Appendix A

Ecoprovinces of the Central North American Cordillera and Adjacent Plains[1]

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INTRODUCTION

The fundamental difference between the map presented here and other regional ecosystem classifications is that this map's ecological units are based on climatic processes rather than vegetation communities (map appears at the end of this appendix). Macroclimatic processes are the physical and thermodynamic interaction between climatic controls, or the relatively permanent atmospheric and geographical factors that govern the general nature of specific climates (Marsh 1988). This approach to regional ecological classification has proven useful to resource managers and interest groups in British Columbia (see British Columbia Commission on Resources and Environment 1994; British Columbia Ministry of Environment, Lands and Parks 1993; Hume 1993; Province of British Columbia 1993; Quesnel and Thiessen 1993; Senez 1994; Wareham 1991; Western Canada Wilderness Committee 1992).

The ecoregion mapping concepts from Demarchi (1993) and Demarchi et al. (1990) were applied to the map, but due to time and budgetary constraints existing ecoregion classifications had to be used. The resultant map uses ecoprovince lines and mapping concepts from the British Columbia Ecoregion map - 1:2,000,000 (Demarchi 1993); the Terrestrial Ecoregions of Canada - 1:7,500,000 (Ecological Stratification Working Group 1993); Regional and Zonal Ecosystems in the Shining Mountains - 1:500,000 (Demarchi and Lea 1992); Major Ecoregion Subdivisions of the Pacific Northwest - 1:2,000,000 (Demarchi 1991); and other mapping sources described below.

Canada. The ecoprovince units for Canada were adapted from the recent Terrestrial Ecozone and Ecoregion map of Canada (Ecological Stratification Working Group 1993). Ecoprovince units from Demarchi (1993) -1:2,000,000 had previously been incorporated into the Canadian Terrestrial Ecozones and Ecoregions map at 1:7,500,000. For Alberta, ecoprovince lines were adapted from Strong and Leggat's (1992) Ecoregions of Alberta - 1:1,000,000 map with additional consultation with Wayne Pettapiece (Agriculture Canada, Edmonton, Alberta) and Scott Smith (Agriculture Canada, Whitehorse, Yukon Territory). The Aspen-Parkland ecoprovince was adapted as a separate, transitional unit from either the Canadian Prairie or Boreal Lowland ecoprovinces from early work by Crowley (1967) and Bailey (1976). For Saskatchewan, the Ecoregions of Saskatchewan by Harris et al. (1983) were used to augment those of the Canadian map.

United States. For the United States portion of the map, ecoprovince lines were developed using the U.S. Department of Agriculture (USDA) Forest Service ECOMAP Team's map of Ecoregions and Subregions of the United States - 1:7,500,000 (see Bailey et al. 1993). It was used for broad ecoclimatic zona-

[1] *The ecological stratification scheme presented here shows spatial relationships of ecosystems in common to the United States and Canada. The relationships will be important in the development of conservation strategies for forest carnivores. The stratification scheme has much in common with the USDA Forest Service ECOMAP system (U.S, coverage only - Bailey et al. 7993) and is meant to be complementary to that system.*

tion concepts (ecodivisons) and a rough approximation of ecoprovinces. The U.S. Environmental Protection Agency's maps of Ecoregions of the Conterminous United States - 1:2,500,000 and 1:7,500,000 (Omernik 1986, 1987; Omernik and Gallant 1986, 1987a, 1987b, 1987c, 1989) were used for definition of physiographic units. Land Resource Regions and Major Land Resource Areas of the United States - 1:7,500,000 (USDA Soil Conservation Service 1978, 1981) was also used as a basis to aggregate or combine regional units into ecoprovinces. And the National Geographic Society's (1976) Landsat compilation was used for final physiographic definition. Mapping was conducted at 1:4,560,000, in order to be compatible with the composite Landsat image of the National Geographic Society (1976), which was the only available Landsat image for the entire project. Ideally, more detailed Landsat images at 1:250,000 should have been utilized. No attempt was made to correlate lines with vegetation community units (i.e., Brown and Lowe 1980; Franklin and Dyrness 1973; Idaho Department of Water Resources 1990; Kuchler 1975; Ross and Hunter 1976).

The U.S. Environmental Protection Agency map (Omernik 1986) often provided the best fit. But, there were many instances where instead of mapping regional ecosystems, that map approximated a zonation level. The map of ecoregion aggregations by Omernik and Gallant (1989) did not satisfy the identification of broad climatic classes.

The USDA Forest Service ECOMAP Team's map appeared to be at a broad level, perhaps at the scale of presentation (1:7,500,000) (see Bailey et al. 1993). There was a reliance on broad vegetation communities or patterns to reflect ecoclimate zones (Bailey, pers. comm., 1993).

The USDA Soil Conservation Service's (1978, 1981) Land Resource Areas map was based on soils, climate, and land use. Each Land Resource Region encompasses several climatic regions and major physiographic units and appears to be based more on current agricultural practices than on any ecological parameter or process. Land Resource Regions were broad groupings of the Land Resource Areas for agricultural planning purposes. The Land Resource Areas are quite detailed and approximate specific physiographic units or physical landscapes.

Mexico. The ecoprovince units that were defined for northern Mexico were developed from Brown and Lowe's (1980) Biotic Communities map, and Lowe and Brown's (1982) Biogeographic Provinces map.

ECODIVISION AND ECOPROVINCE DESCRIPTIONS

The following is a discussion of ecodivisions and ecoprovinces on the enclosed map, Central North American Cordillera and Adjacent Plains. The ecodivisions and ecoprovinces have not been put into an ecodomain framework because almost all of the mapped area falls within the Dry Ecodomain (see Bailey 1978). Ecoregions have also not been described as part of this current effort. Ecoregion information, however, is available for the Canadian portion (see Ecological Stratification Working Group 1993) and for the United States' portion (see Bailey et al. 1993; Omernik 1986; Omernik and Gallant 1986, 1987a, 1987b, 1987c). The author is unaware of any ecoregion descriptions for Mexico.

BOREAL PLAINS ECODIVISION (1)

This low-lying, upland and plains ecodivision lies at mid-latitudes across the Interior Plains from the Rocky Mountain Foothills in British Columbia and Alberta east to the Canadian Shield in Alberta, Saskatchewan, and Manitoba. The climate is continental, with cold Arctic winters and moderately warm summers. It contains two ecoprovinces.

Boreal Lowlands Ecoprovince

Landforms. This ecoprovince occurs predominantly on the Interior Plains, specifically the Alberta Plateau, northern Alberta Plain, northern Saskatchewan Plain and Manitoba Plain, which consist of low plateaus, plains, and lowlands. All were glaciated by the Laurentian Ice Sheet.

