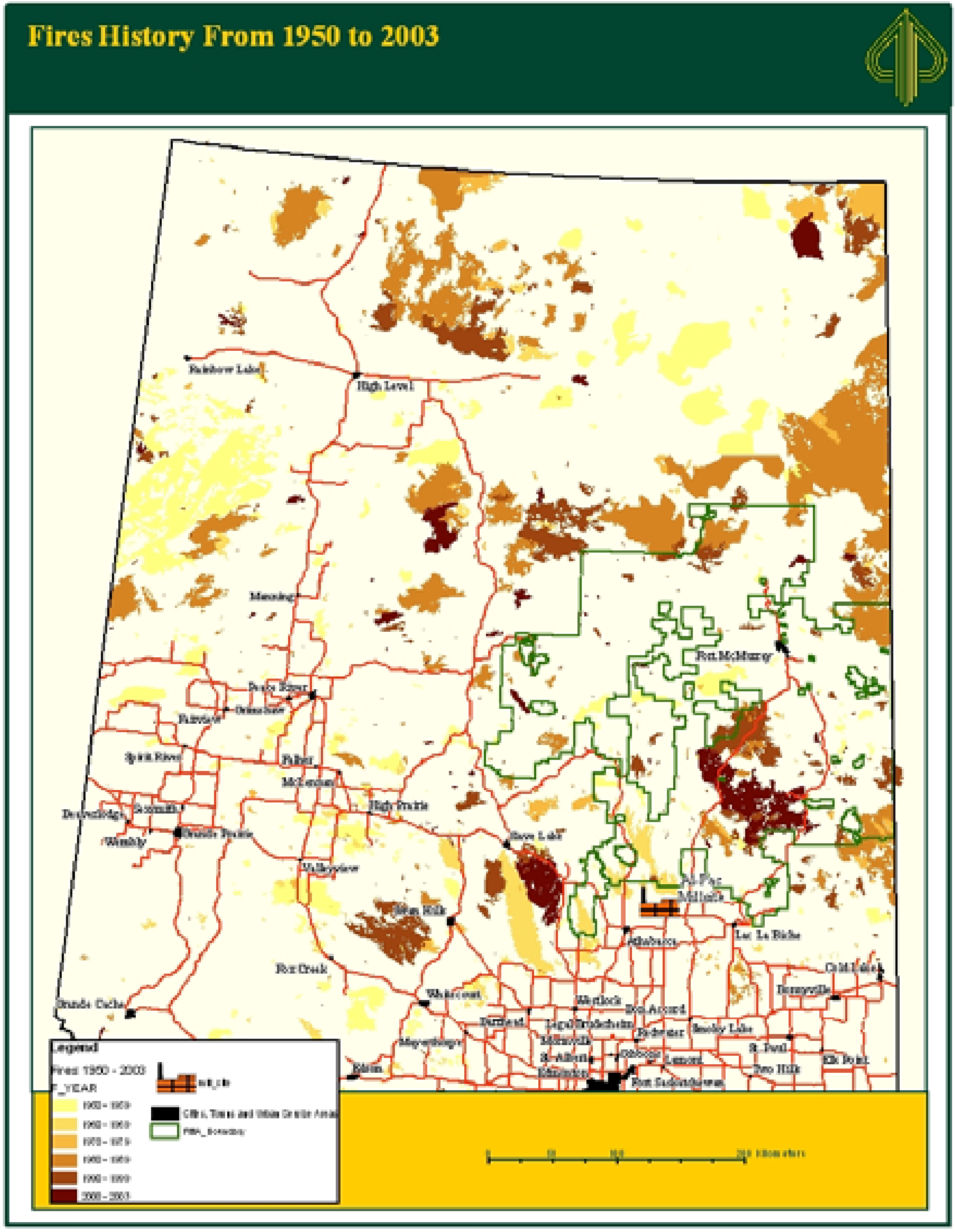

Figure 3.4. Forest fires occurring in Alberta between 1950 and 2003.

3.1.3 Spatial Fire Patterns: what do fires burn in northeastern Alberta?

The influence of large fires on forest landscapes in northern Alberta is profound (Figure 3.4). Cumming et al. (1996) described the landscape of the boreal forest as having a multi-scaled heterogeneity created by processes operating at different temporal and spatial scales – most of it, however, created by episodic, overlapping large fires (Turner and Romme 1994). While large fires burn large areas, they also leave large areas unburned – the resultant landscape is a mosaic of burned and unburned areas creating a complex spatial arrangement of seral stages.
While there is no clearly predictable pattern in the spatial distribution of fires, differences in the rate of burning within the FMA area have been discerned through statistical analysis (Cumming 2001). Given the relatively low rate of burning in the past 25 years (except for 1981, 1982, and 2001) there are many large regions in the province that have not burned at all in the past 50 years. The patchy nature of the burns implies that substantial differences in forest age distribution (variable forest age-classes - i.e., large amounts of older forest and limited amounts of immature forest) will be observed at a landscape scale such as the FMA area.

Burn intensity varies spatially and the seasonal timing of fires also varies within years in response to weather variables (e.g., precipitation and wind speed), physical features of the landscape (e.g., slope, aspect), stand type and suppression activities. For example, flushing (i.e., “leaf-out” or “green-up”) of deciduous stands greatly increases fire resistance. As well, many patches of forest remain unburned because they are downwind of firebreaks such as lakes, streams, and wetlands (Figure 3.6), and are referred to as “fire skips” or “residuals” (see section 3.1.4 for discussions on fire residuals).

Under less extreme climatic conditions, fires are often smaller and less intense, and physical features of the landscape have a greater influence on their behaviour. For example, a firebreak that produces an unburned island in an intense, rapidly moving fire might completely block the forward progress of a less intense fire. Furthermore, when climatic conditions are not extreme, forest stands will vary in their susceptibility to burning and thereby also influence fire behaviour. Cumming (2001) investigated burn rates of various forest types within the Al-Pac FMA area from 1961 to 1996. Deciduous forest types burning least, and Black spruce forest types burning most – based on Cumming (2001) the relationship among various burning rates among forest types in the FMA area can be characterized as the following (Figure 3.5).

Black spruce (0.50) > Pine (0.42) > White spruce (0.17) and Other (0.17) > Deciduous (0.05)

Figure 3.5. Relationship of annual burn rates (%) by forest types within the Al-Pac FMA area (from Cumming 2001).

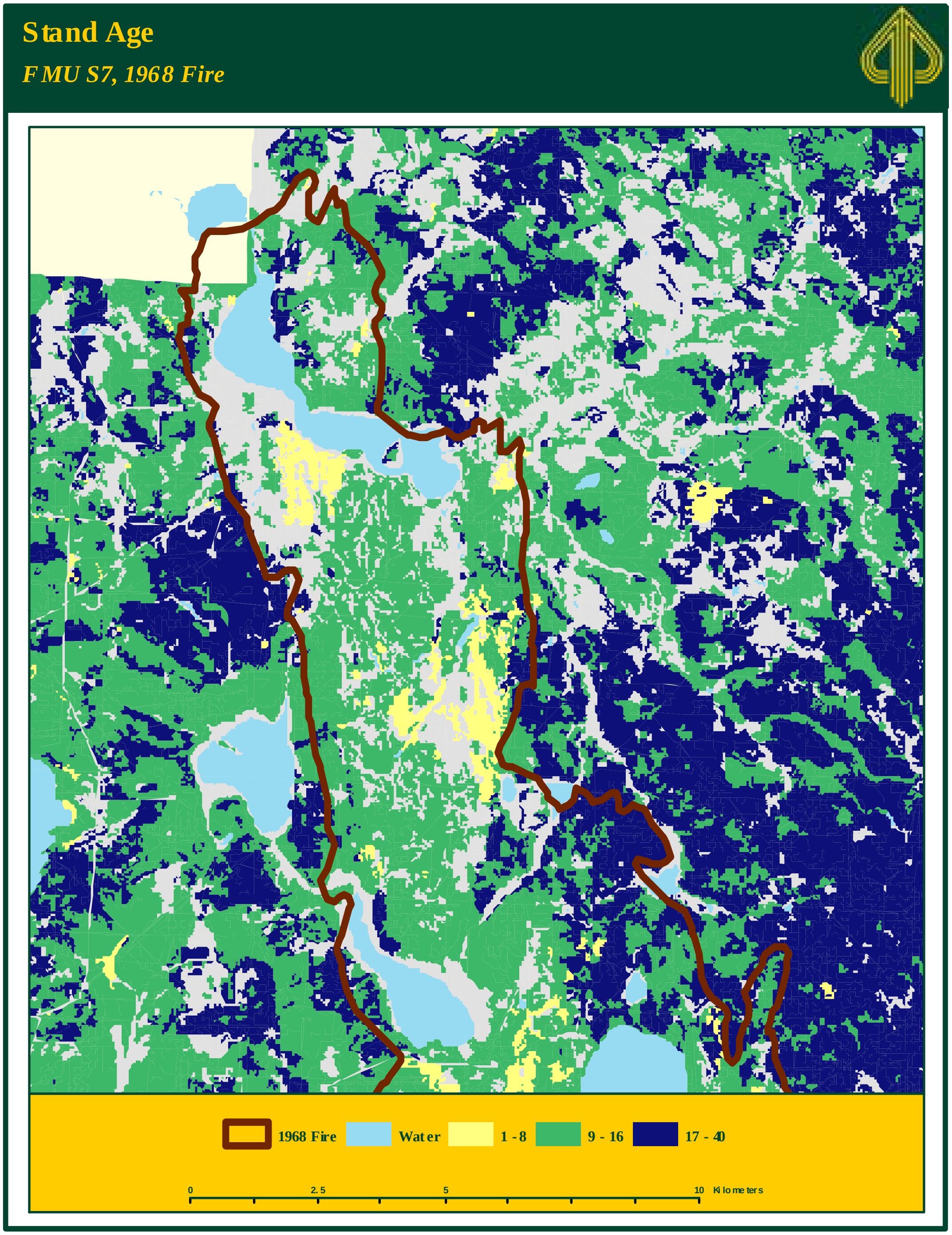

Figure 3.6. Stand age structure following a large fire that occurred in 1968 in FMU S7. The fire (outlined with a thick brown line) was 28,300 ha, of which 9,100 ha are shown. Note the arrangement of large patches of young forest produced by the fire and the patches of older forest dispersed inside the fire boundary.

