Part 1

1.0

Introduction

Environmentally Significant Areas (ESAs) are defined by their important and/or unique environmental values which are vital to the longterm maintenance of biodiversity and ecological processes and services within a region. While the value of ESAs is clear, the criteria used to identify these resources is also of critical importance. A well defined set of criteria (e.g. ecosystem representation, distribution of listed species, rare habitats) to identify ESAs is important to ensure the process is scientifically rigorous, transparent, and repeatable. Further, the systematic application of criteria allow for direct comparisons between ESAs to identify priorities for management in land-use planning processes (Eagles 1984; Smith and Theberge 1987).

Alberta's resource management systems require scientifically credible and relevant tools to support land-use planning processes and environmental stewardship. These tools include spatially explicit information about areas of environmental significance. Within this context, mapped ESAs provide a critical tool for developing spatially explicit, reliable, and rigorous regional and provincial land-use plans.

The purpose of this report is to provide an overview for the update of ESAs in the province of Alberta. In the first section, background on the history and importance of ESAs in the province is provided as well as rationale for the provincial update. The newly defined set of criteria used to update and identify ESAs in the province of Alberta is then described. Next, the complete methodology used to identify ESAs is outlined. The general results of the ESA analysis are then presented, including a summary of the number and area of ESAs identified in this update by Natural Region compared to the first ESA report, and a discussion of these results. Finally, caveats of the analysis and recommendations for future updates are provided.

Background on ESAs

Definition and importance of ESAs

Environmentally significant areas (ESAs) are defined as areas that are vital to the long term maintenance of biological diversity, physical landscape features and/or other natural processes at multiple spatial scales (Jennings and Reganold 1991). Identifying these areas using scientifically rigourous, defendable, and relevant methodology is the first step toward the successful integration of ecological values into provincial planning and management (See Appendix 1 for a discussion of systematic conservation area design principles). The early recognition of ESAs is essential to help identify and prioritize areas that may be important to conserve, or that require special management consideration, thus supporting land-use planning processes (Knight et al. 2006). For example, areas of environmental importance are commonly used to prioritize environmental management toward areas that represent under-protected or vulnerable resources (Margules and Pressey 2000; Pressey and Bottrill 2008), or resources that are highly unique (naturally rare) or "irreplaceable" (Pressey et al. 1994; Margules and Pressey 2000; Pressey and Cowling 2001; Noss et al. 2002). Identifying ESAs using credible, broadly supported methods enables decision makers to rapidly progress through the planning process where informed trade-offs can be discussed, priorities set and clear policy direction achieved.

History of Alberta's ESAs

In the 1980's and early 1990's, individual counties and municipalities in Alberta identified areas that were locally significant as a result of their biological, physical, and/or cultural characteristics; these ESAs were then to be considered during the development of local land-use plans (see Sweetgrass Consultants 1997 and references therein). In general, these sites were deemed to be of regional significance, but some areas were also considered provincially, nationally and/or internationally significant. In 1997, all regional ESA studies were reviewed and those ESAs considered significant at these last three levels were compiled together on a single map to provide an overview of ESAs in Alberta (Sweetgrass Consultants 1997); regionally significant ESAs and ESAs in the Rocky Mountain Natural Region (Natural Regions Committee 2006) of Alberta were not included in this compilation. A separate map of ESAs in the Rocky Mountain Natural Region was completed in January 1998, excluding Jasper National Park (Timoney 1998). This provincial compilation of ESAs was one of the implementation strategies critical to the establishment of a representative network of protected areas throughout the province as determined by the Special Places 2000 program (Government of Alberta 1995).

The compilation of the ESA map for the province of Alberta (Sweetgrass Consultants 1997, in combination with Timoney 1998) involved reviewing a large number of reports from different counties and municipalities across the province. Between these reports, no consistent set of criterion were used to identify ESAs at the local (county/municipal) scale. For example, Bentz et al. (1995) identified important cultural or historical features as one of the criterion for ESAs in the Foothills Natural Region; however, this specific criterion was not considered by Timoney (1998) for the Rocky Mountains Natural Region. Furthermore, while several different criteria were used to identify ESAs at the provincial scale (e.g. areas which provide movement corridors for wildlife, areas that contain unusual diversity of plant and/or animal communities, etc.), it is unclear how some of the criterion were applied. Therefore, while there was some level of objectivity in the selection of ESAs at the provincial scale, there was also a relatively high level of subjectivity in the identification process. The limitations of this subjective approach are the lack of repeatability and transparency, both of which are considered crucial for any given conservation tool to be successfully incorporated into regional land-use planning and to maintain its relevancy over the longterm. Further, ESAs were not directly comparable because different criteria were used to identify them making it difficult to prioritize areas for management consideration.

