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VEGETATION STUDIES PERTINENT TO THE AOSERP STUDY AREA A LITERATURE REVIEW

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1. INTRODUCTION

The objective of this literature review is to briefly discuss and summarize the available vegetation literature pertinent to the Alberta Oil Sands Environmental Research Program (AOSERP) study area. It is intended that this review provide one basis for evaluating the current progress regarding vegetation descriptions in this area and for designing certain future vegetation studies.

This review considers only vegetation studies from northern Alberta or Saskatchewan as they are pertinent to the AOSERP study area. It is not a comprehensive review of boreal vegetation literature.

2. BACKGROUND STUDIES

Background studies of vegetation include those which were conducted prior to development of the oil sands industry in northeastern Alberta and those which have been conducted more recently in other similar boreal forest areas. These studies provide a background for interpretation and comparison with descriptions in the AOSERP area subsequent to 1973.

2.1 REGIONAL DESCRIPTIONS

Halliday's Forest Classification of Canada, published in 1937, divided the forested lands of Canada into eight major regions and several forest sections. This classification was updated and the descriptions expanded by Rowe in 1959 and again in 1972. However, the basic framework of Halliday's classification and map were maintained.

Each edition of this classification placed northeastern Alberta in the Boreal Forest Region. This region which is characterized by coniferous forests of white and black spruce stretches as a continuous belt from the Labrador coast westward to the Rocky Mountains and northwestward to Alaska.

Based on Rowe's (1959, 1972) maps, four sections (subregions) of the Boreal Forest Region are present within the AOSERP study area (Figure 1). The largest portion of the AOSERP study area is included in

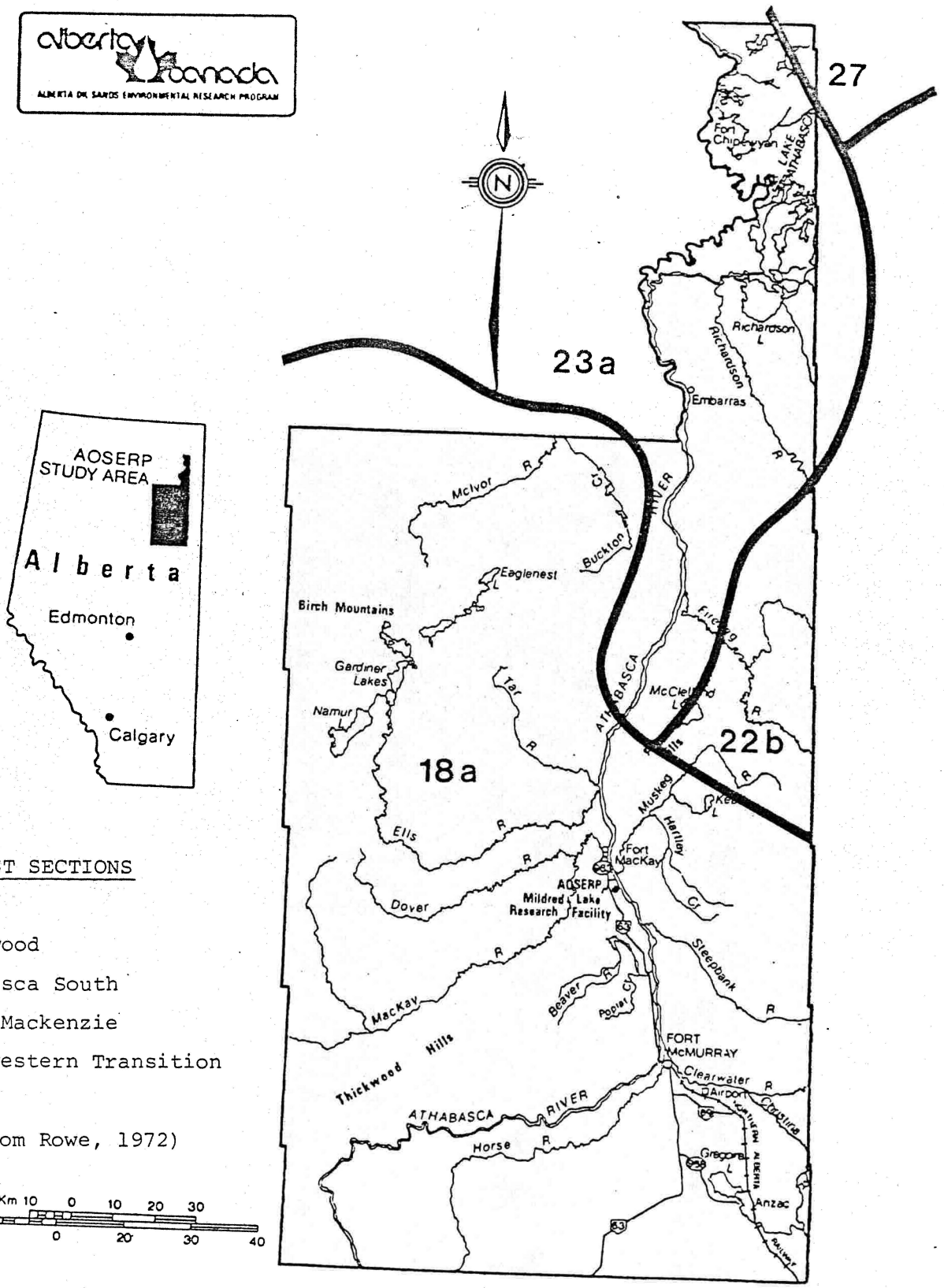

Figure 1. Boreal forest sections of the AOSERP study area.