3.1.4 Post-fire Residuals

A variety of factors – such as differences in fire behaviour and intensity, and differences in fire susceptibility of forest stands – lead to northern Alberta forest landscapes that result in a complex mosaic of burned and unburned forest. Live trees left unburned after wildfire goes through an area are typically referred to as "post-fire residuals" (also referred to as "skips"), and are responsible for much of the natural heterogeneity within boreal forests of northern Alberta.

Similar to the spatial distribution of fires, post-fire residual patches can vary from single isolated trees to larger contiguous patches (Lee 2002). Again similar to fire size distributions, post-fire residual patches follow a skewed distribution when based on frequency (Eberhardt 1986, Smyth 1999, Smyth et al. 2005). That is, the most frequent residuals are small, ranging between 0.1 to 1 ha, while evaluation by area suggests that most of the total area of residuals is found in larger patches ranging from 1 to 5 ha (Smyth & Lee 2001).

In two separate studies of Alberta's boreal forests, Eberhart and Woodward (1987), and Smyth (1999), found that the amount of post-fire residual area increases with the size of the fire. That is, larger fires leave behind more residuals. Generally, fires <200 ha had less than 1% residuals, while fires >2,000 ha had >5% unburned residuals. Smyth and Lee (2001) reported 12% residual for a 36,000-ha burn in a western Alberta riparian area.

The most extensive work on post-fire residuals within the Al-Pac FMA area was performed by Smyth et al. (2005). They investigated eight fires that occurred between 1981 and 1991 within the FMA area, and ranged from 500 to 64,000 ha. Consistent with other studies, they found that the area covered by live residuals was positively related to stand size. Within small stands (<10 ha), mean live tree residuals amounted to 13.3% (range: 0-83%). Within mid-sized stands (10-60 ha), they amounted to 29.5% (range: 0-99%). While within larger stands (>60 ha), mean live tree residuals amounted to 36.9% (range: 3-90%). Overall mean live residuals for all stands combined amounted to 26%. These figures are consistent with other studies in Alberta, where Andison (2001) found mean residuals of 32% (range 0-50%), but also differ from others where Eberhart and Woodward (1987) found mean residuals of only 2% (Table 3.1). This variability among studies illustrates the large variability in natural disturbance patterns.

Table 3.1. Summaries from three post-fire residual studies within Alberta.

Location	Mean residual area (%)	Range (%)	Study
Northern Alberta (Al-Pac FMA area)	26	0 – 98	Smyth et al. 2005
Northern Alberta	2	3 - 15	Eberhart and Woodard 1987
Alberta Foothills	32	0 – 50	Andison 2001

3.1.5 Fire Return Interval

Several researchers have studied historical fire patterns and fire return intervals in northern Alberta, and specifically within the Al-Pac FMA area. Variability exists among studies and opinion among researchers as to fire return intervals within this region. This variability exemplifies Bergeron et al's (1998) statement that no one single fire return interval exists for any region, and that fire return intervals within the boreal forest have been observed to shift from short to long. Differences and variability in estimates of fire return rates can greatly affect forest management regimes, and are therefore important to consider carefully. Under a management regime based on emulating natural disturbance, managers can choose to harvest forests at a rate similar to naturally occurring fire rates, based on a naturally occurring fire return interval. As a result, rates varying from low to high can have profound effects on forest management and ensuing rates of harvest.

The fire return interval is defined as the expected time between fires at any given location (Cumming 2000). There is much debate about what the average fire return interval is across the Canadian boreal forest, and specifically the fire return interval within the Al-Pac FMA area – presumably due to the impossibility of determining the exact parameters of historical fire events prior to the record-keeping era of the mid 1900s. In a national review, Ward and Tithecott (1993) reported a range of fire cycles between 20 and 500 years for the boreal forest, thus illustrating the variability and difficulty of determining fire return intervals. In 2003 Al-Pac hosted a meeting of fire experts to seek expert opinion on what the pre-industrial fire return interval was within the Al-Pac FMA area. Fire cycle estimates reported at this meeting ranged from 40 to 250 years.

In a review of provincial fire statistics and historical data, Tymstra et al. (2005) reported rates for the Alberta Central Mixedwood region (which makes up 85% of the Al-Pac FMA area) and Boreal Highlands (which makes up 15% of the FMA area). They calculated annual burn rates of 0.44% and 0.80% for the Central Mixedwood and Boreal Highlands, respectively. These rates translated to average fire cycle of 226 yrs and 124 yrs, respectively.

Using an age-class distribution roll-back technique, Andison (2003) estimated burn rates by decade within the Al-Pac FMA area, which varied from 4.3% to 30.2% (Table 3.2). From these data, the average burning rate was calculated as 21% per decade, which in turn corresponds to 2.1% annually. These figures then correspond to a 48-yr fire cycle, or fire return interval. On this basis, and work performed in adjacent landscapes within the Mistik FMA area, Andison (2003) believes the fire return interval within the Al-Pac FMA area is between 40 and 60 years.

Table 3.2. Estimated percent area burned by decade within the Al-Pac FMA area (from Andison 2003).

Decade	Estimated % burned
1960s	4.3
1950s	10.5
1940s	28.6
1930s	25.7
1920s	30.2
1910s	26.7
Average	21.0

Conversely, Cumming (2000, 2001) provided estimates of much longer fire return intervals within the Al-Pac FMA area. By summing the areas of all known fires between 1961 and 1996, he estimated the annual burn rate to have been 0.21% for that period, corresponding to a fire return interval of 476 years. In a previous analysis (Cumming 1997) over the interval 1940 to 1993, he attempted to correct for the impact of fire suppression since 1970. This yielded an estimated annual burn rate of 0.41%, which corresponds to a fire return interval of 244 years. On this basis, Cumming believes the fire return interval for the Al-Pac FMA area to be approximately 250 years.

In more recent work, Cumming (2005) showed that fire suppression by initial attack has effectively reduced the proportion of large fires, and detailed the assumptions under which this effect could lead to a reduction in burn rate; these assumptions appear likely to hold at the present time. A far more complex challenge is to determine what effect if any fire suppression has on he final size of fires that escape initial attack. As an initial step, Cumming and Lele (in prep) used survival analysis techniques to show that prompt initial attack does reduce to some degree the average final size of large fires. Cumming (personal communication) states that they cannot yet quantify the net effect of these processes on fire regime, but a reduction by an additional factor of two seems at least plausible. Simulation models of forest succession and dynamics calibrated for the portions of the AlPac FMA using a fire regime generating a mean annual burn rate of about 1% (which translates to a fire return interval of 100 yrs) show that the age structure and species composition of current landscapes, corrected for historical forest harvesting, are within the RNV of simulated landscapes.

3.2 Insects and Pathogens

Forest insects and tree pathogens (diseases) are natural processes that can play a major role in boreal forest dynamics, but have had to date relatively little influence (relative to fire) on broad-scale patterns with the Al-Pac FMA area. Forest health (related to insects and pathogens) is primarily the responsibility of Alberta Sustainable Resource Development (SRD)[3]. Forest companies in Alberta co-operate with Alberta SRD forest health programs that are aimed at continued healthy forest conditions in the FMA area.

From a forestry perspective, good forest health is a desired condition of the forest in relation to management objectives. In a forest health program, biological, physiological, and environmental factors that have an adverse effect on the health of the forest are carefully monitored and/or managed. Maintaining forest health is accomplished through detection, surveying and monitoring, assessment of risk, and the implementation of various management programs in forest stands. As of 2005, there have been no major outbreaks of insects or diseases in the Al-Pac FMA area throughout its history (since 1993). Over the previous 20 years there have been minor spruce budworm and tent caterpillar outbreaks. Budworm infestations have in the past resulted in increased cutblock sizes and early removal of second pass stands to eradicate the problem. There have been no major actions to mitigate tent caterpillar outbreaks on the FMA area. Al-Pac, the Quota Holders, and Alberta Sustainable Resource Development will remain pro-active in a combined approach to identify and manage forest health challenges.

3.2.1 Insects

Forest tent caterpillar and spruce budworm are two principal defoliating insects of the boreal mixedwood forest (Table 3.3). Tent caterpillars undergo dramatic increases and collapse of populations, with a period of approximately 14 years (Roland 2000). During the outbreak phase of their cycle, tent caterpillars are probably the most abundant animal (in terms of biomass) in aspen-dominated boreal forest, causing complete defoliation of trembling aspen trees in some cases. Their defoliation can reduce the incremental growth of aspen trees, and repeated defoliation also increases the risk of tree mortality (Hildahl and Reeks1960).

The last time there was a forest tent caterpillar outbreak in the FMA area was 1988. Trapping data indicate that densities have been increasing across the FMA area since 2000, and are now outbreaking in the more northerly parts (J. Roland, Univ. Alberta, personal communication).