Rationale for update of Alberta's ESAs

Advances in GIS technology and systematic conservation planning tools now allow more rigorous, objective, and repeatable methods to identify and prioritize ESAs that fulfill a list of *a priori* well-defined criteria (Sarkar et al. 2006). The systematic application of specific criteria to identify areas of environmental significance is important for several reasons (Pressey et al. 1993). The systematic selection of ESAs based on recognized conservation area design and general ecological principles provides the scientific rigor and objectivity justifying their selection (Margules and Pressey 2000; The Nature Conservancy 2004). This is important to ensure all environmental values can be properly considered for management and/or protection in land-use planning. It also ensures the most efficient use of limited conservation resources; ESAs can be successfully prioritized because the relative contribution that different areas make towards reaching overall conservation goals can be quantified (Noss et al. 2002; Noss 2003). This in turn helps to reduce the opportunistic or politically-biased approaches, which have historically characterized conservation planning and have resulted in a skewed distribution of protected areas (Pressey et al. 1993; Scott et al. 2001).

An update of the provincial portfolio of ESAs is timely given the recently introduced Land-use Planning Framework for the province of Alberta (Government of Alberta 2008). An updated provincial ESA map will identify areas that could be given special consideration during regional land-use planning.

There are several criteria that have been used to identify ESAs in other regions (e.g. ANZECC / MCFFA 1997; Florida Natural Areas Inventory 2000). Examples of these include:

- Areas that contain rare species;
- Linkages and conservation corridors;
- Areas that perform natural floodplain function;
- Areas that provide protection to surface waters;
- Functional wetlands;
- Areas that perform ecological or hydrological functions, such as aquifer recharge;
- Areas of high quality wilderness.

Several criteria were included to update and identify a comprehensive, scientifically defensible portfolio of ESAs in the province of Alberta.

ESA Classification Criteria

The updated ESA criteria

The following criteria were selected to identify and define ESAs in the province of Alberta:

CRITERION 1:
Areas that contain elements of conservation concern

International, national, and provincial elements of conservation concern (e.g. species listed as endangered by COSEWIC) are those that may require special management consideration to ensure their longterm persistence in the environment. Therefore, identifying and mapping occurrences of these elements of conservation concern as well as assemblages of occurrences is the first criterion used to identify ESAs in Alberta.

CRITERION 2:
Areas that contain rare or unique landforms

A landform is defined as the morphology of the land surface that results from the interaction of physical processes (e.g. flowing water, wind, glacial action, weathering) and crustal movements with the geology of the earth's surface (Whittow 1984). Landforms are recognized as integral components of the landscape, contributing to landscape diversity and the aesthetic value of a region. Unique landforms can include broad features, such as plains, plateaux, and mountains, as well as smaller features, such as sand dunes, eskers, glacial moraines and alluvial fans. Also included are rare or unique wetland types, such as patterned fens, channel fens, and marl ponds. Landforms included under this criterion are those considered rare (5 or less occurrences in the province) or those considered to be an outstanding example of a given landform.

CRITERION 3:
Areas that contain habitat for focal species

Focal species refers to a small group of species that are listed provincially, nationally or internationally, and whose distributions, abundances and habitat requirements are well studied. Included in this group are umbrella, flagship and/or indicator species. Typically, umbrella species (e.g. grizzly bear) have resource requirements that encompass the needs of many other species (Lambeck 1997; Noss 1999a); therefore, by managing for the life requisites of umbrella species it is assumed that the requirements of other elements will be met in at least some portion of the landscape. Flagship species (e.g. woodland caribou) are socially important species, which are usually threatened and thus are used to rally public support for conservation. Indicator species are those that, by their presence or abundance, are used as measures of habitat or ecosystem quality. Four wide ranging species which are listed provincially and nationally were selected as focal species (i.e. grizzly bear, ferruginous hawk, western burrowing owl, and woodland caribou) to include under Criterion 3.

CRITERION 4:
Areas that contain important wildlife habitat

Important wildlife habitats provide resources, often localized and ephemeral, essential to meeting the life requisites of certain species at specific times of the year. The availability of these types of habitats can severely undermine the survival and reproduction of the species that depend on them. Examples of important wildlife habitat include bird rookeries, wintering concentration areas, migratory staging areas, and hibernacula. Important wildlife habitat was therefore included as a criterion to identify ESAs in Alberta.

CRITERION 5:
Riparian areas

Riparian zones, as ecotones between aquatic and terrestrial ecosystems, form a dynamic, heterogeneous part of any landscape which is critical to the function of both aquatic and terrestrial ecosystems (Gregory et al. 1991). These ecotones supply ecological goods and services, such as surface water filtration, sedimentation and erosion control, and bank stability, as well as provide a source of nutrients, allochthonous input, and woody debris; these goods and services all serve to protect water quality and maintain stream channel morphology (Lowrance et al. 1997; Bunnell et al. 1999; Nelson et al. 2009). In addition, riparian areas are characterized by unique microclimatic conditions, higher productivity (e.g. greater vegetation growth), and increased moisture compared to other terrestrial communities; these environmental conditions result in structurally complex and diverse vegetation communities which support a disproportionately high level of biodiversity relative to their area (Bunnell et al. 1999). Given their ecological importance, three riparian criteria were developed to help identify ESAs in Alberta.

It is generally recognized that riparian buffers along headwater reaches (i.e., those adjacent to first- and second-order streams) have a much greater influence on the overall surface water quality within a watershed compared to buffers adjacent to downstream reaches (Correll 2005). Therefore, first- and second-order streams in the Rocky Mountains and Foothills Natural Regions (Natural Regions Committee 2006) were included as a criterion to identify ESAs in Alberta.