the Mixedwood Section which is characterized on upland sites by mixed forests with varying proportions of trembling aspen (*Populus tremuloides*), white spruce (*Picea glauca*) balsam poplar (*Populus balsamifera*), balsam fir (*Abies balsamea*), and white birch (*Betula papyrifera*). According to Rowe (1972) aspen typically dominates young forests on recently burned sites while white spruce dominates mature forests which have escaped recent disturbance. Jack pine (*Pinus banksiana*) occurs locally on dry sandy sites and forms a mixture with black spruce (*Picea mariana*) on level tops of some higher hills. Black spruce and larch (*Larix laricina*) muskeg occur in depressions and poorly drained flats.

Rowe's (1972) Upper Mackenzie Section (Mackenzie Section in Halliday 1957) includes riverine forests of the Mackenzie drainage system. In the study area, this section occurs along the Athabasca River north from McClelland Lake. Topographic conditions are typically a sequence of alluvial flats bordering the river, low benchlands and terraces above the flats and finally undulating to rolling uplands. The alluvial flats and low terraces support excellent merchantable forests of white spruce in addition to balsam poplar forests. The higher terraces and uplands are characterized by large areas of jack pine and trembling aspen on sandy soils. In contrast to the Mixedwood Section, white spruce is a minor component of the upland forest.

The Athabasca South Section is a sand plain characterized by extensive jack pine forests which are often open grown or parklike. Characteristic tree species of the Mixedwood Section such as trembling aspen, balsam poplar, and white spruce are uncommon.

The Northwest Transition Section includes a very minor portion of the AOSERP study area (Figure 1). This is a northern forest fringe area where the distribution, abundance, and size of trees is reduced compared to areas further south.

These four sections of the boreal forest in Alberta are also briefly characterized by La Roi (1967). In addition to a brief description of each section, he presents a more extensive, although popularized description of forests in the Mixedwood Section (termed Boreal Mixedwood Section by La Roi) including a comparison of aspen

dominated and spruce dominated forests, their vegetation, environmental differences, and successional sequences.

2.2 VEGETATION TYPE DESCRIPTIONS

2.2.1 Background Studies Within AOSERP Study Area

The earliest written accounts of vegetation types in northeastern Alberta come from early exploration and survey expeditions beginning in the early 1800's. The Clearwater and Athabasca rivers were major transportation routes and as a result, several general descriptions and impressions of these valleys are given in the early literature. These early accounts are summarized by Raup (1933, 1934, 1935, 1946).

In 1946, Raup published the results of an extensive study of vegetation in the Athabasca-Great Slave lake Region. This large region includes northeastern Alberta, northwestern Saskatchewan and southern portions of the District of Mackenzie. Thus it encompasses essentially all of the AOSERP study area. Only forested vegetation, made up of seven principal forest types (parklike white spruce, flood plain white spruce, upland mesophytic white spruce, jack pine, balsam fir-white spruce, black spruce-lodgepole pine, and bog forest) was described by Raup.

A small scale map is presented by Raup which outlines the areas dominated by each of these forest types. According to this map, the AOSERP study area lies primarily within areas dominated by upland mesophytic white spruce forests with smaller areas in floodplain white spruce, balsam fir-white spruce, and jack pine forests. For the AOSERP study area, this map corresponds quite closely to that prepared by Halliday (1937) and Rowe (1969, 1972) with the principal difference being that Raup shows a balsam fir-white spruce forest type along the Clearwater River and the Athabasca River to approximately 70 km north of Fort Mackay.

Characteristic species of trees, shrubs, herbs, mosses and lichens were listed by Raup (1946) for various associations of each of the principal forest types. The most mesophytic forests of the region

were concluded to be the balsam fir-white spruce forests, confined primarily to valleys and terraces of the Athabasca and Clearwater rivers. The flood plain white spruce forests (roughly comparable to Upper Mackenzie Section of Rowe, 1972) were divided into two associations. The first is dominated by balsam poplar and the second by white spruce. Similarly, three types of upland mesophytic white spruce forests (similar to Mixedwood Section) were described: white spruce woods, white spruce-trembling aspen woods and aspen woods. The bog forest type was not mapped but was described as being dominated by black spruce, tamarack, labrador tea, and sphagnum mosses.