Generally however, forest insects have not been considered a major disturbance factor within the Al-Pac FMA area. Direct control of insects in the FMA area is usually not necessary, because the impact of most insects has not been critical to fibre supply. As stated previously, there have been no major insect outbreaks in recent history that have required major management control efforts. However, within the FMA area, four insect species are of concern to managers and potentially affect forest dynamics (Table 3.3).

[3] Further information on Alberta's Insects & Disease program can be found on the Alberta Environment website (http://www.srd.gov.ab.ca/forests/health).

Table 3.3. Insect species of concern to managers that potentially affect forest dynamics within the Al-Pac FMA area.

Insect	Scientific name	Host
Tent Caterpillar	*Malacosoma disstria*	Aspen and Poplar
Spruce budworm	*Choristoneura fumiferana*	Spruce and Balsam Fir
Satin Moth	*Leucoma salicis*	Aspen and Poplar
Aspen Tortrix	*Choristoneura conflictana*	Aspen and Poplar

3.2.2 Pathogens

Similar to insects, pathogens are not considered a major disturbance factor within the Al-Pac FMA area. Although many pathogens attack aspen and conifers, relatively few kill or seriously injure living trees – thus lessening their importance as a disturbance agent in boreal forest dynamics. The common deciduous leaf diseases, in general, are widely distributed throughout the range of aspen, whereas there are subtle differences in distribution between the important decay fungi, and apparently entirely different areas of distribution of major canker causing organisms. There have been no major outbreaks of tree pathogens within the Al-Pac FMA area that have resulted in major management control efforts. However, there are large gaps in knowledge of disease organisms and their influence on natural and regenerated stands in boreal forests. These knowledge gaps are being addressed through government and industry research and monitoring initiatives and programs throughout Alberta. Three main pathogens occur within the Al-Pac FMA area and potentially affect forest dynamics (Table 3.4).

Table 3.4. Tree pathogens of concern to managers that potentially affect forest dynamics within the Al-Pac FMA area.

Pathogen	Scientific name	Host
Armillaria Root Rot	*Armillaria ostoyae*	All commercial tree species
Shepherd's Crook	*Venturia* species	Aspen and Balsam Poplar
Aspen Trunk Rot	*Phellinus tremulae*	Aspen and Balsam Poplar

3.3 Wind

In some forested ecosystems, wind disturbance can play a fundamental role in shaping forest dynamics (e.g., Coastal British Columbia [Stathers et al. 1994]; southeast Alaska [Nowacki and Kramer 1998]). However, wind is not considered a significant disturbance factor at a landscape scale within the Al-Pac FMA area. Occasional, small, site-specific wind events (individual or groups of trees blown over) can occur within the forests of the Al-Pac FMA area, resulting in salvage operations within effected stands. However, no major catastrophic wind event has occurred within the FMA area in the last 10 years requiring specific management or planning on a broad scale in the last ten years.

4.0 The Non-Industrial Forest Condition (NIFC)

4.1 Methods

4.1.1 Baseline data: Alberta Vegetation Inventory

The current Alberta Vegetation Inventory (AVI) data (as of January 2006) for the Al-Pac FMA area was used as the baseline data to generate a non-industrial forest condition (NIFC) for this document. All industrial feature polygons within the AVI were removed to produce a snapshot of the current forest cover without industrial impacts. This is a reasonable approach, since only 2.2 % of the FMA area within the AVI is attributed to industrial activities (see processing steps below for listing of attributes used to define industrial). As well, since Al-Pac is a relatively young operation, there are no second-rotation deciduous areas harvested within the FMA area, thereby further validating the approach.

Al-Pac initiated the AVI of their FMA area in 1991 and completed the full inventory in 2001. AVI is a photo-based inventory supported with air and ground observations. Aerial photography is acquired at various scales. The photos are used to create orthophotos, which are a spatially accurate, photo-like product used to correct the scale of the forest cover type lines and new planimetric detail (rather than stereoplotting). The airphotos are stratified by photo-interpreters into similar vegetative cover types, in accordance with the most current AVI Standards Manual. AVI updates to the FMA area database will meet or exceed minimum requirements identified in the Alberta Sustainable Resource Development AVI Standards Manual (Version 2.1; www.srd.gov.ab.ca/land/g_data-catalogue_avi.html), and as such will include conifer understory mapping. Polygon boundaries and other lines are then transferred from the airphotos to orthophotos using a stereoscope and are then digitized and merged with the provincial basemaps in a geographic information system (GIS).

Vegetative cover types are classified based on species, height, age, crown closure, coniferous understory, stems per hectare, and site conditions. The validation process requires a forest classifier to fly over the area making equal to or greater then 30 air calls per township, while crews conduct ground traverses and establish equal to or greater then 10 ground samples per township. Incorporated into this validation process is an age program in which tree ages are collected, with species, diameter and height information, to aid in the classification of vegetation types. Using the air photos and the field information, the classifier then describes each forest type and creates an attribute file, which is merged with the digital map file to produce the forest cover map.

Forests are dynamic and constantly changing through growth and disturbances, both natural and human caused. Forest inventories become outdated if they are not maintained therefore Al-Pac and the quota holders will continue the annual systematic update of harvest depletions, fires, other natural disturbances and land use activities (e.g., roads, seismic lines, pipelines) within the FMA area. Updates will be done to current provincial standards using aerial photography on a five-year cycle (one-fifth of the FMA area per year), with every second land use update completed in conjunction with the ten-year re-inventory of vegetation.

All updates of basemap features (watercourses, lakes, roads, etc.) will be digitally captured and coded as per Alberta Government Map Base Update Specifications and Procedures.

4.1.2 GIS-based methodology

4.1.2.1 Removing industrial features from the current 2006 AVI to produce a Non-Industrial forest condition

Processing of the more then 880,000 polygons of AVI dataset within the Al-Pac FMA area to produce a NIFC was essentially a two-step process:

(1) All industrial feature polygons (Figure 4.1) where removed from the forest cover data by "growing in" the surrounding forest cover in over top of the industrial features polygon (see detailed description below)

(2) Existing cutblocks were removed from the forest cover by assigning them the forest cover attributes of the nearest merchantable stand. This process created a forest cover database for the FMA area without any industrial feature footprints, and with forest cover attributes similar to current stand types.

The following describes this process in more detail.

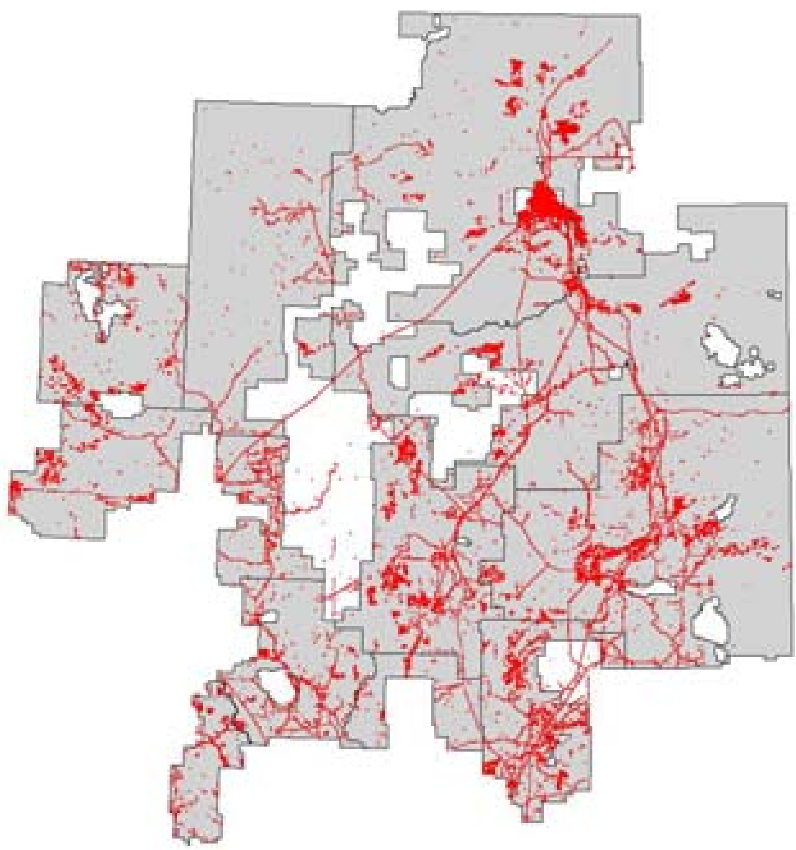

Figure 4.1. Industrial polygons (red) within the Al-Pac Forest Management Area. Source: Alberta Vegetation Inventory - 2005.

All steps described below were performed within each township contained in the Arc librarian structure used by Al-Pac to store the AVI dataset.

Step 1. All industrial feature polygons within the AVI were selected from the ANTH_VEG and ANTH_NON codes (Tables 4.1 and 4.2).

Step 2. These industrial feature polygons were then attributed to a unique masking attribute value.

Step 3. The AVI data was then converted to raster data with 1-m cell size based on its unique polygon ID number.

Step 4. The ArcGIS Grid NIBBLE command (ESRI 2005) is then used to replace areas in the grid corresponding to a mask value with the value of the nearest raster cell neighbour until the entire mask area was processed (Figures 4.2 and 4.3). Briefly, the NIBBLE command replaces cells (i.e., industrial cells in this case) with duplicates of adjacent cells (i.e., surrounding forest in this case) until all industrial cells are removed and replaced with forest cover cells.

Table 4.1. ANTH_VEG* codes selected within the AVI database to capture industrial polygons within the Al-Pac FMA area.