Large river basins in Alberta are impacted by several land uses (e.g. oil and gas development, agriculture, forestry, urbanization), which increases risk to these systems. Given the recognized ecological value of lotic systems (e.g. high biodiversity and productivity), as well as their socioeconomic importance (e.g. water supply for drinking, crop irrigation, and industrial operations), two additional riparian criteria were used to identify ESAs in Alberta: intact riparian areas along 11 major river basins, and riparian areas (regardless of intactness) along the six major rivers in the province (i.e. Athabasca River, Milk River, North Saskatchewan River, Peace River, Red Deer River, South Saskatchewan River).

CRITERION 6:
Large natural areas

The resilience and ability of ecological systems to maintain core ecological processes and services are related to their size and intactness (Noss 1990; Anderson 1991); however, large natural areas of native vegetation are becoming increasingly rare in Alberta. For this reason, large natural areas were included as a criterion to identify ESAs in Alberta.

CRITERION 7:
Sites of recognized significance

Sites with recognized significance were those identified at the international, national, and provincial levels by various national and international organizations. These sites are generally (but not always) protected areas or parks that have already been recognized as significant for environmental, cultural, and/or social reasons. Included under this criterion were UNESCO World Heritage Sites, sites recognized by the Ramsar Convention on Wetlands, lakes and wetlands identified as Important Bird Areas (IBAs), and rivers identified by the Canadian Heritage Rivers System. Additionally, legislated national and provincial protected areas greater than 1,000 ha in size were included under this criterion.

Criteria summary

These seven well-defined criteria, applied in a systematic fashion, provided the basis for identifying ESAs in the province of Alberta with the scientific rigor, defensibility, and repeatability that should characterize any conservation planning exercise (Noss 2003). Although kept to a minimum, some level of subjectivity was still incorporated into the process (e.g. selection of focal species included under Criterion 3). This subjective assessment is still considered acceptable as long as the rationale behind these decisions is made explicit and kept open to peer-review (Noss 2003). With information made transparent and explicit, decision-makers are still equipped to take actions that are scientifically defensible and that result in the highest level of biodiversity conservation.

Methods

This ESA analysis included several GIS data layers which mapped the occurrence of the seven identified criteria in the province of Alberta; these layers were used alone or in combination to identify ESAs throughout Alberta (Table 1). See Appendix 2 for more detailed information on the data sources used to build the seven criteria layers.

Building the Criteria layers

CRITERION 1:
Areas that contain elements of conservation concern

Elements of conservation concern were identified at the international, national, and provincial levels. International elements of concern are imperilled species and plant communities which have a global rank of G1 or G2 (Stein and Davis 2000). National elements of conservation concern are those that are listed or proposed for listing as "Endangered" or "Threatened" by the Committee on the Status for Endangered Wildlife in Canada (COSEWIC 2005) and/or the Species At Risk Act (Environment Canada 2002). Provincial elements of concern are those designated or proposed as "At Risk" under The General Status of Alberta Wild Species 2005 (Alberta Fish and Wildlife Division 2005), or as "Endangered" or "Threatened" under the Alberta Wildlife Act (Wildlife Act 2000). Also included at this level are those elements assigned a provincial rank of S1 or S2 by the Alberta Natural Heritage Information Centre (ANHIC) (Information Centre, Parks Division, Alberta Tourism, Parks and Recreation 2008). Finally, vegetation communities identified and tracked by ANHIC, regardless of their conservation rank, were included under this criterion.

Occurrence records for these elements were obtained from the ANHIC Element Occurrence Database. From this database, only records that had precision values of "S" (i.e. the element is known to occur within about 250 m of the given geographic coordinates) or "M" (i.e. the element is known to occur within about 2.5 km of the given geographic coordinates) were retained.

Not all elements of conservation concern were included under Criterion 1. Provincially listed lichens were not included because this taxon is considered understudied in the province of Alberta (J. Gould, pers. comm.). Occurrence records for some listed species (i.e. grizzly bear, woodland caribou, burrowing owl, ferruginous hawk) with large area requirements were also not incorporated under this criterion as element occurrences. Instead, these species were included under Criterion 3 in which key habitat for these species was identified and mapped.

Overall, a total of 10,291 element occurrence records, corresponding to 985 species and vegetation communities, were considered in the analysis under this criterion.

See Appendix 3 for the complete list of elements of conservation concern, and their associated ranking, included under Criterion 1.

TABLE 1

GIS layers used to map the occurrence of environmental values in Alberta. These layers were combined to create the seven criteria layers used to identify ESAs.