The only other background descriptions of vegetation which included the AOSERP area were those contained in exploratory soil survey reports by Lindsay *et al.* (1957, 1961, 1962). These soil reports provide brief comments on the vegetation and the correlation of vegetation types to soil types. The authors noted that open sphagnum bogs with occassional stunted black spruce are characteristic of deep organic deposits but as organic accumulations become thinner, growth of black spruce improves. Sedges, reedgrass and horsetail characterize wet meadow soils with less than 30 cm of peat accumulation. Most inorganic soils of medium to fine texture are forested by a mixed cover of trembling aspen and white spruce. White spruce dominates the more poorly drained soils and aspen the better drained soils. Mixed stands of aspen and jack pine occupy sandy soils with high watertables while pure jack pine stands occur on well drained, porous, sandy soils.

No other vegetation studies are known to have been conducted in the AOSERP study area prior to initiation of the oil sands development. However, the results of vegetation studies in other boreal forest areas of Alberta and Saskatchewan provide valuable background information for interpreting vegetation patterns within the AOSERP area.

2.2.2 Background Studies Outside the AOSERP Study Area

Studies by Raup (1930, 1933, 1935) provide some of the earliest descriptions of vegetation types in northeastern Alberta. In a comprehensive study of vegetation in Wood Buffalo National Park, Raup (1935) describes upland forest, muskeg, upland lake shore, and prairie

vegetation types. Principal and secondary species are listed for white spruce forests, jack pine forests, aspen forests, sedge meadows tall shrub community, bog shrub community, and treed muskeg. Maps outlining major physiognomic types were prepared for local areas of the Park.

Lacate *et al.* (1965) report the results of a forest reconnaissance survey of the Peace River area, Wood Buffalo National Park. Three of the major forest types described by Raup (1946) were considered characteristic of the area: flood plain white spruce forest, upland mesophytic white spruce forest, and jack pine forest. Emphasis was given to the first since it includes the most productive and accessible timber. Successional trends culminating in a mature white spruce forest on the alluvial lowlands are briefly characterized and the composition and cover of the shrub, herb, and moss layers of seral and mature stands is briefly contrasted.

The uplands of the area were concluded to be much more diverse than the lowlands including many poorly defined site and vegetation types with numerous transitional forms. Brief observations are made of jack pine forests on dry sandy soils, and aspen forests on more moist soils. The importance of fire in determining the characteristics of both upland and lowland forests is emphasized.

An extensive landscape classification and mapping study in the Peace-Athabasca delta of northeastern Alberta is reported by Dirschl *et al.* (1974). The area of this study overlaps a small portion of the AOSERP study area. For purposes of small scale mapping (1:37 000), seven terrestrial vegetation types (delta coniferous forest, delta deciduous forest, tall shrub, low shrub, fen, immature fen or marsh, forests on bedrock outcrops, and grasslands on outcrops) and seven aquatic types were recognized. For larger scale mapping (1:10 000) several vegetation dominance types on various land types were recognized; for example *Salix interior* type on point bars. Thus, these types are considerably more detailed than most other classifications of the region. Percent cover of major species are listed for 39 sample plots. In addition, vegetation successional trends within the delta are hypothesized, especially in relation to changing water levels.

An extensive survey and classification of boreal forest vegetation from Alaska to Labrador is reported by La Roi (1967) and La Roi and Stringer (1976). La Roi (1967) describes the vascular species composition and La Roi and Stringer (1976) the bryophyte species composition of six black spruce and six white spruce-fir stand groups.

Forest communities of northwestern Alberta in the Mixedwood and Hay River sections of Rowe (1972) are described by Moss (1953). He classified the forest into a white spruce association, black spruce-feathermoss association, black spruce-peat moss association, tamarack association, balsam fir vegetation, pine association, and poplar association. Four variations of the white spruce association (needle cover, grass shrub, shrub-herb, and feathermoss) were noted, based on composition of the undergrowth. These were related to the white spruce types described by Raup (1946) for northeastern Alberta. Two prevalent variations of the pine forests based on undergrowth composition were described as pine-feathermoss and pine-heath. The poplar association was divided into balsam poplar and aspen poplar variations but not further subdivided on the basis of undergrowth. Although this study was conducted outside of the AOSERP area and thus types may not be strictly comparable, it presents one of the most detailed early classifications of boreal forests in Alberta.

A classification of forested land within the Mixedwood Section of Alberta, south of the AOSERP study area, is outlined by Duffy (1965). The classification ranks physiographic sites in order of white spruce timber productivity. Seven vegetation communities are recognized and related to soil characteristics and tree productivity. Characteristic species of each community are listed but no quantitative data on composition are presented.

In Saskatchewan, vegetation studies of forests in the Mixedwood Section of Rowe (1972) are reported by Kabzems *et al.* (1976), Swan and Dix (1966), and Dix and Swan (1971). Kabzems *et al.* (1976) describe 23 forest ecosystems based on canopy dominants, undergrowth composition, and soil drainage. Forest ecosystem types are arranged in six series according to soil drainage characteristics. Three

pine, four white spruce, three aspen, four white spruce-aspen, five black spruce, two tamarack, one pine-black spruce, and one tamarack-black spruce ecosystem types are described. The *Picea glauca-Populus/Cornus* ecosystem on well drained soils is concluded to be the characteristic forest of the section and includes most white spruce-aspen mixed forests. Succession and timber productivity are described for each ecosystem type. Swan and Dix (1966) describe gradients in the structure, composition, and environmental relations of the Mixedwood Section of boreal forest in central Saskatchewan but do not classify types. Dix and Swan (1971) describe successional characteristics and the role of fire in the boreal forests of central Saskatchewan.