Code	Description
CA	Annual Crops – cultivated farmland, or farmland planted with annual crop species.
CIP	Pipelines, transmission lines, airstrips, microwave tower sites that have been seeded to perennial grasses.
CIW	Geophysical activities including well sites that have been seeded to perennial grasses.
CP	Perennial Forage Crops – reclaimed lands, farmland planted with cultivated grasses and/or legumes. These lands are used primarily for grazing livestock or may have the cultivated species harvested at least once a year. These lands contain < 10% crown closure of woody cover (shrubs). These lands also included pastures that have been irrigated or otherwise treated to improve their productivity.
CPR	Rough Pasture – similar to improved pasture (CP) with > 10% woody cover. Normally, this pasture has not been irrigated, fertilized or cultivated to improve productivity. An open or closed shrub notation must be added to indicate the height, extent and type of shrub cover.

ANTH_VEG code:* A vegetated stand where the vegetation has been influenced by human activity, usually in areas that have been planted with cultivated species.

Table 4.2. ANTH_NON codes selected within the AVI database to capture industrial polygons within the Al-Pac FMA area.

Code	Description
AIE	Peat Extractions
AIF	Farmsteads
AIG	Gravel pits including borrow pits
AIH	Permanent right of way; roads, highways, railroads, dam sites, reservoirs.
AII	Industrial (plant sites), sewage lagoons.
AIM	Surface mines
ASC	Cities, towns, villages, hamlets
ASR	Ribbon development, rural recreation, rural stores and isolated housing subdivisions, cottages, rural residential, acreage owners, (agriculture is not the primary source of income).

*ANTH_NON code: A layer where the major component is anthropogenic non-vegetated created by human activity.

Figure 4.2. Example industrial polygons (yellow) within the AVI database and attributed with masking values.

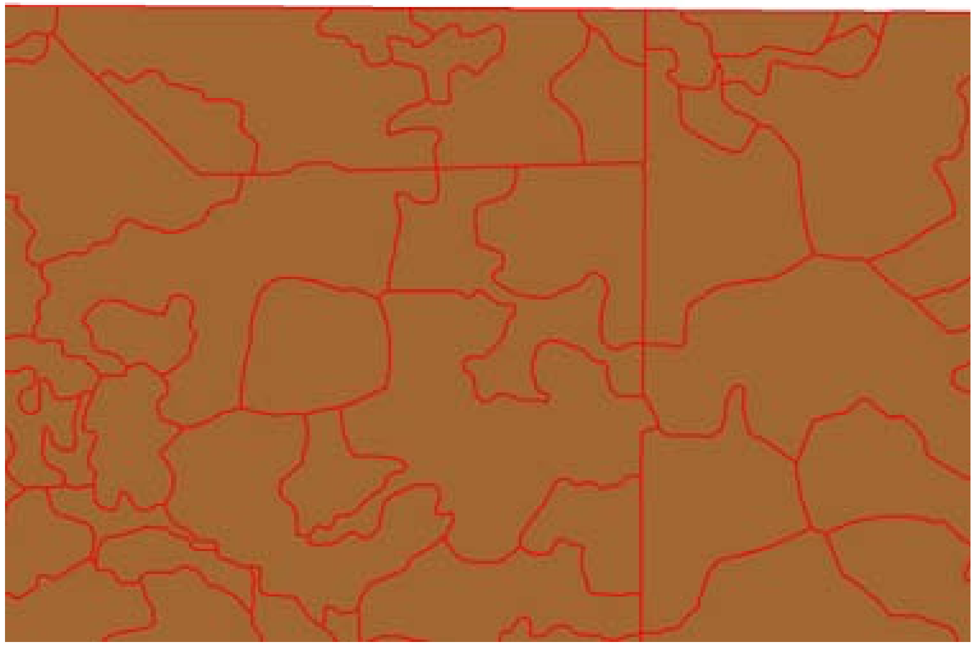

Figure 4.3. The example area (from Figure 4.1) after NIBBLE command processing (the straight lines are an artefact of raster data processing).

Step 5. The resulting raster was then converted back to a polygon coverage.

Step 6. Existing cutblocks within the AVI that contained no forest cover information were selected, based on modifier attributes: "CC" (cutblock) or "CL" (clearing). For cutblocks (modifier = "CC") that had forest cover information, the information was either the original forest cover information before harvesting, or the current growing forest cover that has been updated with ongoing AVI update process (Dave Cheyne, personal communication). These cutblocks were not removed in the process, but treated as existing forested stands. While this could potentially introduce a younger age-class bias, these stands only made up 0.27% of the AVI stands processed, thereby minimizing any effects.

Step 7. The ArcGIS NEAR command was used to locate the nearest merchantable forest stand to the selected cutblock. Forest cover attributes of the nearest merchantable stand were then transferred to the cutblock in question.

As a result of this portion of the dataset creation, a total of 144,000 ha of industrial polygons (2.2% of the 6,521,723-ha FMA area) were attributed to pre-industrial forest condition polygons (Figure 4.1).

4.1.2.2 Reclassifying the new AVI data

The process described in the preceding section resulted in an AVI forest cover database that contained no industrial feature polygons within the Al-Pac FMA area. The next processing phase involved reclassifying the new AVI data to create 25 forest cover classes that were used to characterize the pre-industrial forest conditions.

The 25 classes were based on 20 harvestable forest classes and 5 other classes. The 20 harvestable forest classes were derived from 5 forest types (deciduous, pine, white spruce, black spruce, mixedwood; Table 4.3), in combination with 4 age classes (juvenile, immature, mature, old; Table 4.4). The 5 other classes were: burn, non-forested vegetated, forested non-productive, water, and other (Tables 4.5 and 4.6).

Table 4.3. Selection criteria for forest types based on dominant tree species.

Forest type*	Dominant Species**
Deciduous	Aw, Pb, Bw
White Spruce	Sw, Fb
Black Spruce	Sb
Pine	Pj, Pl
Mixedwood	Crown closure < 50%

*Based on dominant tree species with crown closure $\geq$ 50%.
**Aw = aspen, Pb = balsam popular, Bw = white birch,
Sw = white spruce, Fb = balsam fir, Sb = black spruce,
Pj = jack pine, Pl = lodgepole pine.

Table 4.4. Selection criteria for age classes based on stand age and structural characteristics.

Age class	Criteria
Juvenile	1-10* yrs or 1-20† yrs. This is the establishment or regeneration phase of tree growth (seedlings or suckers). No merchantable volume in this stand type.
Immature	11-60* yrs or 21-60† yrs. Trees or stands that have grown past the regeneration or juvenile stage but are not yet mature. Trees are still considered non-merchantable. The stand is represented by the rapid growth segment of a yield curve.
Mature	61-100* yrs or 71-120† yrs. Trees or stands that are sufficiently developed to be harvestable and that are at or near rotation age. These stands represent the peak growth volume segment of a yield curve.
Old	100+* yrs or 120+† yrs. An aging stand that is past the mature stage. Stands have declining growth volume rates and increased individual mortality. These stands demonstrate changes in the upper forest canopy (i.e. gap dynamics) and have an increasing recruitment of snags and downed woody debris.

*Applies to deciduous, mixedwood and pine; †Applies to black and white spruce

Table 4.5. Selection criteria (AVI codes) for burns, non-forested vegetated, water, and other classes within the Al-Pac FMA area pre-industrial forest analysis.

Class	Attribute*	Code	Description
Burn	MOD1	BU	Burn/partial burn
Burn	NAT_NON	NMB	Recent burn including snag modifier and snag density if present
Non-forested vegetated	NFL	BR	Bryophyte – mosses and/or bryophytes
Non-forested vegetated	NFL	HF	Herbaceous (Forbs) – natural herbaceous plant cover dominated by forbs (not graminoids). Forbs included aquatic plants living in shallow water.
Non-forested vegetated	NFL	HG	Herbaceous (Grassland) – natural meadow and grassland and/or sedges, graminoids predominant.
Non-forested vegetated	NFL	SC	Closed shrub (crowns of most shrubs interlocking)
Non-forested vegetated	NFL	SO	Open shrub (crowns of most shrubs not touching each other)
Water	NAT_NON	NWL	Seasonally thaws: lakes, ponds
Water	NAT_NON	NWR	River
Other	NAT_NON	NMC	Cutbank
Other	NAT_NON	NMS	Sand
Other	NAT_NON	NWF	Flooded – areas periodically inundated with water
Other	NAT_NON	NWI	Permanent Ice/Snow

*MOD1 = condition or treatment providing additional information; NAT_NON = natural cover types with < 6% plant cover; NFL = major component is naturally non-forested with ≥ 6% plant cover, but < 6% tree cover.

The forested non-productive class was derived from the following criteria:

- Stands containing Lt (tamarack)
- Stands with crown closure code "A" (6-30%)
- Stands with timber productivity "U" (unproductive)
- Stands with a non-commercial site index (see Table 4.6)

Table 4.6. Alberta Vegetation Inventory criteria* for non-commercial site indices by tree species. Values represent height and age cut-offs that distinguish between commercial and non-commercial growth trajectories by species.