Criteria	Layer	Use and Description
CRITERION 1:	ANHIC Element occurrence Database	
CRITERION 2:	Priority Landforms in Alberta	Point geographic location of priority landforms
	Sand dunes	Mapping of sand dunes identified as priority landforms
	Badlands in South-eastern Alberta	Mapping of badlands identified as priority landforms
	Special Features in Alberta	Mapping of priority landforms
CRITERION 3:	Grizzly Bear Priority Areas	Mapping of habitat for grizzly bears
	Habitat Suitability Index (HSI) Models	Mapping of habitat for ferruginous hawk and western burrowing owl
	Peatland Inventory of Alberta	Mapping of peatland habitat for woodland caribou
	Alberta Caribou Committee, Caribou ranges	Boundaries of woodland caribou ranges in Alberta
	Alberta forest landscape fragments	Mapping of large (›5,000 ha) forested remnants
	Native Prairie Vegetation Inventory	Mapping of large (›500 ha) grassland remnants
	Central Parkland Vegetation Inventory	Mapping of large (›500 ha) parkland remnants
CRITERION 4:	ANHIC Element occurrence Database	Mapping of wildlife habitat
CRITERION 5:	Alberta Base Feature Single Line Network	Perennial and intermittent streams for protection of headwaters
	Alberta Base Feature Hydrology	Mayor rivers in Alberta
CRITERION 6:	Alberta forest landscape fragments	Mapping of large (›5,000 ha) forested remnants
	2005 Natural Regions and Subregions of Alberta	Representation of large (›5,000 ha) forested remnants in each Natural Subregion
	Central Parkland Vegetation Inventory	Mapping of large (›500 ha) parkland remnants
	Native Prairie Vegetation Inventory	Mapping of large (›500 ha) grassland remnants
CRITERION 7:	Ramsar wetlands	Wetlands identified as internationally important by the Ramsar Convention
	Canadian Important Bird Areas	Areas identified as ecologically significant for birds
	Canadian Heritage Rivers System	River systems identified as significant
	World Heritage Sites	Areas identified as significant by UNESCO
	Protected Areas in Alberta	Areas identified as significant by Parks Canada or by Alberta Tourism, Parks and Recreation.

CRITERION 2:
Areas that contain rare or unique landforms

Priority landforms, considered outstanding or unique representatives within the province of Alberta and beyond, were obtained as a point dataset from ANHIC. Because landforms are more accurately represented by polygons rather than points, each point in the dataset was matched to one of the following, in order of priority:

- Sand dunes (Geological Survey of Canada 2001);
- Badlands in South-eastern Alberta (Parks and Protected Areas Division, Alberta Community Development, 2003);
- Special Features in Alberta (Alberta Environmental Protection 1998);

If a landform point did not correspond to a matching polygon in any of the above datasets, then the quarter section in which the point was located was identified as containing the unique or outstanding landform.

A total of 251 priority landform polygons were considered in the analysis under this criterion. See Appendix 4 for the complete list of priority landforms included under Criterion 2.

CRITERION 3:
Areas that contain habitat for focal species

Four focal species limited by their habitat or area requirements were selected to be included under Criterion 3: grizzly bear *(Ursus arctos)*, ferruginous hawk *(Buteo regalis)*, western burrowing owl *(Athene cunicularia hypugaea)*, and woodland caribou *(Rangifer tarandus caribou)*. Intact high quality habitat was identified within provincial ranges of these species and included as the data layer for Criterion 3. Important habitat for these species was identified using three methods.

For grizzly bears, important habitat was identified from a Grizzly Bear Priority Areas layer provided by the Foothills Model Forest Institute. This layer was created by combining a good-quality habitat layer (as represented by population-level seasonal average Resource Selection Function surface) and a low mortality risk layer (as represented by low density of motorized linear access features, excluding seismic lines). This layer delineates areas that serve as grizzly bear population sources, and thus are considered important habitats for this species.

For western burrowing owl and ferruginous hawk, Habitat Suitability Index (HSI) Models developed by the SHARP (Blouin et al. 2004) and MULTISAR (Downey et al. 2004) projects for the Grassland and Parkland Natural Regions were used to identify important habitat. Areas with the highest index value (HSI values of 0.75-1) were identified as high quality habitat. These areas were further refined to include only high quality intact habitat consisting of patches of native vegetation larger than 500 ha (see Criterion 6 for a complete description of "intact" native grassland).

See Appendix 5 for the list of focal species and their associated ranking, included in Criterion 3.

CRITERION 4:
Areas that contain important wildlife habitat

To identify important habitat for woodland caribou, large intact patches of habitat, i.e. forest patches larger than 5,000 ha and more than 1 km away from human disturbances (as defined by Global Forest Watch 2008; see Criterion 6), were identified within all the caribou herd ranges in Alberta (Dzus 2001). The woodland caribou-boreal ecotype is known to prefer large expanses of black spruce bogs and black spruce-tamarack fens (Dzus 2001); therefore, these large intact patches of habitat were further restricted to occur within peatlands identified from the Peatland Inventory of Alberta (Vitt et al. 1998). For the woodland caribou-mountain ecotype, large intact patches of forest were identified as important habitat, regardless of forest age or forest type.

Important wildlife habitat, including bird colonies, migratory staging areas, and hibernacula were identified from the Alberta Natural Heritage Information Centre (ANHIC) Element Occurrence Database and included under Criterion 4.

A total of 516 wildlife habitat polygons were considered in the analysis under this criterion.

CRITERION 5:
Riparian areas

Criterion 5a: Surface Water Protection Headwater streams in Alberta, considered of vital importance for surface water protection, are those located in the Eastern Slopes region. Since there is no spatial data delineating this area, the Rocky Mountains and Foothills Natural Regions (Natural Regions Committee 2006) were used to approximate it. Perennial and intermittent streams from the Alberta Base Feature Single Line Network dataset were clipped to the outline of these two natural regions and further buffered by 30 m to each side (Fischer and Fischenich 2000) to delineate this criterion.