Three other vegetation studies of boreal forest vegetation in Alberta deserve mention, although they were conducted in the Lower Foothills Section of Rowe (1972) and thus types may not be directly comparable to types found in the AOSERP study area.

Achuff and La Roi (1977) studied 30 stands of spruce-fir forests in highlands of northern Alberta. These highlands are flat topped plateaus rising 300 to 600 m above the more gently undulating lowlands and include, for example, the Christina Highlands south of Fort McMurray and the Pelican Mountains near Lesser Slave Lake. Although these highlands are not represented in the AOSERP study area, some of the higher elevations of the area such as the Birch Mountains may include vegetation types transitional to those described by Achuff and La Roi (1977).

Four community types were recognized by Achuff and La Roi (1977) on the basis of undergrowth composition. The most extensive and lowest elevation type (*Viburnum/Hylocomium*) is frequently reported from other boreal areas of Alberta. It corresponds generally to the white spruce woods described by Raup (1946) for northeastern Alberta and the white spruce-feathermoss type documented for northwestern Alberta by Moss (1932).

In another study in the Lower Foothills Section of Alberta (near Chick Lake), Lesko and Lindsay (1974) describe 15 forest community types based on composition of the tree and lesser vegetation. Nine white spruce, two lodgepole pine, three black spruce, and an

alluvial forest complex type were described and related to soil survey mapping units and timber productivity. Variability in undergrowth composition was identified by the forest types but not strongly related to soil type. Soils with extreme drainage characteristics (very rapid or poor) were found to have very specific forest types while others have a large diversity of types with broad overlappings.

Forest vegetation of the Swan Hills of west central Alberta is documented by Moss and Pegg (1963).

In the Aspen Grove Section of central Alberta (in the Edmonton Region), Moss (1932) described the species composition and tree growth of three forest types (aspen, balsam poplar, and white spruce). Quantitative data on species composition is given for each vegetational stratum although variations within the types are not described.

Wetland vegetation types of the boreal forests of Alberta and Saskatchewan are described by Lewis and Dowding (1926), Lewis *et al.* (1928), Moss (1953), and Jeglum (1973). Lewis and Dowding (1926) describe the muskeg vegetation in the vicinity of Edmonton and Lewis *et al.* (1928) describe vegetation associations of swamp, moor, and bog forests in central Alberta.

Moss (1953) characterizes swamps, marshes, wet meadows, saline meadows, *Drepanocladus* bogs, and Sphagnum bogs in northwestern Alberta. Composition of these types is similar to types described by Raup (1935) in northeastern Alberta. Succession and retrogression caused by burning of wetlands are described. Jeglum (1973) describes the structure, composition, and environmental characteristics of fens, bogs, and moist forests in the Mixedwood Section of Saskatchewan. Wetland vegetation of the Peace Athabasca delta is discussed by Dirschl *et al.* (1974).

Forest cover type maps at a scale of 1:63 360 and 1:126 720 are available for the entire AOSERP study area. These maps were prepared by the Alberta Forest Service from interpretation of black and white aerial photographs flown between 1950 and 1954. Map units are annotated for forest cover type (pine, spruce, balsam fir, tamarack, deciduous, and combinations of these species), height class and density class. Broad categories of non-forested types including burned areas,

marsh or bog, treed muskeg, scrub, grassland, and potentially productive areas are also outlined. However, the utility of these maps for vegetation interpretation is severely limited by the fact that mapping categories combine several vegetation types.

A more detailed, larger scale (1:31 680) set of forest cover maps (Phase III maps) is available for approximately 60% of the study area. These maps are published by Alberta Energy and Natural Resources and present more detailed information on forest height and crown cover, commercialism class, disturbance, date of stand origin, area of map units, and site class. Although tree species composition of the forested units is described, no information on undergrowth is presented. In areas of non-productive forest, mapping categories are treed muskeg, scrub coniferous, scrub deciduous, open muskeg, grassland, sand or unconsolidated deposits, clearing, rock barren, soil barren, and water. Prior to publication of Intera's maps (Thompson *et al.* 1978), these were the most detailed vegetation maps of the AOSERP study area. Stringer (1976) found that a close correlation exists between existing vegetation and these forest cover maps.

A comprehensive report dealing with timber volume summaries and timber management plans for the Alberta oil sands area has been prepared by the Alberta Timber Management Branch, Grey *et al.* (1973).

3. RECENT VEGETATION DESCRIPTIONS OF THE AOSERP STUDY AREA

Industrial development of oil sands in northeastern Alberta and a recognition by the governments of Alberta and Canada of the need for environmental research related to this development, resulted in the establishment of the Alberta Oil Sands Environmental Research Program (AOSERP) in 1975 (Smith 1979). Under sponsorship of the Program, inventory studies of vegetation within the AOSERP study area were initiated. In addition, other government agencies such as the Alberta Forest Service provided information relating to vegetation of the area. Descriptions of vegetation on individual oil sands leases by industry has provided an additional significant contribution to the knowledge of vegetation in the area.