Stand Height (m)	Stand age threshold (years) by leading species**			
	Sb	Pj or Pl	Sw or Fd or Fb	A or Aw or Bw or Pb
1	>18	>13	>27	>18
2	>18	>13	>27	>18
3	>18	>13	>27	>18
4	>28	>22	>38	>26
5	>37	>28	>49	>34
6	>47	>37	>60	>46
7	>57	>47	>72	>53
8	>68	>57	>84	>67
9	>80	>68	>95	>75
10	>93	>80	>107	>86
11	>117	>95	>120	>101
12	>123	>111	>134	>117
13	>140	>130	>148	>136
14	>165	>160	>165	>160
15	>180	>180	>180	>180

*age at which a tree must attain the associate height; otherwise is considered a non-commercial growth rate. The non-commercial site index subjective deletion excluded slow growing stands that may never reach merchantable height. The approach is based upon a height-age requirement that states a stand must attain a height of 15 meters by 180 years of age.
**Sb = black spruce, Pj = jack pine, Pl = lodgepole pine, Sw = white spruce, Fd = Douglas-fir, Fb = balsam fir, A/Aw = aspen, Bw = white birch, Pb = balsam popular

The reclassified forest cover was then run through the ArcGIS DISSOLVE command to merge similar adjacent polygons into single polygons based on having the same NIFC class. However, polygons having the same NIFC class, but separated by water (e.g., a stream) were not merged, and remained as two separate polygons. The database was then run through the ArcGIS ELIMINATE command to remove sliver polygons of less then 1 hectare with no NIFC class attribute. Slivers were joined to the adjacent NIFC polygon they shared the largest edge with.

The resulting reclassified vegetation inventory database was then used for all mapping and statistical descriptions of the NIFC.

4.2 Characterization of the Non-Industrial Forest Condition at Year 2006

4.2.1 Forest Composition

The NIFC land base composition for the Al-Pac FMA area (total area = 6,521,723 ha) is dominated by the forested non-productive class (53% of land base; Figure 4.4). Productive forest types make up 33% of the land base, with the remaining 14% of the area made up by non-forested vegetated, burn, water, and other (Figure 4.4, see section 4.1.2.2 for class descriptions. Within productive forest types, deciduous forests make up 61%, followed by Pine with 18%, Black spruce with 13%, White spruce with 6%, and mixedwood forests at 1% (Figure 4.5).

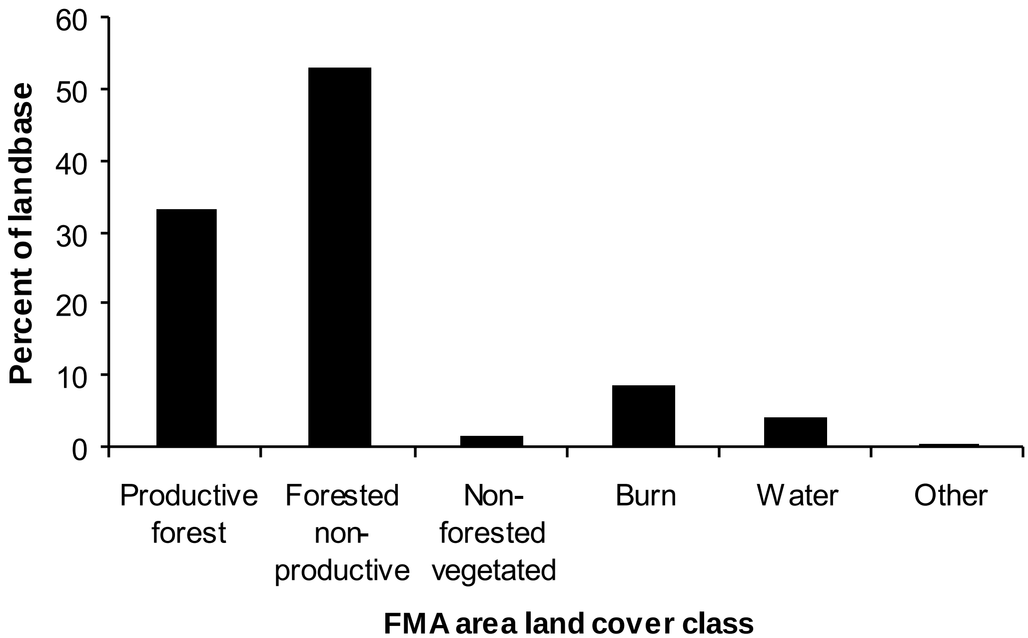

Figure 4.4. Non-industrial land base composition within the Al-Pac Forest Management Agreement area. (see section 4.1.2.2 for class descriptions).

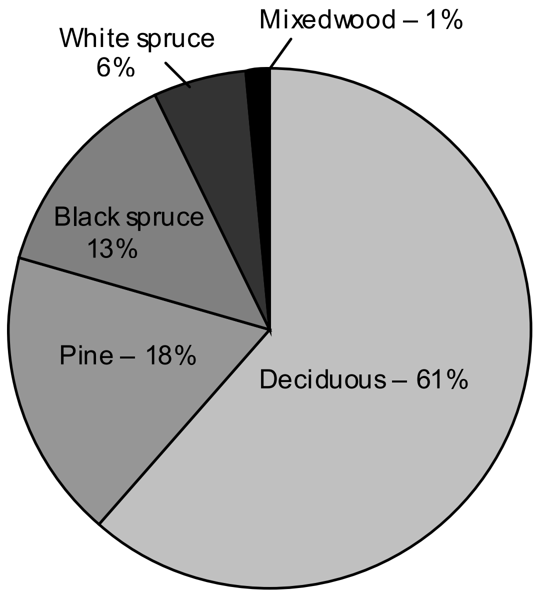

Figure 4.5. Non-industrial productive-forest composition within the Al-Pac Forest Management Agreement area (see section 4.1.2.2 for forest type descriptions).

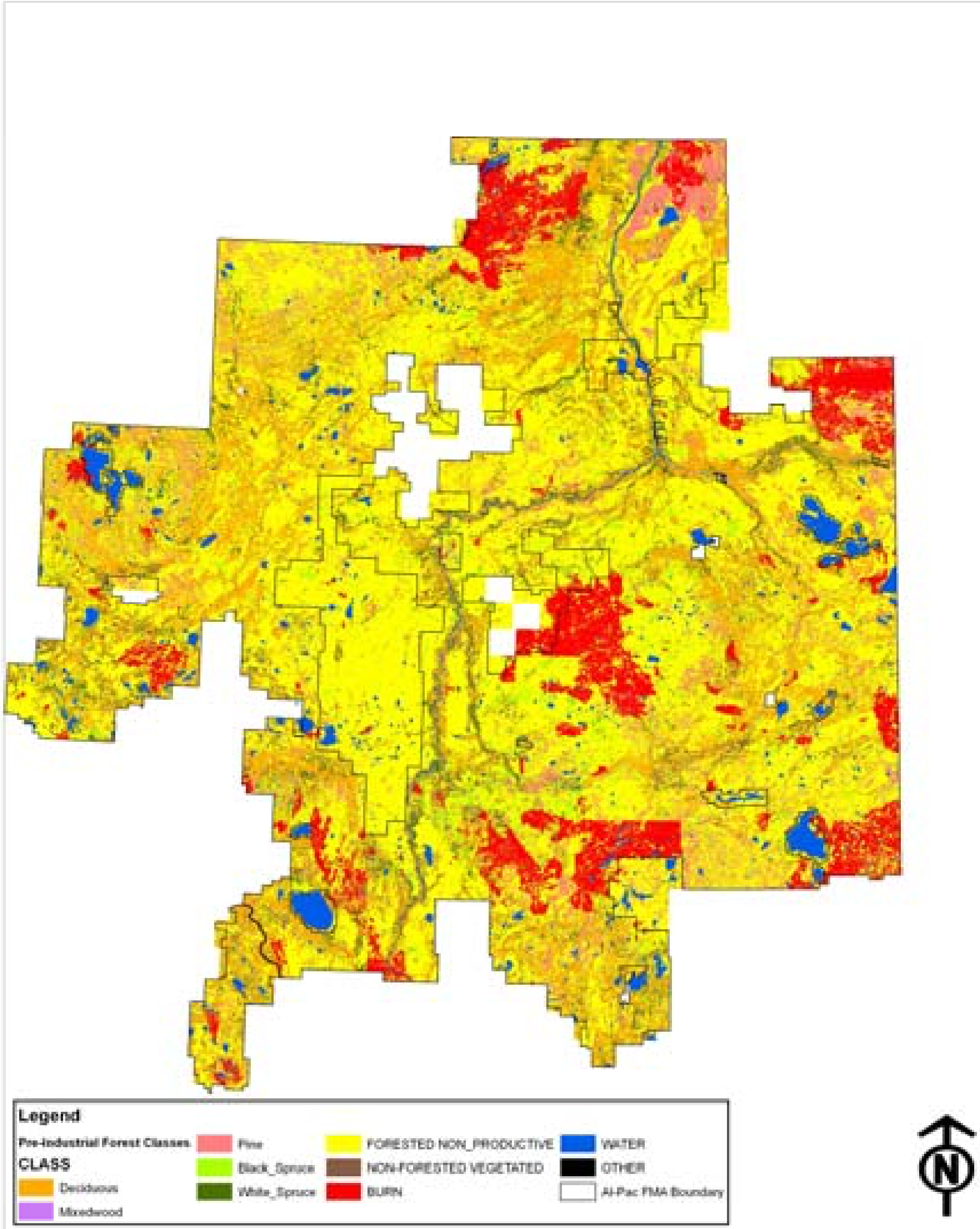

Figure 4.6. Non-Industrial Forest Condition classes spatial distribution within the Al-Pac Forest Management Agreement area (see section 4.1.2.2 for age class definitions).