Climate. Cold, dry Arctic air masses are dominant in the winter and spring. In the summer and fall warmer, wetter Pacific westerlies dominate (Strong and Leggat 1992). Much of the summer and fall moisture is from surface heating of the many wetlands, streams, and lakes.

Vegetation. Quaking aspen with bluejoint, prickly rose, and bunchberry dominate most upland sites; wetter sites are dominated by quaking aspen and balsam poplar; poorly drained sites are vegetated by an overstory of black spruce with an understory of Labrador tea, bog cranberry, and mosses; jack pine communities are common on the uplands, but white spruce and black spruce are the potential climax forest species (Strong and Leggat 1992).

Boreal Uplands Ecoprovince

Landforms. This ecoprovince occurs on the Alberta Plateau and consists of plateaus, plains, prairies, and lowlands and is generally a rolling upland once away from the deeply incised river beds.

Glaciation. The entire area was glaciated during the Pleistocene by westward-moving ice sheets that originated in the Arctic of Hudson Bay and Baffin Island (Fulton 1989). A large glacial lake was formed in the Peace Lowland basin.

Climate. The climate is typically continental since most of the moist Pacific air has dried and crossed successive ranges of mountains before it reaches the area. Air movement is generally level, with intense orographic lifting in the vicinity of the Peace River. In warmer months, rain is largely caused by surface heating, which leads to convective showers. Winters are cold because there are no barriers to irruptions of Arctic air.

Vegetation. A single climax community, the boreal white and black spruce forest, dominates this ecoprovince. Quaking aspen seral forest occurs in the Peace River lowland and black spruce muskeg occurs throughout most of the upland surface. On the western-most areas, just east of the Rocky Mountain Foothills on low ridges, more mountainous vegetation develops such as the Engelmann spruce and subalpine fir forests that occur on the summits of those ridges.

HUMID CONTINENTAL HIGHLANDS ECODIVISION (2)

This complex mountains, plateaus, and basins ecodivision is situated at mid-latitudes across the central interior of British Columbia, from the Coast Mountains east to the Interior Plains and south into northeastern Washington, northern Idaho, and northwestern Montana. The climate is sub-continental with cold, commonly Arctic winters and warm, dry summers. Precipitation is predominantly from Pacific air masses, but surface heating of wetlands, streams, and lakes provides additional moisture. This ecodivisions contains three ecoprovinces.

Central British Columbia Plateaus Ecoprovince

Landforms. This ecoprovince consists of the flat to rolling Chilcotin and Cariboo plateaus and the southern two-thirds of the Nechako Plateau. It also contains the Chilcotin Ranges west to the center of the Pacific Ranges and the Bulkley and Tahtsa Ranges of the Kitimat Ranges. Those mountain ranges on the east side of the Coast Mountains are included because they are much drier than the windward side and therefore have a more interior-type of climate.

Glaciation. The entire area was glaciated during the Pleistocene, and ice sheets moved northeastward from the Coast Mountains. Glacial lakes and subsequent lacustrine deposits occur primarily in the Fraser River Basin area.

Climate. The area has an atypical continental climate: cold winters, warm summers, and a precipitation maximum in the late spring or early summer. However, the moderating influences of Pacific air occur throughout the year, as is the case for most of British Columbia south of 57N. This ecoprovince lies in a rain shadow leeward of the Coast Mountains. In summer there is intense surface heating and convective showers, and in the winter there are frequent outbreaks of Arctic air (these are less frequent than in the Sub-Boreal Interior ecoprovince to the north).

Vegetation. The area contains interior Douglas fir, pinegrass forests in the southern landscapes; lodgepole pine, quaking aspen, spruce forests in the center; and hybrid spruce, lodgepole pine and quaking aspen forests in the north. In addition, bunchgrass steppe with big sagebrush occurs within the deeply entrenched portions of the Fraser and Chilcotin rivers. Douglas fir, lodgepole pine, and pinegrass forests occur at middle elevations in the Chilcotin Ranges and southern Chilcotin Plateau. Engelmann spruce and subalpine fir forests occur on the middle slope of all mountains and the higher portion of the northern Chilcotin and southern Nechako Plateaus. Alpine occurs on all mountain summits.

Shining Mountains Ecoprovince

Landforms. This ecoprovince consists of six main physiographic systems: the highlands on the western flank, the Columbia Mountains, the Southern Rocky Mountain Trench, the Continental Ranges of the Canadian Rocky Mountains, the Rocky Mountain Foothills of Alberta (including the Porcupine Hills) and Montana, the Belt Formation or Border Ranges of the northern Rockies in Montana, and the mountains of the Panhandle of Idaho.

Glaciation. The entire area was glaciated during the Pleistocene, and the most intensive was the Cordilleran glaciation in the Columbia and Canadian

Rocky Mountains. Portions of the Rocky Mountain Foothills may have been unglaciated during periods of waning glaciation because this was the eastern boundary of the Cordilleran Ice Sheet and the western boundary of the Laurentian Ice Sheet. In the southern mountains, glaciers occurred on the upper slopes, but not in the valleys, even though glacial lakes often dominated those valleys.

Climate. Air masses approach from the west and lose moisture, first as they pass over the western Columbia Mountains and Bitterroot Ranges and. again as they pass over the Rocky Mountains. The Southern Rocky Mountain Trench bisects two large mountain blocks with similar physiography and macroclimatic processes. During the summer, intense surface heating creates strong updrafts in the mountains. The resulting downdraft over the center of the Rocky Mountain Trench clears the skies and enhances the sunny conditions. During the winter and early spring, outbreaks of Arctic air bring cold, dense air to the Rocky Mountain Foothills and eastern Rockies. The Rocky Mountain Trench serves as an access route for Arctic air that occurs in the Sub-Boreal Interior of ecoprovince.

Vegetation. Four climax communities dominate this ecoprovince: the interior western redcedar and western hemlock forests in the lower to middle slopes of the Columbia Mountains and Bitterroot Ranges and wetter localities in the Rockies and northern portion of the Rocky Mountain Trench; the interior Douglas fir, bunchgrass, bitterbrush forests of the Southern Rocky Mountain Trench lower slopes of the Clark Fork Valley; Engelmann spruce and subalpine fir forests on the middle slopes of all mountains; and dry, rock dominated alpine tundra on the mountain summits. In addition, ponderosa pine, bunchgrass, and bitterbrush forests occur in the Southern Rocky Mountain Trench. Douglas fir, lodgepole pine, and pinegrass forest occurs in the valleys and lower slopes of the Continental and Border ranges of the Rockies and eastern Purcell Mountains; the interior Douglas fir and grand fir forests occur sporadically c)n mid slopes in the Coeur d'Alene Mountains and in the Clark Fork Valley. Quaking aspen parkland with rough fescue occur at lower slopes in the Rocky Mountain Foothills.