The most detailed and comprehensive description of vegetation types within the AOSERP study area is provided by Stringer (1976). This study was initiated by AOSERP soon after its formation in order to obtain baseline vegetation descriptions for use in designing a full-scale vegetation survey and mapping program. Eighty-four plots were selected as representative of all major vegetation types in the study area. The structure and species composition of each plot were described and data were classified into ten distinct vegetation types. These are fen, sandbar willow scrub, tall river alder-willow scrub, tall willow scrub, bottomland balsam poplar forest, upland white spruce-aspen forest, black spruce bog forest, semi-open black spruce tamarack bog forest and muskeg, lightly forested tamarack and open muskeg, and jack pine forests. In addition, two weakly defined types (Mixedwood and deciduous forest and Mixedwood and Coniferous forest) are also described.

Although the definitive characteristics of these types are largely physiognomic, the species composition and structural characteristics of the 12 types are described in text and species composition tables. No subdivisions of these types on the basis of undergrowth composition is presented. The correlation of the 12 types with units on forest cover maps prepared by the Alberta Forest Service is discussed and the photointerpretive characteristics of the types are described as an aid to mapping. An extensive list of species, both vascular and nonvascular and a discussion of taxonomic problems is included.

Since Stringer's (1976) report is the basis for many of the subsequent vegetation descriptions in the AOSERP study area, it is examined in greater detail in Section 6.0. The correspondence of his 12 types to those of other authors is outlined along with a brief evaluation of the classification.

Stringer's (1976) vegetation classification, with some modification, has been used in a comprehensive biophysical inventory and mapping program of the AOSERP study area (Thompson *et al.* 1978, Turchenek and Lindsay 1978). Intera Consultants Ltd. (Thompson *et al.* 1978) used Stringer's types as the basis for vegetation mapping at a scale of 1:50 000 from interpretation of false color infrared aerial photographs (1:60 000). Mapping was carried out over approximately

7 500 km^2 or a quarter of the entire AOSERP area. No "ground-truthing" studies were included in this mapping program.

The vegetation mapping units used by Intera and their correspondence to Stringer's(1976) classification are listed on Table 1. A close correspondence of types is evident. However, certain of Stringer's types are combined or subdivided for purposes of mapping at a scale of 1:50 000. For example, the sandbar willow scrub, tall river alder-willow scrub, and tall willow scrub are combined into the deciduous shrub mapping unit (Bottomland and Riparian Communities) since these types could not be distinguished at the scale of 1: 50 000. In addition, Stringer's upland white spruce and aspen forest type is subdivided into three mapping units based on whether the canopy is dominated by deciduous, coniferous, or a mixture of species. Finally, Stringer's weakly defined upland mixedwood and deciduous type is not distinguished from his upland white spruce and aspen forest type for mapping purposes.

Intera also included six mapping unit categories not described by Stringer. These include upland undifferentiated and wetland undifferentiated to include areas too complex to map at greater detail. They also include in the upland open category for open areas within aspen forests; the composition is assumed to be grasses, low herbs and shrubs. The three remaining new categories are burn, non-vegetated and aquatic vegetation. Although these maps, especially when used in combination with Stringer's (1976) descriptions, display a considerable volume of information regarding vegetation of the AOSERP area, certain weaknesses are present as discussed in Section 6.0.

Stringer's (1976) classification was also used with some modification by Turchenek and Lindsay (1978) for mapping of biophysical land systems in the AOSERP study area. Although vegetation is not mapped, it is one of the definitive characteristics of the land system. Similar to Intera, Turchenek and Lindsay combined the three shrub types and subdivided the upland white spruce-aspen forest type for mapping purposes.

In addition to these extensive studies sponsored by AOSERP, other vegetation descriptions and maps have been prepared for

Table 1. Comparison of the vegetation classification systems used by Intera (Thompson *et al.*, 1978) and Stringer (1976) in the AOSERP study area

VEGETATION TYPES		
INTERA		STRINGER
Class	Type	Type
BOTTOMLAND AND RIPARIAN COMMUNITIES	Bottomland and riparian forest	Bottomland balsam poplar forest
	Deciduous shrub	Sandbar willow scrub Tall river alder-willow scrub Tall willow scrub
UPLAND COMMUNITIES	Undifferentiated	———
	White spruce-aspen forest-deciduous	Upland white spruce and aspen forest Upland mixedwood and deciduous forest
	White spruce-aspen forest-mixed	
	White spruce-aspen forest-coniferous	
	Mixed coniferous	Mixedwood and coniferous forest
	Jack pine	Jack pine forest
	Upland open	———
WETLAND COMMUNITIES	Undifferentiated (usually complex)	———
	Fen communities	Fen
	Black spruce bog	Black bog forest
	Semi-open black spruce bog	Semi-open black spruce-tamarack bog forest
	Lightly forested tamarack and open muskeg	Lightly forested tamarack and open muskeg
BURN	Burn	———
NON VEGETATED		———
AQUATIC VEGETATION		———

individual lease areas, sponsored by the oil sands industry. These studies have, for the most part, been at a level of detail similar to the types of Stringer (1976).