4.2.2 Age class distribution FMA area 2006

The age class distribution of the NIFC productive forests within the Al-Pac Forest Management Agreement area for this point in time is dominated by mature forests (64%; Figures 4.6, 4.7, and 4.8). Mature and old forests combined make up 84% of the NIFC productive forests (Table 4.7). Less than 16% of the NIFC forest is juvenile and immature (Figure 4.7). This age class distribution is consistent across all forest types (Figure 4.7). All forest types are dominated by mature forest (range = 44% to 83%, excluding white spruce) with the exception of white spruce, which is dominated by old forests (79%; Figure 4.7).

Table 4.7. Amount of mature and old* forest within NIFC productive forest classes within the Al-Pac Forest Management Agreement area.

NIFC class	% mature within class	% old within class	% of landbase
White spruce	9	79	6
Black spruce	58	18	13
Pine	83	10	18
Deciduous	66	18	61
Mixedwood	44	40	1

*Refer to table 4.4 for age class definitions

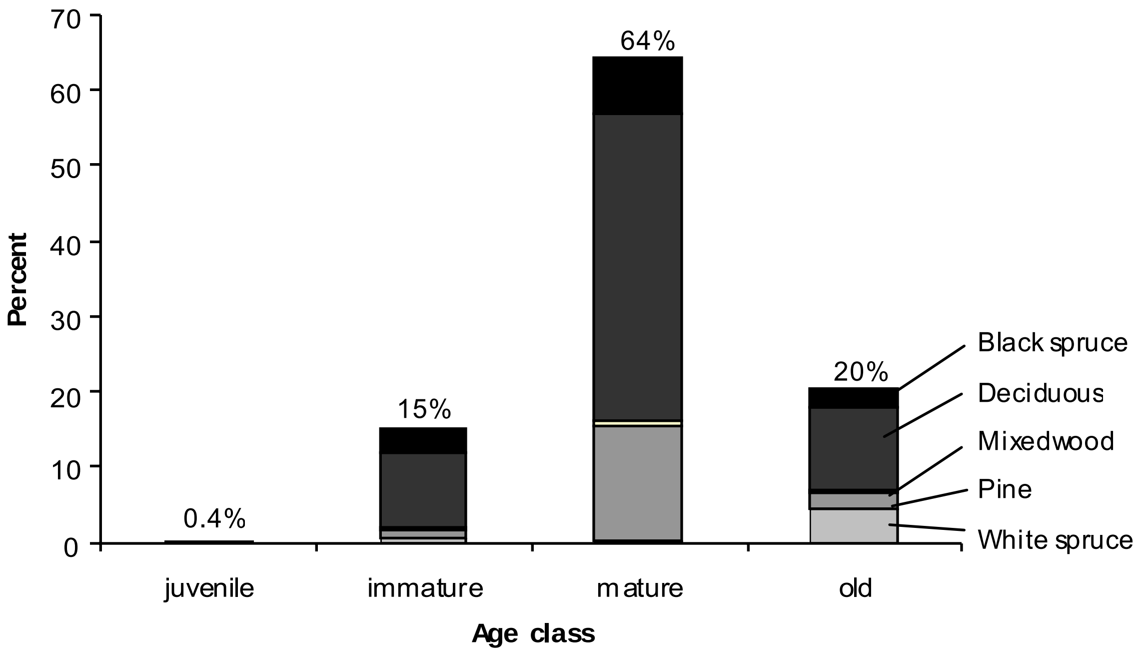

Figure 4.7. Non-industrial forest condition age class distribution within productive forests within the Al-Pac Forest Management Agreement area (see section 4.1.2.2 for age class and forest type definitions).

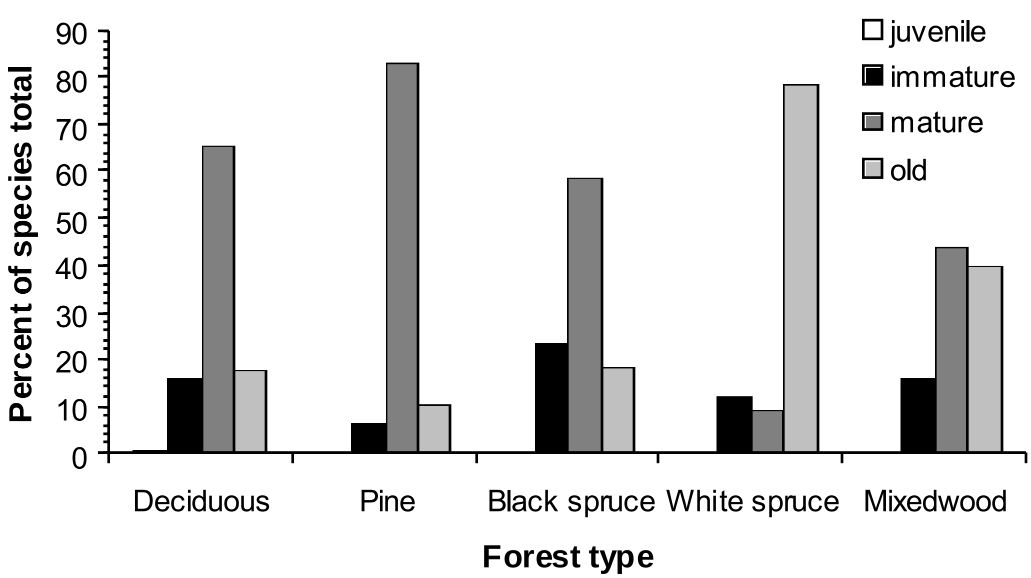

Figure 4.8. Non-industrial forest condition age class distribution for this point in time within productive forests by forest type, within the Al-Pac Forest Management Agreement area (see section 4.1.2.2 for age class and forest type definitions).

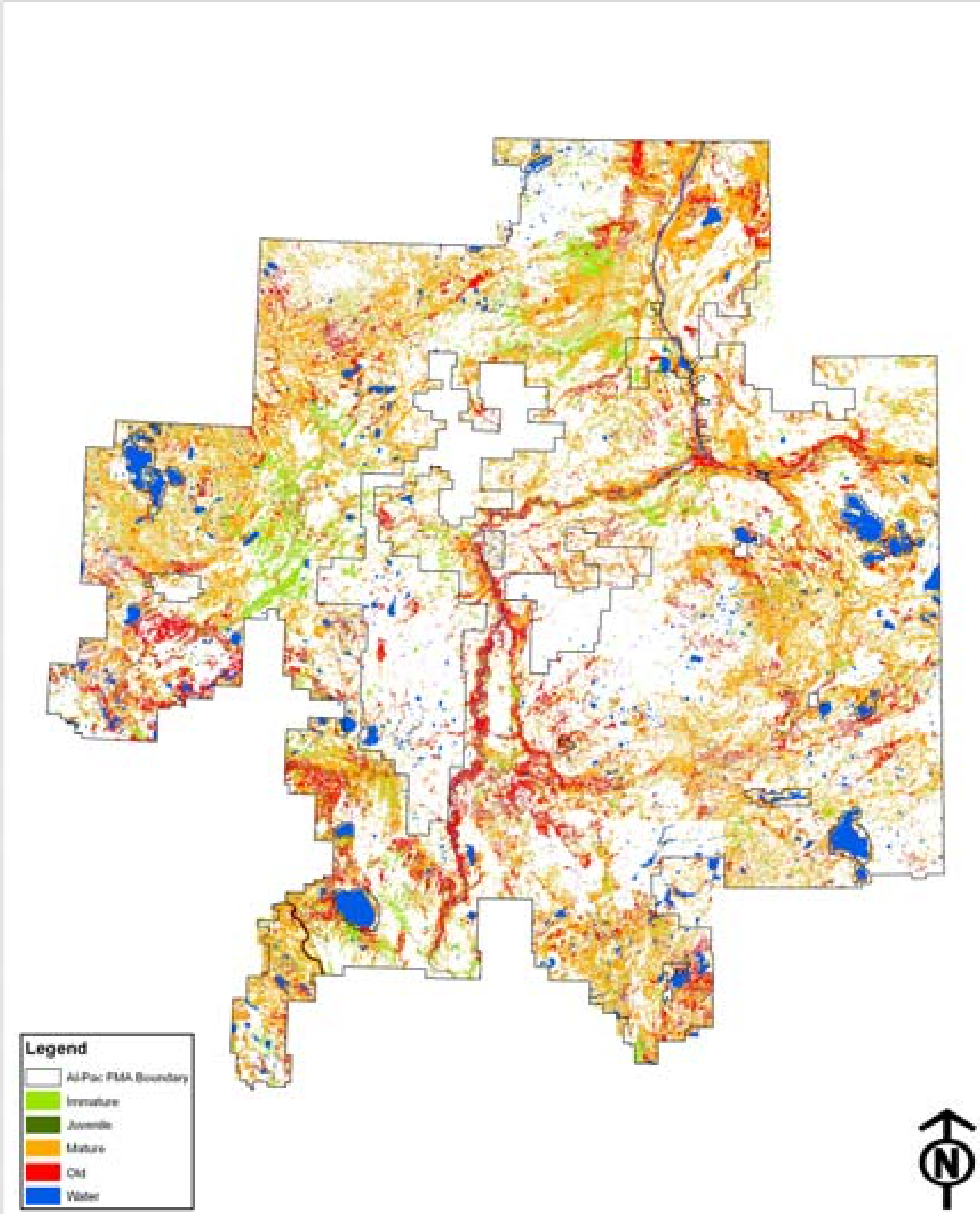

Figure 4.9. Age-class spatial distribution of productive non-industrial forests within the Al-Pac Forest Management Agreement area (see section 4.1.2.2 for age class definitions).