Sub-Boreal Interior Ecoprovince

Landforms. This ecoprovince consists of several physiographic systems: the Coast Mountains, the Interior Plateau, the Omineca Mountains and the Rocky Mountains. The mountains in the west include the southeastern portion of the Boundary Ranges and the Skeena Mountains. The mountains to the north include the southern Omineca Mountains. The mountains to the east include the Misinchinka and Hart ranges of the Rocky Mountains and associated Foothills. In the center and south is the low-lying plateau area of the Nechako Lowlands and northern portion of the Nechako Plateau.

Glaciation. The entire area was glaciated during the Pleistocene by glaciers that coalesced on the plateaus and lowlands. Glaciers moved southeast from the Boundary Ranges and south from the Skeena and Omineca Mountains. They met glaciers that moved northeastward across the Interior Plateau and moved together over the Hart Ranges (Claque 1989). Large glacial lakes formed in the Nechako Lowland and Northern Rocky Mountain Trench.

Climate. Prevailing westerly winds bring Pacific air to the area over the Coast Mountains by way of the low Kitimat Ranges or the higher Boundary Ranges. Much of this area is in a rain shadow. Coastal air has low moisture content when it arrives. Moisture does enter the area when there is a southwest flow over the low Kitimat Ranges. Summer surface heating leads to convective showers, and winter frontal systems result in precipitation that is evenly distributed throughout the year. Outbreaks of Arctic air are frequent. The southern boundary of the Ecoprovince approximates the southern boundary of the Arctic air mass in January.

Vegetation. Sub-Boreal spruce forests with hybrid spruce, subalpine fir, and lodgepole pine dominate the Nechako Plateau, Nechako Lowlands, Northern Rocky Mountain Trench, and many of the valleys. Engelmann spruce and subalpine fir forests occur on the middle slopes of all mountains, and alpine tundra occurs on the upper slopes of those mountains. In the wetter valleys of the Skeena Mountains, interior western redcedar and western hemlock forests occur. In the northern Omineca Mountains and valleys of the Rocky Mountain Foothills, forests of white spruce, lodgepole pine, quaking aspen, and black spruce occur.

HUMID CONTINENTAL PLAINS ECODIVISION (3)

This plains ecodivision is situated at mid-latitudes across the Interior Plains of Alberta, Saskatchewan,

and Manitoba, and then south on the Red River Plain of North Dakota and Minnesota. This area is transitional between the boreal, continental climate to the north and the prairie continental climate to the south and west. Winter consists of cold, dry, Arctic air, while summers are hot and humid with surface heating of wetlands, streams, and lakes. There are two ecoprovinces but only one for this project.

Aspen-Parkland Ecoprovince

Landforms. This ecoprovince occurs on gently undulating to rolling glacial deposits, usually consisting of packed morainal, coarse flood-washed, or finer lake-deposited materials (Klassen 1989).

Climate. The winter climate is affected by a ridge of high pressure that usually extends from the Gulf of Alaska to Hudson Bay. The cold, dense Arctic air from the north generally deflects the milder, westerly Pacific air southward. Winters are long and severe. Summer and spring climates are warm and humid, often being affected by moist air from the Gulf of Mexico (Hare and Thomas 1979).

Vegetation. Quaking aspen that occur as clones are surrounded by rough fescue, bluebunch fescue, junegrass, and needlegrasses that dominate the natural landscape. Quaking aspen and balsam poplar stands occur on moister sites. Eastern cottonwood, green ash, and Manitoba maple are common along the riparian areas. In the eastern portion, quaking aspen and bur oak communities dominate (Harris et al. 1983; Strong and Leggat 1992). The natural ecosystems of the entire area have been affected by the reduction of wildfire, the elimination of free-ranging plains bison, and cultivation (Harris et al. 1983).

HUMID MARITIME AND HIGHLANDS ECODIVISION (4)

This ecodivision consists of complex coastal marine areas, lowlands, archipelagos and rugged mountains. It lies perpendicular to the prevailing Northeast Pacific air masses and the Sub-Arctic Current of the Northern Pacific Ocean. The climate is generally wet and mild throughout the year, with hot, dry periods in the late summer in the south, and with intense precipitation during the fall, winter, and early spring. Arctic air invades this area only infrequently. There are two ecoprovinces.

Georgia-Puget Basin Ecoprovince

Landforms. This ecoprovince is a large basin that encompasses the southeastern Vancouver Island Mountains, the Nanaimo Lowlands, the Strait of Juan de Fuca and the eastern slopes of the Olympic Mountains in the west; the Strait of Georgia, Gulf Islands, and Puget Sound in the middle; and the Georgia Lowlands, Fraser Lowlands, Puget Lowlands in the east.

Climate. Pacific air reaches this area primarily after lifting over the Insular and Olympic mountains. That air descends into the central straits and sounds before it rises over the extensive Pacific and Cascade ranges. Surface air flow is level or subsiding and creates clearer and drier conditions than in coastal areas adjacent to the Pacific Ocean. Temperatures throughout the area are modified by the ocean and marine environments and only exceptionally will Arctic air flow over the Pacific Ranges to bring short periods of intense cold and high winds.

Vegetation. Temperate rainforests dominated by western hemlock, Douglas fir, and western redcedar occur on most mountain and upland sites. Low elevation plains and rocky sites along the western portion are dominated by coastal Douglas fir and salal forests. Garry oak and arbutus trees occur northward along eastern Vancouver Island and the Gulf Island, giving the coastline of this area a Mediterranean appearance. Mountain hemlock and subalpine forests occur on the higher portions of the Vancouver Island Ranges.

Pacific Northwest Coast and Mountains Ecoprovince

Landforms. This ecoprovince includes the windward side of the Coast Mountains, Coast Range, Cascade Range, Vancouver Island, all of Queen Charlotte Islands, the Alexander Archipelago, St. Elias Mountains, and the continental shelf from Cook Inlet to southern Oregon. Large coastal mountains, a broad coastal trough and the associated lowlands, islands, and continental shelf also occur here.

Glaciation. This ecoprovince was glaciated most heavily in the northern portion and less so in the Cascade Range but was unglaciated in the Coast Range and Willamette Valley of Washington and Oregon. Glaciers and ice-sheets that originated along the crest of the coast mountains moved west and southward to the ocean, sculpting the valleys and faults into fjords and channels. Even the continental

shelf was affected as it received the glacial debris and outwash, forming a deep blanket of sediment.

Climate. The major climatic processes involve the arrival of frontal systems from the Pacific Ocean and the subsequent lifting of those systems over the coastal mountains. In winter, oceanic low pressure systems dominate the area and pump moist, mild air onto the entire coast. In the summer, high pressure systems occur over the north Pacific Ocean and low pressure frontal systems become less frequent in the southern portion and tend to strike the coast of Alaska.