Criterion 5b: Riparian areas along large rivers Major rivers within each of the 11 major river basins within Alberta were identified from the Alberta Base Feature Hydrology dataset. The rivers selected under this criterion included:

- Hay River Basin: Chinchaga River, Hay River.
- Buffalo River Basin: Buffalo River, Yates River, Whitesand River.
- Peace River Basin: Birch River, Kawka River, Little Smoky River, Mikkwa River, Peace River, Simonette River, Slave River, Smoky River, Wabasca River, Wapiti River.
- Athabasca River Basin: Athabasca River, Berland River, Christina River, Clearwater River, MacKay River, McLeod River, Pembina River, Wildhay River.
- Beaver River Basin: Beaver River, Sand River.

- North Saskatchewan River Basin: Battle River, Brazeau River, Clearwater River, Nordegg River, North Saskatchewan River, Ram River.
- Red Deer River Basin: Reed Deer River.
- South Saskatchewan River Basin: South Saskatchewan River.
- Bow River Basin: Bow River, Highwood River.
- Oldman River: Belly River, Oldman River, St. Mary River.
- Milk River Basin: Milk River, North Milk River.

These rivers were buffered by 500 meters to each side (Fischer and Fischenich 2000), to further represent riparian areas in the province.

Criterion 5c: Six major rivers in Alberta The six main rivers in the province included under this criterion were: Athabasca River, Milk River, North Saskatchewan River, Peace River, Red Deer River, and South Saskatchewan River (including the Bow River and Oldman River reaches). These rivers were identified from the Alberta Base Feature Hydrology dataset, and buffered by 200 m to each side, which is the buffer size recommended for maintenance of water quality (Liu et al. 2008) and forest-dependent bird species (Hannon et al. 2002).

CRITERION 6:
Large natural areas

Two methods were used to identify large natural areas of native vegetation in the province. For the Rocky Mountains, Foothills, Boreal, and Canadian Shield Natural Regions (Natural Regions Committee 2006), large natural areas were defined as forest patches larger than 5,000 ha and more than 1 km away from any human disturbance (e.g. roads, cutblocks, facilities, etc.) using a dataset available from Global Forest Watch (Global Forest Watch 2008). This data was further used in combination with the Alberta Natural Subregions layer, in order to ensure that remaining large natural areas in the province were sufficiently represented within each of the Natural Subregions in the above mentioned Natural Regions.

For the Grassland and Parkland Natural Regions (Natural Regions Committee 2006), the Native Prairie Vegetation Inventory and the Central Parkland Vegetation Inventory were queried in order to identify patches of native vegetation. Given the extent of land conversion and fragmentation affecting native ecosystems in these two natural regions, large patches were defined as patches of native vegetation larger than 500 ha. To account for edge effects resulting from human activities, which has the potential to reduce the quality of natural habitat patches, these large patches were further refined by subtracting 100 m to each side of any major highway. The 100 m buffer was selected because it is the minimum recommended setback

distance for this type of land use activity (Alberta Sustainable Resource Development 2001). It must be noted that smaller roads and oil and gas activity (e.g. well sites) were not accounted for in this analysis.

CRITERION 7:
Sites of recognized significance

Sites with recognized environmental, cultural and social significance were identified as those recognized by the Ramsar Convention on Wetlands, by the Canadian Heritage Rivers System, or as Important Bird Areas (IBAs, Bird Studies Canada and The Canadian Nature Federation (2004)), or as World Heritage Sites by UNESCO. Also included under this criterion were any large (1,000 ha or larger) legislated protected area, on the assumption that these sites have previously been recognized for their environmental, cultural, and/or social significance at the provincial or national level. The minimum area of 1,000 ha was set following the United Nations minimum size criterion for inclusion within the 1997 United Nations List of Protected Areas (IUCN World Comission on Protected Areas 1998)

A total of 168 polygons were considered in the analysis under this criterion. See Appendix 6 for a complete list of the sites of recognized significance included under Criterion 7.

Combining the criteria layers to identify ESAs

ESA units of analysis

The Alberta Township System (ATS) grid served as the basis for conducting the analysis to identify ESAs; from this grid system, the quarter-sections (~64 ha in size) were used as the unit of analysis. A total of 1,669,255 quarter-sections covering the entire province were analyzed for their environmental significance. Depending on the criteria (e.g. large natural areas, focal species habitat), entire quarter sections could be considered environmentally significant. However, for other criteria (e.g. occurrences of elements of conservation concern, unique landforms), the quarter-section boundary indicates that environmentally significant values occur within this area, though the entire quarter-section may not be considered of environmental significance. Further refinement of quarter-section (ESA) boundaries may be required at finer (e.g. regional) scales to appropriately manage for the values present within these identified ESAs.