4.2.3 Patch Size Distribution

Since fire is the predominant natural disturbance agent within the Al-Pac FMA area, the distribution of stand sizes typically reflects the interplay between fire and forest succession (Figures 4.12 and 4.13). Large fires produce large homogenous patches, albeit with many small unburned islands. Succession, and subsequent fires, differentiates the forest into smaller units in response to differences in site characteristics and seed availability. Thus, stand size decreases over time as different species react to the site variables and create varying microclimates over time. Therefore, on average, forest stands are substantially smaller than the original underlying fire disturbance patterns that create them.

Nonetheless, similar to fire size distributions (see section 3.1), patch size distributions within the NIFC Forest Management Agreement area display a classic negative exponential distribution (often referred to as a "reverse-J" distribution; Figures 4.10 and 4.11). That is, the vast majority of forest and other patches are small (< 10 ha), and only a few patches are very large (> 1000 ha; Figure 4.10). Indeed, among productive forest types, mean patch sizes are between 5.8 and 15.0 ha (Table 4.8). Further, between 69 and 93% of all patches are smaller than 10 ha, depending on the species or NIFC class (Table 4.9).

Table 4.8. Patch size parameters among forest and other NIFC classes in the Al-Pac Forest Management Agreement area.

NIFC Class	% FMA area	Number of patches	Mean patch size (ha)	Range (ha)
Forested Productive				
White Spruce	4.3	45,217	5.6	0.01 – 1,121
Black Spruce	4.3	38,858	6.4	0.02 – 887
Pine	5.8	41,038	9.3	0.01 – 5,264
Deciduous	19.9	87,265	15.0	0.01 – 10,105
Mixedwood	0.42	4,467	5.8	0.15 – 236
Forested Non-Productive	51.5	50,015	67.4	0.01 – 1,032,386
Non-Forested Vegetated	1.4	9,192	9.8	0.01 – 662
Burn	8.4	3,533	156.3	0.01 – 97,367
Other	0.3	6,418	2.7	0.02 – 66
Water	4.3	5,367	45.2	0.03 – 18,202

Table 4.9. Amount of patches less than 10 ha among NIFC class types.

NIFC class	% patches < 10 ha
White Sprue	93
Black Spruce	88
Pine	72
Deciduous	69
Mixedwood	88
Forested Non-Productive	87
Non-Forested Vegetated	75
Burn	70
Other	97
Water	71

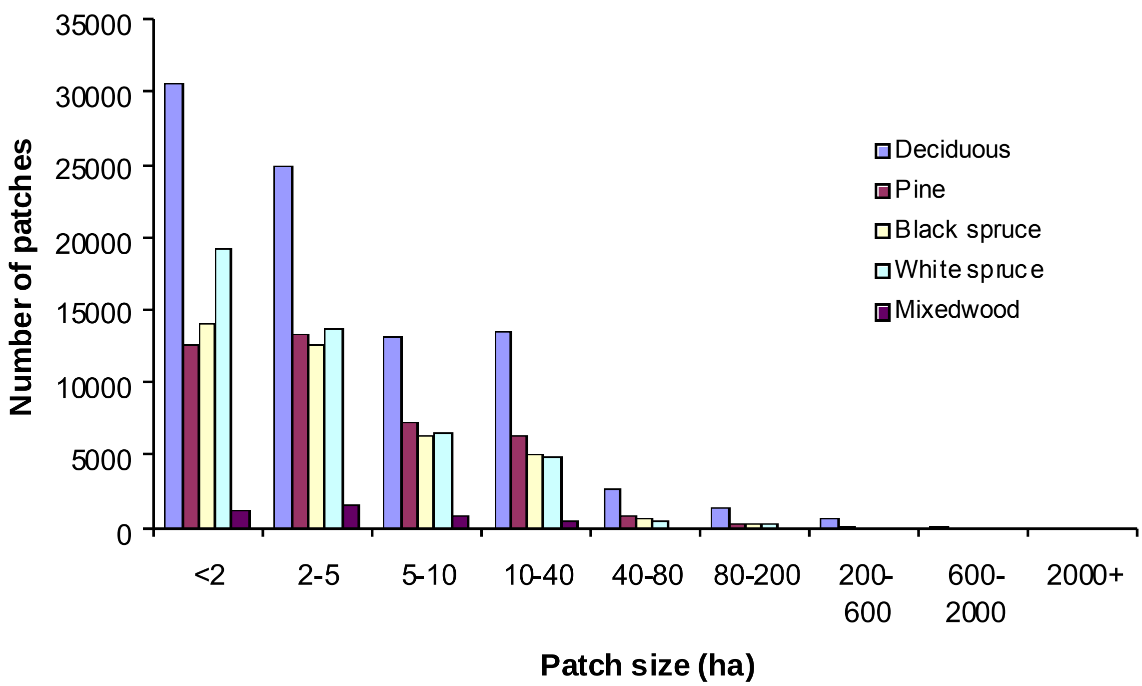

Figure 4.10. Patch size distribution for NIFC productive forest patches (all ages combined) within the Al-Pac Forest Management Agreement area.

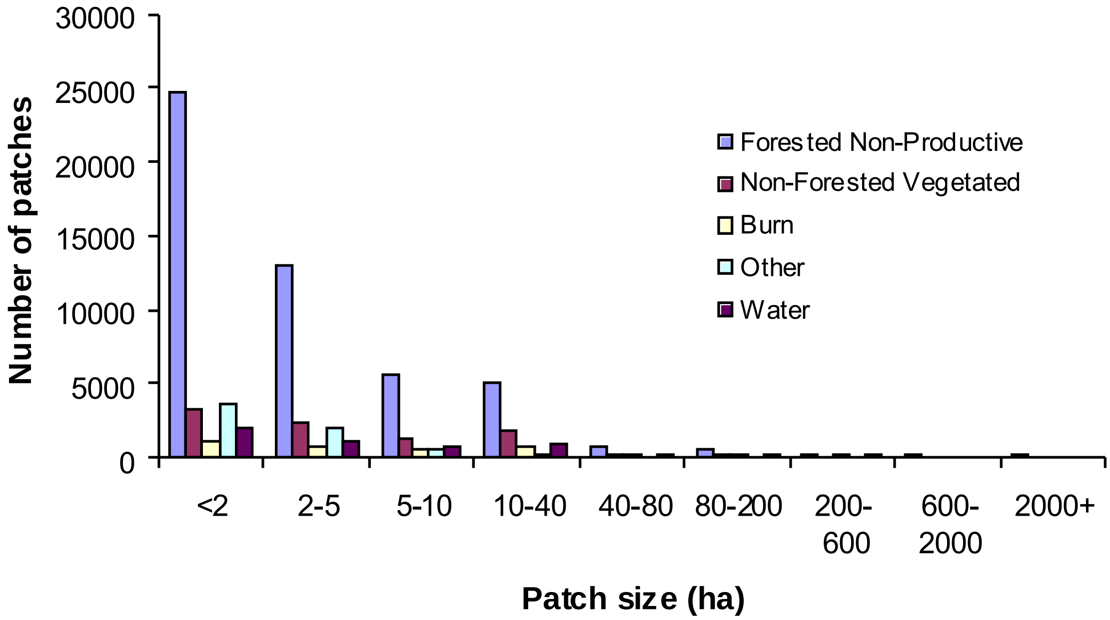

Figure 4.11. Patch size distribution for NIFC non-productive forest and other patches within the Al-Pac Forest Management Agreement area.