Vegetation. Temperate rainforests of western hemlock, yellow cedar, western redcedar, and sitka spruce dominate most of the mountains and lowlands. Mountain hemlock subalpine forests and alpine tundra communities occur on the mountain summits. Glaciers are common, and large icefields persist on the St. Elias Mountains, Boundary, and Pacific ranges. More locally, drier coastal Douglas-fir forest occurs in the Willamette Valley; interior western redcedar and western hemlock forests occur in the Nass Basin, a coast-interior transition area; and Engelmann spruce, subalpine fir, and boreal white spruce and black spruce forests occur along eastern-most valleys that lead into the interior of the continent.

MEDITERRANEAN HIGHLANDS ECODIVISION (5)

This coast, foothills, basins, and mountains ecodivision occurs at south to mid-latitudes from Baja California north across California to southern Oregon. This area lies perpendicular to the West Wind Drift and California Current of the Northern Pacific Ocean and to Pacific air masses. This wet, mild air mixes with the hot, dry, desert air of the interior creating a strong Mediterranean climate-a wet winter followed by a dry summer. In this current effort, four ecoprovinces have been recognized, but further evaluation is required to determine if such a designation is warranted.

California Coast and Foothills Ecoprovince

Landforms. This ecoprovince includes the Central Western and Southwestern California Geographic subdivisions (Hickman 1993), which extend south onto the Baja California peninsula to approximately 30ºN (Brown and Lowe 1980; Lowe and Brown 1982). The South Coast and Peninsula ranges are a series of northwest-southeast trending foothills and valleys, whereas the Transverse Ranges are oriented east-west. This ecoprovince also includes the coast and islands such as the Channel and Farallon islands and the continental shelf from Bahia Santa Marie north to San Francisco Bay.

Climate. Prevailing westerly winds dominate this area. Moderate temperatures and moisture meet hot, dry interior climates, creating fog that persists along the coast and windward side of the mountains. Seasons are dominated by wet, cool months in the winter and early spring, and by dry, hot months from late spring to fall (Munz and Keck 1970).

Vegetation. Forests include thick-leaved species of California live oak, canyon live oak, interior live oak, California laurel, arbutus, and Pacific bayberry on the north-facing slopes; chapparal shrubland of chamiso, manzanita, Christmasberry, California scrub oak, and mountain mahogany on the south-facing and drier sites; and sagebrush-steppe of soft chess, cheatgrass, and California sagebrush on the coastal plains and interior valleys.

Great Central Valley Ecoprovince

Landforms. This ecoprovince is a low elevation, broad alluvial valley bordered by sloping fans, dissected terraces, and low foothills (Bailey 1978; Munz and Keck 1970).

Climate. Moist Pacific air rises over the Coast Ranges to the west creating a rainshadow in the Great Central Valley. The prevailing winds from the west also help to moderate the hot, dry air from the deserts to the southeast. An important climatic factor is the fog that occurs in the winter, bringing humid, cool conditions to this area (Munz and Keck 1970).

Vegetation. This ecoprovince has been converted to agricultural and urban developments, but the potential dominant vegetation is needlegrasses and threeawns. At present, the undeveloped areas are dominated by annual grasses such as bromes, fescues, and oats. Chapparal or broad-leaved sclerophyllic shrub vegetation occurs in sporadic patches as do southern oak woodlands (Munz and Keck 1970). The rivers flow through alkaline flats where greasewood, picklewood, saltgrasses, and shad scale are prevalent. Tule marshes border the lower reaches of the San Joaquin and Sacramento rivers (Bailey 1978).

Sierra Nevada Ecoprovince

Landforms. This ecoprovince is composed of the southern portion of the Cascade Ranges and the high, rugged Sierra Nevada. Some mountains had glaciers during the Pleistocene epoch. The Sierra Nevada consists of an immense granitic batholith. While its steep eastern face rises abruptly above the Great Basin to the east, the western slope is a more gradual tilted plateau that is scored with deep canyons (Hickman 1993; Munz and Keck 1970).

Vegetation. On the western foothills dense stands of blue oak and Digger pine occur with scrub live oak. Annual grasses such as chess, wild oats, and ripgut brome are dominant understory species. Vegetation changes from ponderosa pine, manzanita, and black oak, to forests of Douglas fir, incense cedar, sugar pine, lodgepole pine, and then to red fir, Jeffery pine, mountain hemlock, and white-bark pine forests with rising elevation. Bristlecone pine grows at treeline. Alpine occurs on the highest summits. Giant Sequoia grow in the moist southern valleys (USDA Soil Conservation Service 1981).

Northern California Coast Ranges Ecoprovince

Landforms. This ecoprovince is composed of the Klamath Mountains and Coast Ranges of northern California and extreme southwestern Oregon. The province rises in a series of low hills and mountains from the Pacific Coast.

Climate. The climate is greatly influenced by the Pacific maritime westerlies that baring mild temperatures and intense moisture during the winter and spring. During the summer and fall, hot, sub-tropical desert air arrives from the east and south.

Vegetation. Forests range from western hemlock, grand fir, Sitka spruce to Douglas fir, arbutus, broadleafed maple. Wet, fog-dependent redwood forests with Douglas fir, salal, and rhododendron occur along the coast (Hickman 1993; Munz and Keck 1970).

SEMI-ARID STEPPE HIGHLANDS ECODIVISON (6)

This basin, plateau, and mountain ecodivision lies east of the Coast Mountains and Cascade Ranges of southern British Columbia, Washington, and northern Oregon. Much of the western area is in the rainshadow of those mountains. Pacific air is generally level and sub-continental in effect and does not contribute much precipitation, until it reaches the mountains to the east. Winters are cold and dry and usually not affected by cold, Arctic air; summers are warm to hot and dry, but with peak precipitation in the early growing season. Three ecoprovinces are recognized in this current effort, but the complex Northern Rocky Mountain Forest ecoprovince should be re-evaluated.

Columbia Plateau Ecoprovince

Landforms. This Ecoprovince is predominantly a level surface of Tertiary lavas that have been deeply dissected by the Columbia and Snake rivers. Much of the northeastern portion has been scoured by excessive flooding during the later stages of the Pleistocene glaciation (Alt and Hyndman 1984; Thornbury 1969). This ecoprovince also includes the dry-forested, leeward portion of the Cascade Ranges.

Climate. The climate of this area is moderated by the surrounding mountains. Much of the moisture has been precipitated from the westerly Pacific air masses as they cross the Cascade Ranges. The air flowing down the leeward slopes warms and retains moisture as it crosses the plateau. The great chain of mountains to the north and east protect this area from all but severe outbreaks of Arctic air in the winter and spring. In the late summer and early fall, hot sub-tropical air can move in from the south prolonging the hot, dry summer conditions (Franklin and Dyrness 1973).