An important exception to the use of quarter-sections to identify ESAs was the use of the actual boundaries for some criteria, in particular, some unique landforms (Criterion 2) and some sites of recognized significance (legislated protectected areas, UNESCO World Heritage Sites and Canadian Heritage Rivers System sites under Criterion 7) which have pre-defined boundaries. Analytically, if any of these polygons overlapped with newly identified ESA polygons, the boundary of the landform or site of recognized significance was adopted as the ESA boundary; any remaining area (deriving from the use of the quarter-section as the unit of analysis) was discarded if it was simply the remaining part of a quarter-section, or marked as being a separate part of that same ESA if it was more than one quarter-section in size.

ESA Identification

Each quarter-section in the province was analyzed to determine which criteria (as described in "Building the criteria layers" section) were present. ESAs were identified at the scale of quarter-section if those cells fulfilled any one of the following rules:

1. Contained five or more different elements of conservation concern (Criterion 1);
2. Contained priority landforms (Criterion 2);
3. Contained high quality habitat for wide-ranging species (Criterion 3) **overlapping** large natural areas (Criterion 6);
4. Contained bird colonies, migratory staging areas, and/or hibernacula (Criterion 4);
5. Intersected a stream important for surface water protection (Criterion 5a) **in combination with** at least one other criterion;
6. Intersected riparian zones of major rivers (Criterion 5b) **in combination with** at least one other criterion;
7. Intersected one of the 6 major rivers in Alberta (Criterion 5c);
8. Was identified as a large natural area (Criterion 6) **in combination with** at least one other criterion;
9. Contained sites of recognized significance (Criterion 7).
10. Contained a combination of two or more criteria. For example, a quarter-section was identified as an ESA if it contained an occurrence record for an element of conservation concern (Criterion 1) and a stream important for surface water protection (Criterion 5a).

In addition to the above rules, quarter-sections that contained four or less elements of conservation concern under criterion 1, but that were spatially adjacent to quarter-sections already identified as ESAs using the above rules were also marked as environmentally significant.

Once ESAs were identified at the quarter-section scale, ESAs that were spatially adjacent to other ESAs were merged. Given that a large number (~2,000) of ESAs still remained following this amalgamation, attempts were made to further reduce this number. ESAs with less than 5 elements of conservation concern that overlapped with only Criterion 5a, 5b or 6 were individually examined to determine if they were "irreplaceable", i.e. whether the elements of conservation concern present in them were not represented anywhere else. If such was the case, the ESA was retained. Conversely, if the elements under criterion 1 were already represented in another "neighbouring" ESA (defined as being within 200 km for most elements, or within 500 km

for wide-ranging species such as the peregrine falcon), the ESA was discarded. This analysis was performed to ensure that distant occurrences, likely representing disjunct populations of a given element of conservation concern, were maintained and therefore potentially important geographic (genetic) variation.

See Appendix 7 for more detailed information on the ESA toolbox, a series of python scripts that were built to run the ESA analysis.

Assigning significance ratings to ESAs

Each ESA was assigned a significance rating according to the elements that it contained. The order of precedence for assigning the rating was (1) **International,** (2) **National,** and (3) **Provincial.** Conservation elements with the highest concern level within an ESA took precedence when assigning the overall level of significance; for example, if five G1 elements as well as some S1 elements occurred within the same ESA, it was rated as being of international significance.

First, there was a preliminary sorting process through which only elements or sites of provincial or greater significance were selected. From this selection of elements/sites, ESAs were ranked as having a provincial or a higher significance rank accordingly. **Internationally** significant elements were those ranked as Globally Rare (G1 or G2), internationally recognized landforms (as identified by Alberta Environmental Protection 1998), RAMSAR wetlands, continentally or globally significant Important Bird Areas, and UNESCO World Heritage Sites. **Nationally** significant elements were those ranked as "Endangered" or "Threatened" by SARA or COSEWIC, nationally recognized landforms (as identified by Alberta Environmental Protection 1998), nationally significant Important Bird Areas, National Parks, and rivers identified by the Canadian Heritage Rivers System. All the remaining elements were considered **provincially** significant.

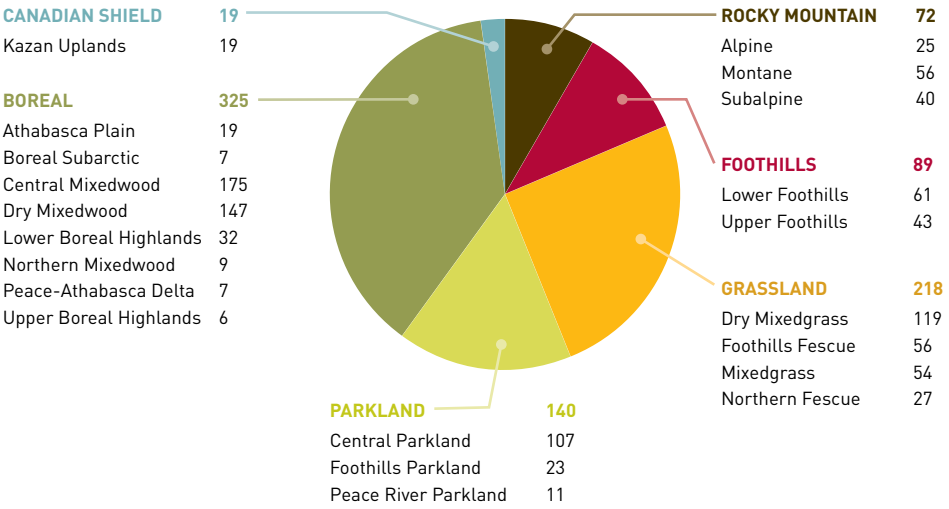
Results

A total of 754 ESAs were identified using the seven predefined criteria (Figure 1).