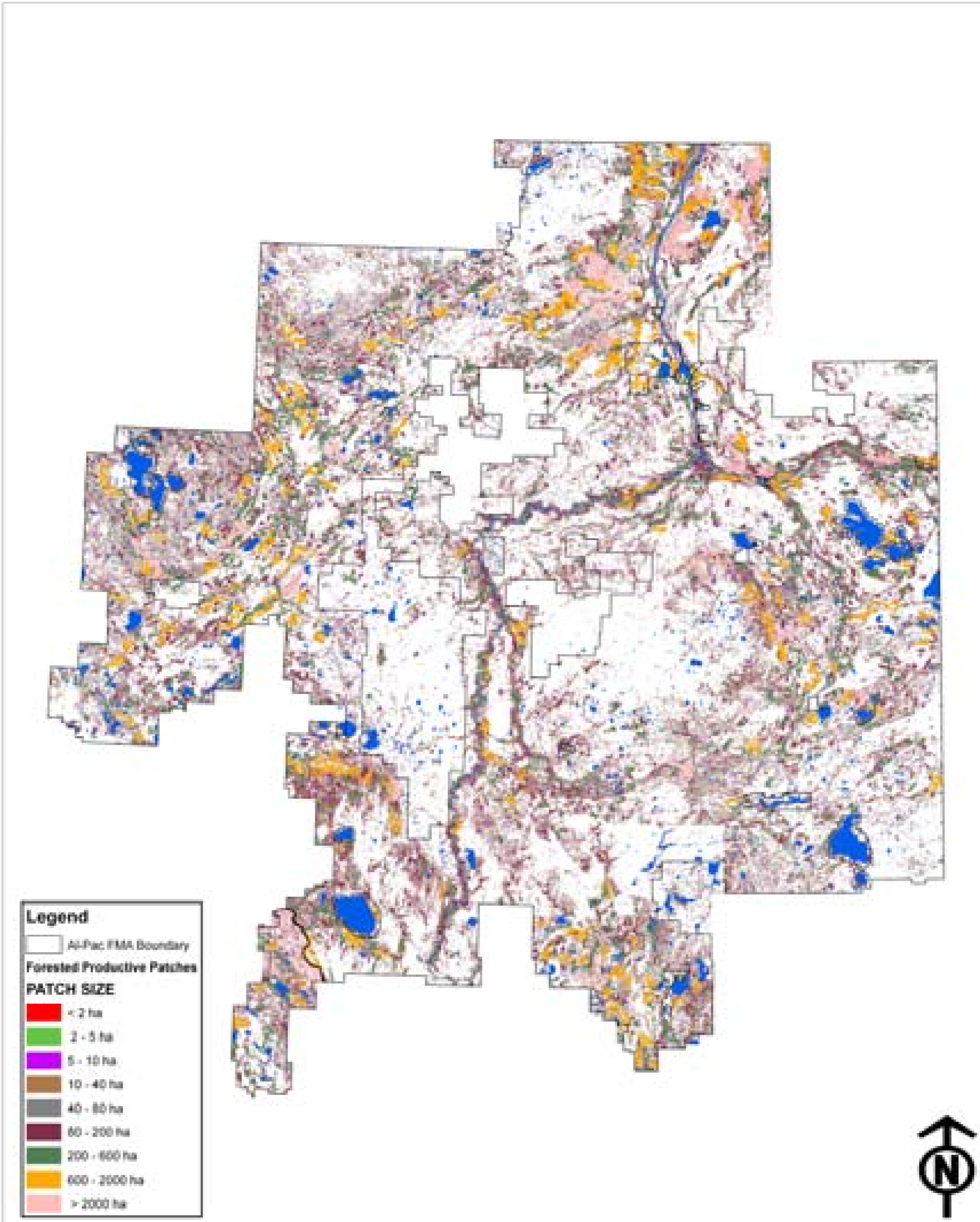

Figure 4.12. Spatial distribution of productive pre-industrial forests by patch size class within the Al-Pac Forest Management Agreement area.

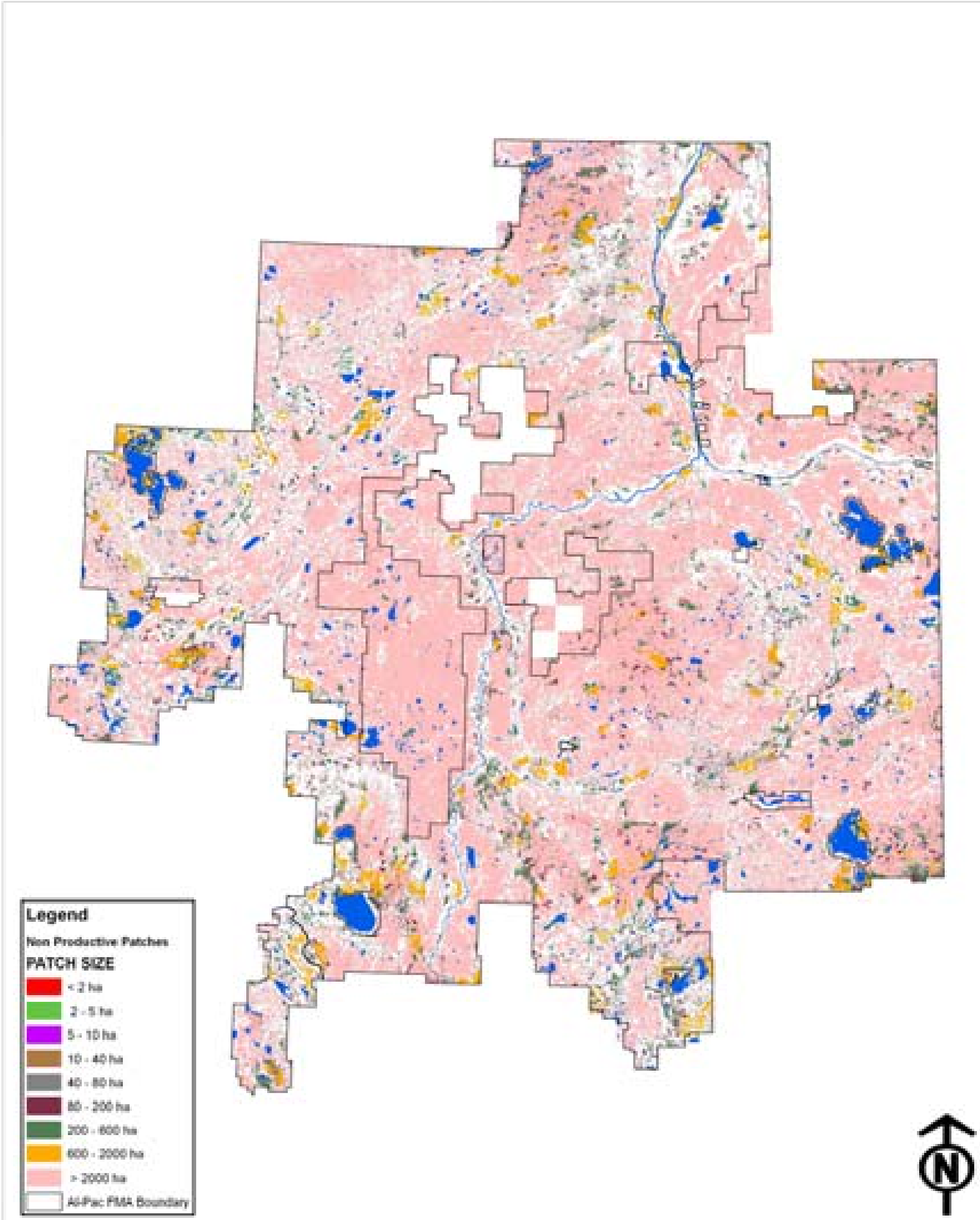

Figure 4.13. Spatial distribution of non-productive pre-industrial forests by patch size class within the Al-Pac Forest Management Agreement area.

5.0 Summary and conclusions

5.1 Major Disturbance Factors

5.1.1 Fire

- Fires two hectares or less account for 79% of all fires recorded in the FMA area from 1961 to 2003. However large fires (>1000 ha), while relatively rare, account for 96% of the FMA area burned, and very large fires (between 5,000 and 150,000 ha) are responsible for 83% of the area burned within the FMA area.

- An average of 36,119 ha of forest has burned annually within the Al-Pac FMA area. However, variability in weather and other forest fire conditions results in large annual variability in the amount of area burned among years ranging from a low of 14 ha in 1996, to a high of 332,734 ha in 1982.

- Cumming (2001) investigated burn rates within the Al-Pac FMA area. He calculated that for the 36-yr period between 1961 and 1996, This in turn corresponds to a 482-yr fire cycle. In contrast, Andison (2003) investigated burn rates within the FMA area and calculated much shorter fire return intervals and reports estimates of 60 to 70 years.

- Cumming (2001) investigated burn rates of various forest types within the Al-Pac FMA area. Deciduous forest types burning least, and Black spruce forest types burning most – based on Cumming (2001) the relationship among various burning rates among forest types in the FMA area can be characterized as the following: Black spruce > Pine > White spruce and other > Deciduous

- Similar to the spatial distribution of fires, post-fire residual patches can vary from single isolated trees to larger contiguous patches. The most frequent residuals are small, ranging between 0.1 to 1 ha, while evaluation by area suggests that most of the total area of residuals is found in larger patches ranging from 1 to 5 ha.

5.1.2 Insects and Disease

- Forest insects are natural processes that can play a major role in boreal forest dynamics, but have had relatively little influence (relative to fire) on broad-scale patterns with the Al-Pac FMA area

- Similar to insects, tree pathogens (diseases) are not considered a major disturbance factor within the Al-Pac FMA area. There have been no major recorded outbreaks of tree pathogens within the Al-Pac FMA area that have resulted in major management control efforts

5.1.3 Wind

- Wind has not been considered a significant disturbance factor at a landscape scale within the Al-Pac FMA area. Occasional, small, site-specific wind events (individual or groups of trees blown over) can occur within the forests of the Al-Pac FMA area.

5.2 Pre-Industrial Forest

- Processing of the more then 880,000 polygons within the AVI data within the Al-Pac FMA area to produce a NIFC was essentially a two-step process: (1) all industrial feature polygons where removed from the forest cover data by "growing in" the surrounding forest cover in over top of the industrial features polygon.(2) existing cutblocks were removed from the forest cover by assigning them the forest cover attributes of the nearest merchantable stand. This process created a forest cover database for the FMA area without any industrial feature footprints, and with forest cover attributes similar to current stand types.

- The NIFC land base composition is dominated by the forested non-productive class 53% of land base. Productive forest types make up 33% of the land base, with the remaining 14% of the area made up by non-forested vegetated, burn, water, and other. Within productive forest types, deciduous forests make up 61%, followed by Pine with 18%, Black spruce with 13%, White spruce with 6%, and mixedwood forests at 1% (mixedwood may be under represented as the classification scheme does not utilize understory vegetation).

- The age class distribution of the NIFC productive forests at this time point (as age class distribution will fluctuate within a range of natural variability) is dominated by mature forests (64%) made up of primarily deciduous and jack pine. Mature and old forests combined make up 84% of the NIFC productive forests. Less than 16% of the NIFC forest is juvenile and immature. This age class distribution is consistent across all forest types. All forest types are dominated by mature forest (range = 44% to 83%, excluding white spruce) with the exception of white spruce, which is dominated by old forests (79%).

- Patch size distributions within the NIFC Forest Management Agreement area display a negative exponential distribution. That is, the vast majority of forest and other patches are small (< 10 ha), and only a few patches are very large (> 1000 ha). Indeed, among productive forest types, mean patch sizes are between 5.8 and 15.0 ha. Further, between 69 and 93% of all patches are smaller than 10 ha, depending on the species or NIFC class.

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