Vegetation. Dominant vegetation typically includes big sagebrush, pasture sage, bluebunch wheatgrass, and bluebunch fescue, rough fescue, and snowberry occur with increased elevation to the east. In the mountains, ponderosa pine forests give way to Douglas fir and grand fir montane forests, which give way to subalpine forests of Engelmann spruce, grand fir, subalpine fir, and lodgepole pine on the upper forest slopes and higher valleys. Alpine tundra communities occur on the summits of the higher mountains (Daubenmire 1970; Franklin and Dyrness 1973).

Northern Rocky Mountain Forest Ecoprovince

Landforms. This ecoprovince consists of several mountain ranges with different origins that collectively form a major east-west mountain block. The Blue Mountains in the west are predominantly of

sedimentary and volcanic origins, with wide, raised valleys and deep dissected river gorges. The mountains of central Idaho consist of the Idaho Batholith and are high and rugged, with deep narrow valleys. The mountains of eastern Idaho and Montana are Precambrian volcanic and sedimentary with high rugged ridges rising abruptly from wide flat-bottomed valleys. The mountains of Wyoming are volcanic, with high valleys and higher mountain ranges (McKee 1972).

Glaciation. These mountains were not overridden by glacial ice-sheets but were sculpted by mountain glaciers in the Clearwater Mountains of Idaho, the Bitterroot Ranges, and mountain ranges in Wyoming.

Climate. The mountainous topography of this ecoprovince results in a very complex climate. It receives the Pacific westerlies after they have crossed the Cascade Ranges and the Columbia Plateau, giving added moisture to the western flank. These mountains are also a barrier to outbreaks of Arctic air flowing southwestward across the Interior Plains of North America or southward across the interior of British Columbia. In the summer and fall this ecoprovince receives intense heat from southern subtropical air masses.

Vegetation. The plant communities are complex in lower elevations and includes big sagebrush, bluebunch wheatgrass stands. Douglas fir, grand fir, and ponderosa pine forests dominate the middle elevations; Engelmann spruce, lodgepole pine, and subalpine fir occur on the upper mountain slopes; and alpine communities occur only on the highest mountains in the eastern portion of this area (Bailey 1978; Ross and Hunter 1976; Steele et al. 1983).

Thompson-Okanogan Highlands Ecoprovince

Landforms. This ecoprovince includes the Thompson Plateau, the Pavilion Ranges, the eastern portion of the Cascade Ranges south to Lake Chelan, the western margin of the Shuswap Highlands, and the Okanogan (spelled Okanagan in Canada) Highlands. The leeward portion of the coastal mountains and the drier portion of the highlands are included because they share much the same climate as the main plateau area.

Climate. Air moving into this ecoprovince from the Pacific has already lost most of its moisture on the west-facing slopes of the coastal mountains. The air moving across the plateau surface tends to be level, resulting in little precipitation, except through surface heating of lakes and streams. There are occasional irruptions of hot, dry air from the Great Basin to the south in the summer. They bring clear skies and very warm temperatures. In winter and early spring, frequent outbreaks of cold, dense Arctic air occur because there is no effective barrier once it enters the interior plateaus of British Columbia. However, such events are less frequent than on the plateaus farther north.

Glaciation. Pleistocene glaciation was very intense throughout, except for the portion in Washington where valley glaciers and mountain glaciers remained distinct. Large glacial lakes formed and then were filled with silt in the Thompson, Nicola, and Okanagan valleys.

Vegetation. Three climax plant communities dominate this ecoprovince: the bunchgrass steppe, often with big sagebrush in the lower slopes of the large basins; the interior Douglas fir and bunchgrass forests on the lower elevations of the plateau surface; and the Douglas fir, lodgepole pine and pinegrass forests on the higher elevations of the plateaus and highlands. Engelmann spruce, subalpine fir forests occur on the higher elevations of the plateau and on the middle to upper slopes of the mountain ranges. On the highest summits of the Okanagan and Pavilion ranges, alpine tundra occurs. Ponderosa pine, bunchgrass, and rabbitbrush parkland occur sporadically on the middle slopes of the large, dry basins.

SUB-TROPICAL DESERTS ECODIVISION (7)

This complex coastal, basin, plateau, and mountain ecodivision lies at mid-southerly latitudes in northern Mexico and the southwestern United States. Climate is extremely arid with high temperatures. Days are very hot, but nights are cold due to outgoing radiation causing extreme day to night temperature variation. Three ecoprovinces have been delineated for this project, but more are likely to occur in Mexico.

Chihuahuan Desert Ecoprovince

Landforms. Broad desert basins and valleys are bordered by gently sloping to strongly sloping fans and terraces. Steep north-south trending mountain ranges and many small mesas occur in the west (USDA Soil Conservation Service 1981).

Climate. Most of the precipitation comes in convectional storms during the summer months; rain and even snow in the mountains fall occasionally in the winter. The most arid season is late spring and early summer. Due to the high elevation, mean temperatures are moderate but the summer days are hot (Bailey 1978; USDA Soil Conservation Service 1981).

Vegetation. In the eastern plains and basin, vegetation consists of Trans-Pecos shrub savanna on the lower plains, changing to grama-tobosa prairie and finally to oak-juniper woodland with rising elevation. In the western mountains and mesas, grama-tobosa shrubsteppe occurs at the lower elevations changing to oak-juniper woodland and finally to Arizona pine forest on the summits of the highest mountains (Brown 1982d, 1982e).

Sonoran-Mojavian Deserts Ecoprovince

Landforms. This ecoprovince is characterized by extensive, undulating plains from which isolated low mountains and buttes abruptly rise. The mountains are rocky but flanked by alluvial fans and outwash aprons. Most minor rivers are dry most of the year (Bailey 1978).

Climate. The climate is characterized by long, hot summers, though the winters are moderate and frosts are common. In the winter, the rain is gentle and widespread but in summer thunderstorms are prevalent. In some years, in the western portion, there may be no measurable precipitation (Bailey 1978).

Vegetation. Plant cover is usually very sparse, with bare ground between individual plants. Cacti and thorny shrubs are conspicuous, but many thornless shrubs are also present. Creosote bush is widespread on the Sonoran Desert Plains. Aborescent cacti and cholla are also common. Mesquite grows along washes and watercourses. On steep rocky slopes paloverde, ocotillo, saguaro, cholla, and compass barrel cactus are abundant. Along the higher, northern portion is a belt of junipers and pinyons (Bailey 1978; Turner and Brown 1982).

Sierra Madre Occidental Ecoprovince

Landforms. This ecoprovince consists of mature, rolling volcanic plateaus, cumulating in high mountains. Deep, rugged canyons dissect the plateaus and mountains (Gordon 1968).

Climate. In general the climate is dry, although there are light winter and heavy summer rainy seasons; early spring is very dry. This pattern falls between the summer-rain type in central and southern Mexico and the winter-rain type of California. The winters are characterized by low relative humidities and are cold with many hard frosts. At higher elevations light snowfalls are common (Gordon 1968).