As part of a wildlife habitat evaluation, Syncrude (1973) described and mapped 11 vegetation types on tar sands Lease #17. These types are: pure aspen, jack pine/lodgepole pine, pure white spruce, white spruce-aspen, pine-aspen, willow-birch muskeg, black spruce muskeg, willow muskeg, recent burn, old burn, riverine, and open marsh. Although little indication is given of non-woody species composition of the types, principal shrub species are identified, especially in relation to browse potential. Spruce-aspen mixedwood forests are contrasted to pine-aspen mixedwood forests and two types of pine forests are noted. The willow muskeg type which had not been described previously was noted to be extensive on recently burned muskeg areas.

In a later report dealing primarily with potential revegetation species, Syncrude (1975) briefly described eight main vegetation types on Lease #17: jack pine, jack pine-aspen, aspen, white spruce-aspen, white spruce, riverine, black spruce, and sedge fen. Similar to many previous descriptions, these types are broad physiognomic types with no emphasis in their definition on lesser vegetation.

On the western half of Syncrude's Lease #17, Peterson and Levinsohn (1977) described and mapped (1:24 000) eight vegetation types. Their willow-reedgrass type and aspen-birch type were concluded to be distinct from types described by Stringer (1976). In addition, their black spruce-feathermoss type may not be the ecological equivalent of the black spruce bog forest of Stringer (1976) as stated but may be more similar to the black spruce-feathermoss type described by Moss (1953). The remaining five types correspond generally to Stringer's (1976) classification.

Vegetation of the Great Canadian Oil Sands (G.C.O.S.) Lease 86 is described and mapped (1:24 000) by R.M. Hardy and Associates (1978). Principal species, site characteristics, and distribution of eight physiognomic types are described. These correspond generally to Stringer's (1976) classification. In addition, community types within the physiognomic types are indicated, but only very briefly described.

Two community types are distinguished within fen, aspen forest, and black spruce forests and three within white spruce-aspen forest.

Shell (1975) and Alsands Project Group (1978) document physiognomic vegetation types on the Alsands project area (Leases 34 and 96). The structure, composition, and site characteristics of ten types are described and mapped with correspondence generally to Stringer's (1976) types.

Major physiognomic vegetation types of the surface minable portion of the Athabasca Oil Sands region are briefly described and mapped by Hardy Associates and Monenco (1979). Lombard North (1974) provides brief descriptions of 11 principal vegetation types on the Amoco Lease near Gregoire Lake.

As part of an upland bird habitat evaluation conducted by the Canadian Wildlife Service, Francis and Lumbis (1978) described the vegetation of 20 census blocks in shrub and forest types. For the most part, blocks encompassed heterogeneous vegetation. Dominant species of the tree and understory strata are documented and community structure and variability are briefly described.

As part of a study to assess the feasibility of lichen monitoring in the Fort McMurray region, Douglas and Skorepa (1976) briefly describe the vascular species composition of four principal forest types: white spruce, black spruce, aspen, and jack pine.

Addison and Baker (1979) have established 11 jack pine forest sites in the AOSERP study area to provide baseline data for long-term monitoring of vascular and lichen communities and soils. It was noted that vegetation of the jack pine sites was variable and could be broken into four groups primarily on the basis of herbaceous composition. The distribution of these groups is apparently related to soil moisture regime.

4. LICHEN COMMUNITY DESCRIPTIONS

Lichen communities may be used as biological indicators of atmospheric pollution and as a result, are of considerable interest in the AOSERP area. However, descriptions of lichen communities and their

relation to potential air pollution in northeastern Alberta are relatively few.

Douglas and Skorepa (1976) discuss the feasibility of establishing a lichen grid monitoring network north of Fort McMurray. Quantitative data from lichen communities on tree branches and trunks were obtained from 12 plots in pine, spruce, and aspen forests. Percent cover and frequency of lichen species are listed. A rich lichen flora occurs on white and black spruces in the region and could be used in a lichen monitoring study. Relatively few lichens occur on aspen.

Addison and Baker (1979) list the percent cover and frequency of four lichen species groups on jack pine stems at increasing distances from the G.C.O.S. plant. They also describe changes in lichen cover in a transplant study conducted over a one year period.

In Alberta, but outside the AOSERP study area, lichen community descriptions are provided by Case (1976) for the Whitecourt area, Skorepa and Vitt (1976) for the Rocky Mountain House area, and Hardy Associates (1979) for the Cold Lake area.

5. RARE VASCULAR PLANT LISTS FOR ALBERTA

Under the Rare and Endangered Plants Project of the National Museum of Natural Sciences, Argus and White (1978) have prepared a provisional list of rare vascular plants of Alberta. This list is based on several herbarium collections and distribution maps. Notes on the species include range, habitat, status, and references documenting the status.

Packer and Bradley (1978) list approximately 540 species of native vascular plants considered rare in Alberta. The degree of rarity, habitat, range, and protection status are described.