The percent of the each Natural Region identified as environmentally significant ranges from a low of 12% in the Parkland Natural Region to a high of 88% in the Rocky Mountain Natural Region (Figure 2). The area considered environmentally significant increased in the Rocky Mountain, Boreal, and Parkland Natural Regions, remained constant in the Grassland and Canadian Shield Natural Regions, and declined slightly in the Foothills Natural Region in this analysis compared to the previous ESA compilation.

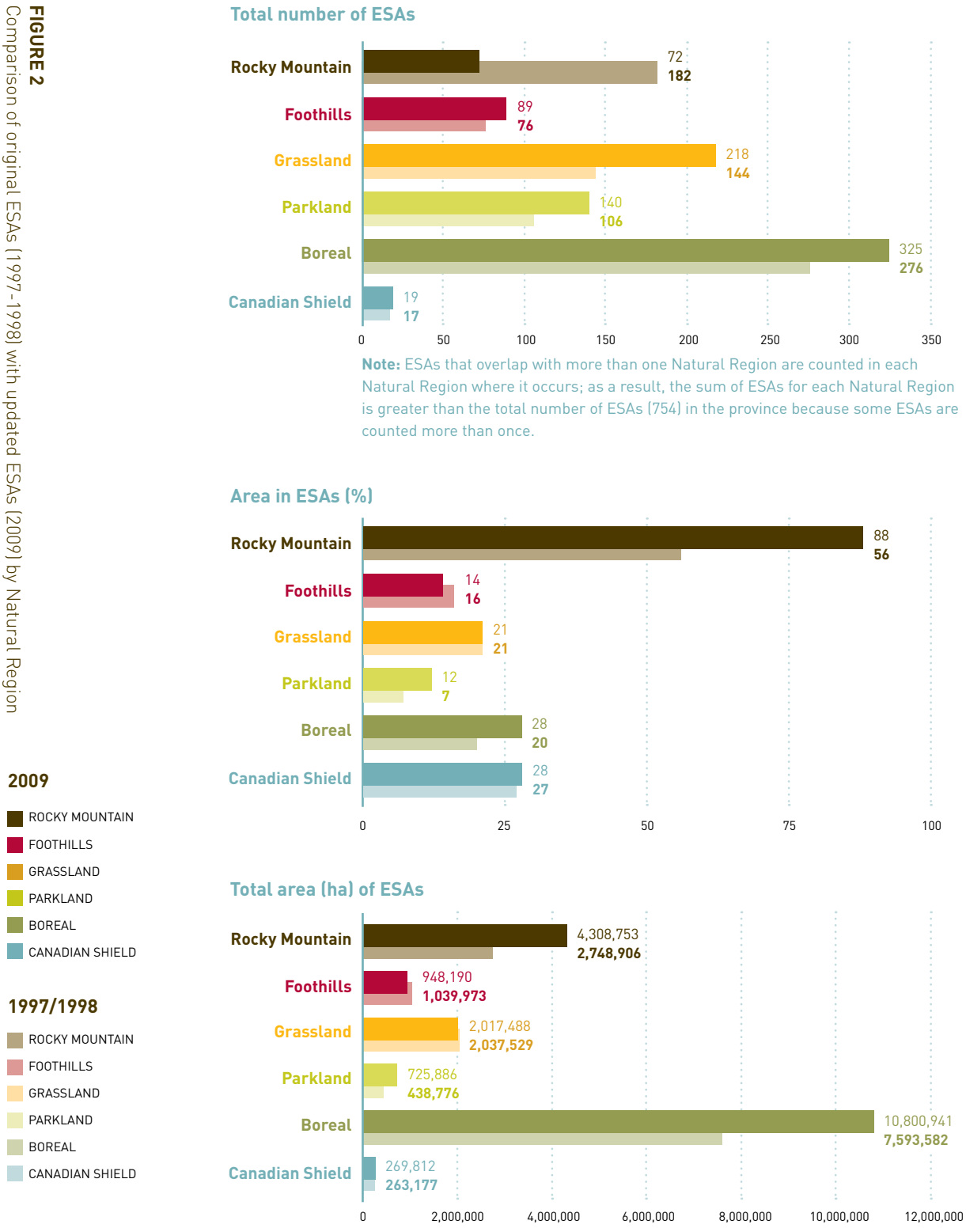
The percent cover of ESAs by Natural Subregions ranges from a low of 8% in the Lower Foothills to a high of 99% in the Alpine Natural Subregion (Figure 3). The Subregions that are well represented in ESAs with greater than 50% of their areal extent identified as environmentally significant include: Alpine, Montane, Subalpine, Boreal Subarctic, Northern Mixedwood, and Peace-Athabasca Delta. Eight subregions have moderate representation in ESAs ranging in area from 20% to 41%, including: Upper Foothills, Dry Mixedwood, Mixed Grass, Peace River Parkland, Athabasca Plain, Central Mixedwood, Upper Boreal Highlands, and Kazan Uplands. Seven Natural Subregions were represented by less than 20% of their total extent within the current ESA network, including: Lower Foothills, Foothills Fescue, Northern Fescue, Central Parkland, Foothills Parkland, Dry Mixedwood, and Lower Boreal Highlands.