Vegetation. The vegetation is a complex of Mexican oak-pine forests. Ponderosa pine is common but there are a dozen other species as well, such as scrub oak, Arizona cypress, true fir, Douglas fir, prickly pear, barrel cactus, and accacia. A dense, low, chapparal-like woodland dominated by scrub oak and acacia grows above the oak-pine forests. In the foothills, a large variety of oaks occur in both the live oak (encinal) and oak-pine woodlands (Brown 1982b; Meyer 1973; Pase and Brown 1982).

SUB-TROPICAL SEMI-DESERT HIGHLANDS ECODIVISION (8)

This complex basin, plateau, and mountain ecodivsion lies in northern Arizona, New Mexico, southern Utah, and southwestern Colorado. The climate is transitional between that of the extreme deserts to the south and the more temperate climates to the north. The hot, dry climates are moderated by the elevation of the plateaus and mountains. There are three ecoprovinces.

Arizona Mountains Ecoprovince

Landforms. This ecoprovince is a series of mountains, ridges, and mesas, culminating on the Mogollon Rim. The area is very hilly and mountainous, but the upland plateau is dissected by many deep canyons (USDA Soil Conservation Service 1981).

Climate. The area is affected by hot, moisture-laden air arriving from the Pacific Ocean to the west and occasionally from the Gulf of Mexico to the southeast. Such air is heated as it crosses over the American deserts. Half of all the precipitation that falls here occurs during the growing season (Pase and Brown 1982).

Vegetation. Climax plant communities occur as successive belts that change with elevation and protection from desert air. On the southwestern side, sagebrush-steppe gives way to oak-juniper scrub, which changes to ponderosa pine forests. At the highest summits, notably the San Francisco, White, Mogollon, Black, Mateao, and Magdelena mountains, spruce-fir/Douglas-fir forests are established. Alpine

tundra occurs on only the tallest of those summits (Humphrey Peak). On the east or Colorado Plateau side, pinyon-juniper woodland is established (Brown 1982a; Pase and Brown 1982).

Colorado Plateaus Ecoprovince

Landforms. This ecoprovince is surrounded by mountains: to the south are the Arizona Mountains, to the east are the Rocky Mountains of Colorado and New Mexico, and to the northwest are the Rocky Mountains of Utah. The northern portion of the Colorado Plateau physiographic unit is affected by more temperate climates and is therefore considered to be another ecoprovince (the Central Rocky Mountain Basins ecoprovince). The Colorado Plateaus ecoprovince consists of the Grand Canyon, Kaibab Plateau, Painted Desert, and San Juan River Valley mesas and plateaus. In general the surface consists of gentle to strongly sloping plains. Volcanic plugs rise abruptly from those plains and deeply incised canyons interrupt the plains' surface (USDA Soil Conservation Service 1981).

Climate. The climate is characterized by high altitude and cold winters. Summer days are usually hot, but nights are cool. Accordingly, diurnal temperature variation is considerable. Summer rains are thunderstorms, but ordinary rains and snowfall come in winter (Bailey 1978, USDA Soil Conservation Service 1981).

Vegetation. The plateau surface consists of Great Basin sagebrush, pinyon-juniper woodland, and grama-galleta steppe. Within the Grand Canyon, creosote bush, saltbush-greasewood, and blackbrush occur (Turner 1982).

New Mexico Rocky Mountains Ecoprovince

Landforms. This ecoprovince is dominated by high, rolling plateaus, with isolated mountains and steeply scarped mesas (USDA Soil Conservation Service 1981).

Climate. The climate is characterized by cold, high elevation winter temperatures and hot summers, although evening temperatures are cool due to rapid high-elevation heat loss. Precipitation usually occurs in winter as rain or snow; thundershowers are typical of summer precipitation (Bailey 1978).

Vegetation. Grassland vegetation of Indian ricegrass, blue grama, dropseed, prickly pear, four-winged saltbush, winterfat, and rabbitbrush gives way to pinyon-juniper woodlands, with big sagebrush at higher elevations. Douglas fir and ponderosa pine grow in more sheltered locations or at higher elevations. On the highest summits, Engelmann spruce and subalpine fir forests occur (Brown 1982b, Pase and Brown 1982).

TEMPERATE SEMI-DESERTS ECODIVISION (9)

This ecodivision is a broad expanse of basins and intervening mountain ridges situated in Nevada, western Utah, southern Idaho, southeastern Oregon, and northeastern California. It has a predominantly semi-arid continental climate with periodic summer rainfall but high temperatures. Winters are cold and dry, and summers warm to hot. This area contains two ecoprovinces.

Great Basin Ecoprovince

Landforms. This ecoprovince consists of the extensive isolated ridges and mountains and wide inter-valleys called the Basin and Range Province (Omernik 1986). The highest accumulation of mountains occur in central Nevada. Most streams do not drain to the sea.

Climate. Summers are hot and dry, and precipitation occurs in the cool winter months.

Vegetation. The landscapes are dominated by much-branched, non-sprouting, aromatic, semi-shrubs with evergreen leaves, such as sagebrush, shadscale, blackbrush, winterfat, greasewood, or rabbitbrush. There are few cacti, and those present tend to be of short stature or prostrate and include chollas, prickly pears, and hedgehog cacti (Turner 1982).

Snake River Basins Ecoprovince

Landforms. This ecoprovince consists of the broad Snake River Plain, Owyhee Mountains, Harney Basin, High Lava Plain, and Black Rock Desert. It also includes the Fremont Mountains of Oregon. Topography is dominated by level Tertiary basalts with deep dissected rivers or stretched landscapes of Basin and Range formations (McKee 1972).

Climate. The climate is influenced by the high mountains to the west, which create a rainshadow for westerly Pacific air masses. The Northern Rocky Mountain Forest ecoprovince also provides an effective barrier to Arctic air moving southwestward

across the Interior Plains or southward through the interior of British Columbia. Summers are hot and dry; precipitation is evenly distributed in fall, winter, and summer (USDA Soil Conservation Service 1981).

Vegetation. Climax plant communities are dominated by sagebrush with wheatgrass; saltbush and greasewood occur on alkaline soils. The northern occurrence of desert communities occur within Harney Basin. Western juniper with ponderosa pine and Douglas fir occur on the higher uplands (Bailey 1978).

TEMPERATE SEMI-DESERT HIGHLANDS ECODIVISION (10)

This is a complex basin, plateau, and mountain ecodivision, situated in eastern Utah, central Wyoming, western Colorado, and north-central New Mexico. It has a semi-arid continental climate that is strongly influenced by the generally high elevations of its plateaus and mountains. Winters are cold and dry, with Arctic air frequently lying along the eastern mountains. Summers are warm to hot with considerable precipitation. This area has four ecoprovinces.