6. EVALUATION

The purpose of this section is to briefly summarize and critique the vegetation literature pertinent to the AOSERP study area and to evaluate the current state of knowledge regarding vegetation of this area. Emphasis in this section will be given to the reports by Stringer (1976) and Thompson *et al.* (1978) since they are the most

comprehensive studies of the area and were designed to provide a basis for other studies.

Prior to initiation of the oil sands industry in the AOSERP study area, little was known regarding vegetation of this area. Regional descriptions and maps by Halliday (1937), Rowe (1972), and Raup (1946) and early reconnaissance surveys by Lindsay *et al.* (1957 *et seq.*) provide a regional perspective for the vegetation but little detailed information on the composition and distribution of types. Raup (1946) described several physiognomic forest types which occur within a large region encompassing the AOSERP study area but provided little basis for detailed evaluation of the AOSERP area. Forest cover maps prepared by the Alberta Forest Service indicate dominant tree species, but provide no information on species composition other than for the forest canopy.

It was not until initiation of the oil sands development that detailed studies of vegetation specifically within the AOSERP area were conducted. The oil sands industry has sponsored several studies of vegetation on individual leases; probably the most intensively studied and mapped area is Syncrude's Lease 17 near Mildred Lake (Cf. Syncrude 1973, 1975, Peterson and Levinsohn 1977).

The most comprehensive description of vegetation of the AOSERP area is by Stringer (1976), who describes 12 vegetation types of the AOSERP area based on quantitative data from 84 plots. The classification was developed by a quantitative clustering routine based on similarities in the composition of all species except trees in the plots. The most "logical groupings" (vegetation types) were subjectively selected from the clusters described by the quantitative technique. Two of the 12 vegetation types (Mixedwood and Deciduous Forest and Mixedwood and Coniferous Forest) indicated by the clustering routine were very weakly defined and not included by Stringer (1976) in his final classification.

Due to the limited number of plots sampled by Stringer (1976), the entire range of vegetation types in the AOSERP study area could not be adequately covered. As Stringer points out, his vegetation classification is preliminary; it "describes the major vegetation types

and indicates some of the minor ones". His vegetation types "should be looked upon as the first tentative steps toward a vegetation classification, and should be used only as a guide to more definitive studies" (Stringer 1976). The background literature discussed in Section 2.0 suggests that vegetation of the AOSERP study area is considerably more complex than Stringer's preliminary classification indicates.

Stringer's (1976) classification emphasizes mature or maturing vegetation and gives relatively little attention to extensive areas that are in early stages of regeneration after fire. Fire is a dominant factor controlling vegetation patterns throughout the boreal forest (Rowe and Scotter 1974, Dix and Swan 1971) as well as in the AOSERP area (Syncrude 1973, Stringer 1976, Peterson and Levinson 1977, Alsands 1978). Since the vegetation of these recently burned areas is diverse and the dynamics of the communities are not well understood, a major problem exists in attempting to classify these areas.

Since they were to be used in an extensive mapping program, the definitive characteristics of Stringer's (1976) vegetation types are largely physiognomic. That is, the types are defined by dominant species and their growth form. No subdivisions of these types into vegetation associations or community types on the basis of lesser vegetation is provided. However, Stringer's type descriptions as well as the background literature suggests that considerable variation may exist within the types in terms of composition of the lesser vegetation. For example, Moss (1953) indicates four and Kabzems *et al.* (1976) describe three undergrowth types in white spruce forests. Thus, Stringer's classification may be appropriate for relatively small scale mapping and overviews of vegetation but may be much less appropriate for detailed, site specific evaluations. His classification is a substantial but preliminary contribution to descriptions of vegetation in the AOSERP study area.

Each of Stringer's (1976) types is listed below together with the corresponding or included types of other classifications as a basis for comparison of level of classification detail.

Fen

The fen type is widely recognized in boreal literature and is often subdivided on the basis of structure, composition and environment. Some apparently corresponding types include:

-Sedge Meadows	Raup 1935
-Fen (22 types)	Jeglum 1973
-Fen Muskeg	Syncrude 1973
-Fen	Dirschl *et al.* 1974
-Sedge-Reed grass	Peterson and Levinsohn 1977

Sandbar Willow Scrub

This type is less frequently described in northeastern Alberta but is apparently widespread. It apparently corresponds to:

-Sandbar Willow Type	Raup 1935
-Low Shrub Type (in part)	Dirschl *et al.* 1974

Tall Willow-River Alder Scrub

This type is commonly combined with the next by other authors.

Tall Willow Scrub

-Tall Shrub Community	Raup 1935
-Tall Shrub Type	Dirschl *et al.* 1974
-Tall Shrub Fen (5 types)	Jeglum 1973

Bottomland Balsam Poplar Forest

-Poplar Association	Raup 1935
-Balsam Poplar Association of floodplain White Spruce Forest	Raup 1946
-Poplar Association (balsam poplar variation)	Moss 1953a
-Riverine Association (in part)	Syncrude 1973
-Deciduous Forest	Dirschl *et al.* 1974
-Balsam Poplar-Alder	Peterson and Levinsohn 1977

Upland Mixedwood and Deciduous Forest

The correspondence of this heterogeneous type to those described by others is somewhat unclear. It probably includes in part at least, the aspen-birch type of Peterson and Levinsohn (1977) and the white birch-dwarf birch type of Turchenek and Lindsay (1978).