Central Rocky Mountain Basins Ecoprovince

Landforms. This ecoprovince consists of many basins, such as the Green River, Uinta and Paradox, and many mountain ranges such as the Roan, Uncompahgre, White River, northern Colorado Plateaus, and Grand Mesa (Mitchell 1993).

Climate. The climate of this ecoprovince is moderated by the surrounding mountains, with complex rising and descending air masses. Maximum precipitation occurs in the winter and spring as Pacific air masses are deflected south around the Arctic air lying in the Interior Plains of North America. In the summer, sub-tropical air masses bring hot, dry weather, although the high elevation of this area causes most of the day-time air to dissipate at night.

Vegetation. This area supports sagebrush-steppe of big sagebrush, needle-and-thread bluebunch wheatgrass, and western wheatgrass. At higher elevations, big sagebrush, rabbitbrush, and winterfat form dense shrub communities with needlegrasses, Arizona fescue, and bluegrasses. Rocky Mountain juniper occurs on shallow upland soils. Ponderosa pine, Douglas fir, and quaking aspen forests occur on low mountain ridges (USDA Soil Conservation Service 1981).

Colorado Rocky Mountains Ecoprovince

Landforms. This ecoprovince consists of very high mountains with wide, high elevation valleys often called "parks." Mountain glaciers during the Pleistocene sculpted most of the mountain summits.

Climate. In the winter moist Pacific westerlies move across Oregon and Idaho and then deflect south of Arctic air masses lying over the Great Plains. The contact of the moist and cold air masses bring frequent snow storms to this ecoprovince. Arctic air can also flow over this area during periods of intense outbreaks. In the summer the intense heat of the subtropical air masses is ameliorated by the nocturnal dissipation of surface heat, due to the high elevations.

Vegetation. Climax plant communities are divided into elevational belts; sagebrush-steppe of big sagebrush, rabbitbrush, needlegrasses, and wheatgrasses give way to ponderosa pine and Douglas fir with junegrass and Arizona fescue. Quaking aspen communities occupy mid-elevations sites along with lodgepole pine and Engelrnann spruce forests. Grasslands and mountain meadows can be found within all mountains. On the summits, rolling alpine tundra or bare rock is common (Mitchell 1993).

Utah Rocky Mountains Ecoprovince

Landforms. This ecoprovince consists of two dominant mountain ranges, the Uinta and Wasatch Mountains, and a series of smaller ranges to the south.

Climate. The climate is affected by Pacific westerlies, which bring considerable winter and spring precipitation, in spite of the Great Basin Desert to the west. Precipitation is equal in summer and winter, with snow being common in the winter. Cold Arctic air often invades this area, having no effective barrier to the east. Summers are warm, but thunderstorms and convective showers bring periodic precipitation. Mountains in this area cool off rapidly in the evening due to their elevation.

Vegetation. Climax plant communities are variable with grassland steppe, mountain shrub, quaking aspen, conifer forests, and alpine rising in sequence with elevation. Big sagebrush and bluebunch wheatgrass are common sagebrush-steppe species. Quaking aspen forests are dominant over much of the landscape (Mueggler and Campbell 1986). Conifer for-

ests at higher elevations consist of Douglas fir, ponderosa pine, Engelmann spruce, white fir, subalpine fir, and lodgepole pine. Curlleaf and birchleaf mountain mahogany, Gambel oak, serviceberry, and chokecherry shrub communities are also abundant. Alpine tundra communities occur on the highest mountain summits (Mauk and Henderson 1984; USDA Soil Conservation Service 1981).

Wyoming Basins Ecoprovince

Landforms. This ecoprovince is composed of a series of high-elevation basins and low ridges; it also includes the Rocky Mountain outlier-the Bighorn Mountain range.

Climate. Summers are short and hot, the high elevation causes great diurnal temperature fluctuations, and the winters are cold. Arctic air can invade this area unimpeded from the northeast, while Pacific westerlies bring moisture. When the two systems coalesce, snow usually results.

Vegetation. Sagebrush-steppe, usually big sagebrush, bluebunch wheatgrass, shad scale, blue grama, needlegrasses, or fourwing saltbush are dominant in the wide basins. Pinyon pine, juniper, ponderosa pine, and Douglas fir forests occur with rising elevations, giving way to Engelmann spruce and lodgepole pine on the higher elevations (Green and Conner 1989; USDA Soil Conservation Service 1981).

TEMPERATE STEPPE PLAINS ECODIVISION (11)

This expansive plain ecodivision extends across the Interior Plains of southern Alberta and Saskatchewan, eastern Montana, Wyoming, Colorado, and western North Dakota, South Dakota, Nebraska, Kansas, and Oklahoma. It has a strong semi-arid continental climate. Cold, usually Arctic winters in the northern portion and warm to hot summers with considerable precipitation occur. The high elevation of the southern portion effectively cools the area so that both northern and southern portions are similar. This area has three ecoprovinces, two of which are shown on the map.

Canadian Prairie Ecoprovince

Landforms. This ecoprovince occurs on the southern portions of the Alberta Plain and Saskatchewan Plain and includes elevated features such as the Cypress Hills, Sweetgrass Hills, and Bearpaw Mountains. It is generally a rolling upland with packed glacial till, coarse glacial-river deposits, and fine glacial lake sediments overlaying level Cretaceous, shale, siltstone, and sandstone. The large rivers are dissected below the upland surface (Beaty 1975; Klassen 1989).

Climate. The climate is continental, with bitterly cold winters and short but warm summers, with a light precipitation regime. In the west the Cordillera modifies the eastward-flowing Pacific air, causing warmer and drier conditions to prevail. In the east sub-tropical air from the Gulf of Mexico causes increased humidity and precipitation (Hare and Thomas 1979).

Vegetation. Needlegrasses, blue grama, and pasture sage dominate the southern and eastern portions. Rough fescue, Parry oatgrass, junegrass, lupines, and northern bed-straw dominate on the higher uplands to the west and near the Aspen-Parkland ecoprovince. At higher elevations on the upland outliers are quaking aspen, lodgepole pine, needlegrasses, wheatgrasses, lupines, and fescues; Douglas fir and ponderosa pine occur on the Sweetgrass Hills and Bearpaw Mountains (Ross and Hunter 1976).

Northern Great Plains Ecoprovince

Landforms. This ecoprovince is a high elevation plain, often called the High Plains or Rocky Mountain Pedimount. It is a rolling upland, often with a steep mountain outcrop that is more typical of the Rocky Mountain Foothills than of the surrounding plains. Being unglaciated, these plains have had a long period of erosion, resulting in wide valleys set between hard rock ridges. In some cases the streams are deeply incised.

Climate. Winters are cold and dry, and summers are warm to hot. Summer precipitation is a result of surface heating of streams. Arctic air may penetrate a considerable way southward, but the winter climate is as much a result of elevation as it is of Arctic air masses.

Vegetation. Native plant communities are typical of the shortgrass prairie: buffalograss, bluegrama, bluebunch wheatgrass, western wheatgrass, needle-and-thread, western needlegrass, and big sagebrush are common plains species. Much of the original vegetation has been replaced with cereal crops and occasionally with irrigated crops. In the mountain outcroppings, ponderosa pine, spruce, and quaking

aspen communities are well represented (Ross and Hunter 1976; USDA Soil Conservation Service 1981).

SUB-TROPICAL STEPPE PLAINS ECODIVISION (12)

This is a complex of plateaus and plains lying in eastern New Mexico, northern and central Texas, and southern Oklahoma. The climate is subtropical. Summers are long and hot, with most of the annual precipitation; winters are short and mild. This area has two ecoprovinces, one of which is shown on the map.

Southern Great Plains Ecoprovince

Landforms. Like the Northern Great Plains, this ecoprovince is a high elevation, rolling plain with dissected river valleys. Hills and uplands are common.

Climate. The climate is greatly influenced by the Gulf of Mexico air masses coalescing with the subtropical desert air from the southwest. Much of the precipitation falls in the spring and fall. Due to the high elevation, freezing conditions may occur during the winter and early spring.

Vegetation. Common native vegetation is mixed-oak savanna of live oak, post oak, and blackjack oak, with little bluestem, sideoats grama, switchgrass, plains lovegrass, and plains brittlegrass. Shinnery oak and sand sagebrush grow in the northern portions on sandy soils (Brown 1982c; USDA Soil Conservation Service 1981).

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ECOPROVINCES OF THE CENTRAL NORTH AMERICAN CORDILLERA AND ADJACENT PLAINS

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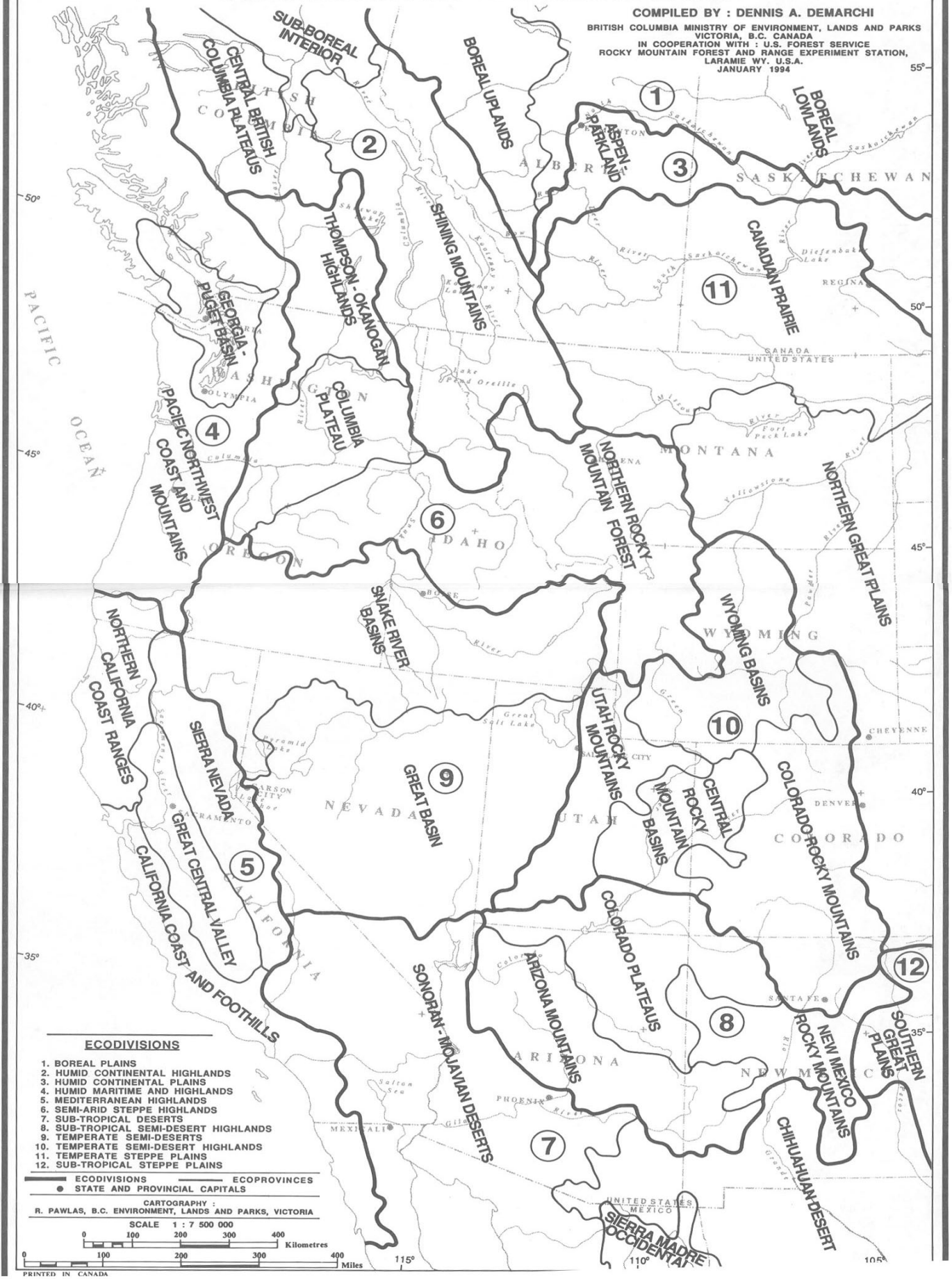
JANUARY 1994



ECODIVISIONS

1. BOREAL PLAINS
2. HUMID CONTINENTAL HIGHLANDS
3. HUMID CONTINENTAL PLAINS
4. HUMID MARITIME AND HIGHLANDS
5. MEDITERRANEAN HIGHLANDS
6. SEMI-ARID STEPPE HIGHLANDS
7. SUB-TROPICAL DESERTS
8. SUB-TROPICAL SEMI-DESERT HIGHLANDS
9. TEMPERATE SEMI-DESERTS
10. TEMPERATE SEMI-DESERT HIGHLANDS
11. TEMPERATE STEPPE PLAINS
12. SUB-TROPICAL STEPPE PLAINS

ECODIVISIONS — ECOPROVINCES
● STATE AND PROVINCIAL CAPITALS

CARTOGRAPHY :
R. PAWLAS, B.C. ENVIRONMENT, LANDS AND PARKS, VICTORIA

SCALE 1 : 7 500 000

0 100 200 300 400 Kilometres

0 100 200 300 400 Miles

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