Upland White Spruce-Aspen Forest

This type, although usually subdivided, is recognized by almost all descriptions of boreal forests in northern Alberta and Saskatchewan. It apparently corresponds to or includes:

-White Spruce Forests plus Aspen Forests	Raup 1935
-Upland Mesophytic White Spruce Forests (including white spruce woods, white spruce-trembling aspen woods, and aspen woods)	Raup 1946
-White Spruce Forests (7 community types)	Duffy 1965
-Pure Aspen Type plus Pure White Spruce Type plus Boreal Mixedwood Type (spruce-aspen subtype)	Syncrude 1973
-*Picea glauca* forests (4 ecosystems) plus *Populus tremuloides* forests (3 ecosystems) plus *Picea glauca/Populus* forests (4 ecosystems)	Kabzems *et al.* 1976
-White Spruce-Aspen Type	Peterson and Levinsohn 1977

Black Spruce Bog Forest and Muskeg

-Bog Forest	Raup 1935
-Bog Forest	Raup 1946
-Black Spruce Peat Moss Association	Moss 1953a
-Moist Forest (in part)	Jeglum 1973
-Black Spruce-Feathermoss ?	Peterson and Levinsohn 1977
-*Picea mariana* Forests (3 ecoystems)	Kabzems *et al.* 1976

Semi-Open Black Spruce-Tamarack Bog Forest and Muskeg

-Treed Muskeg	Raup 1935
-Treed Muskeg	Syncrude 1973
-Muskeg	Jeglum 1973
-Black Spruce-Labrador Tea	Peterson and Levinsohn 1977

Lightly Forested Tamarack and Open Muskeg

-Bog Shrub Communities	Raup 1935
-Tamarack Association	Moss 1953a
-Bogs (2 types)	Moss 1953b
-Willow Muskeg	Syncrude 1973
-*Larix laricina* Forests (2 ecosystems) plus *Larix laricina-Picea* Forests	Kabzems *et al.* 1976
-Open Bog	Jeglum 1973

Upland Mixedwood and Coniferous Forest

Stringer (1976) states that this type is weakly delimited and did not include it in his final classification. It includes predominantly jack pine-black spruce forests and appears to correspond to or includes the *Pinus-Picea mariana* Forest (one ecosystem) of Kabzems *et al.* (1976). Raup (1946) describes a Black Spruce-Lodgepole Pine Forest which may be similar.

Upland Jack Pine Forest

This type is described or mentioned in almost all reports of boreal forest vegetation in Alberta and Saskatchewan. It has been subdivided on the basis of undergrowth by some authors. Corresponding descriptions are:

-Jack Pine Forest	Raup 1935
-Jack Pine Forest	Raup 1946
-Pine Association (including Pine-Feathermoss and Pine-heath communities)	Moss 1953a
-Jack Pine/Lodgepole Pine Type	Syncrude 1973
-*Pinus banksiana* forests (three ecosystems)	Kabzems 1976

Other principal vegetation types described in northern Alberta which do not appear to have a corresponding classification in Stringer (1976) include:

- -White Spruce Association of Floodplain White Spruce Forests (Raup 1946)
- -Black Spruce-Feathermoss Association (Moss 1953a)
- -Balsam Fir Vegetation (Moss 1953a)
- -Willow Muskeg (Syncrude 1973)
- -Willow-Reed grass (Peterson and Levinsohn 1977)

As described in Section 3.0, Stringers (1976) vegetation types have been used with some modification as the basis for an extensive vegetation mapping program of the AOSERP study area by Intera (Thompson *et al.* 1978). The vegetation maps are presented at a scale of 1:50 000 and display a considerable volume of information regarding vegetation of the AOSERP study area and the distribution of Stringer's (1976) vegetation types.

However, if these maps are to be used for detailed resource evaluation studies, certain weaknesses are apparent. These result from four characteristics of the maps: 1) they have not been "ground-truthed", 2) the legend of vegetation types may be incomplete, 3) they present no detail on lesser vegetation, and 4) the mapping scale is relatively small.

Since the maps are based entirely on aerial photo interpretation and have not been "ground-truthed", it is inevitable that they include errors of interpretation.

The legend of vegetation types on the maps may be incomplete since Stringer's (1976) classification which is heavily used as the basis for the mapping, gives little attention to vegetation in early stages of regeneration after fire. The map legend includes a burn category but this imparts little information as to the nature of the regenerating vegetation.

The maps produced by Intera present no site specific information on lesser vegetation. Thus in forested areas, the maps do not present substantially more information than is available from forest cover maps produced by the Alberta Forest Service. The

background literature discussed in Section 2.0 indicates that classifiable variability is present in the lesser vegetation of forests.

At a mapping scale of 1:50 000, the map units must often include a diversity of vegetation types since small scale patterns are prevalent. The map unit annotation often does not adequately describe this diversity. If the maps are used for regional rather than detailed specific evaluations, the mapping scale may be more appropriate.

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