FIGURE 1
Number of ESAs by Natural Region and Subregion



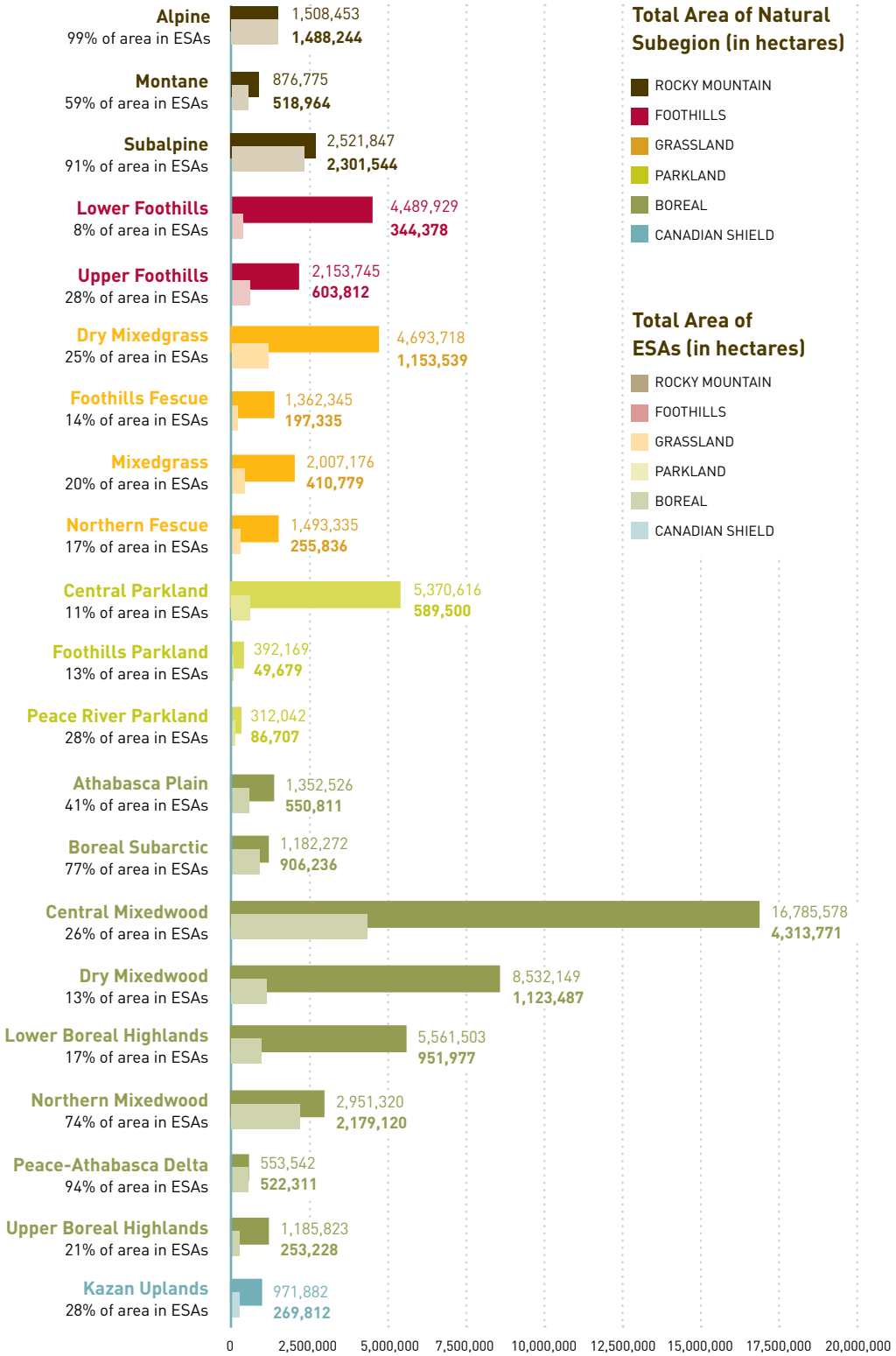
Note: ESAs that overlap with more than one Natural Region or Subregion were counted in each Natural Region or Subregion where it occured; as a result, some ESAs were counted more than once and thus the sum of ESAs will be greater than the total number of ESAs (754).

FIGURE 2
Comparison of original ESAs (1997-1998) with updated ESAs (2009) by Natural Region



Note: ESAs that overlap with more than one Natural Region are counted in each Natural Region where it occurs; as a result, the sum of ESAs for each Natural Region is greater than the total number of ESAs (754) in the province because some ESAs are counted more than once.

FIGURE 3
Area of ESAs by Natural Subregion



Discussion

A total of 754 ESAs were identified across Alberta, totalling 19,071,145 ha. The ESA network is not evenly distributed across the province but varies between Natural Regions and Subregions (Figure 4); this variation is related to the amount of large natural areas (Criterion 6) and protected areas (Criterion 7). Those subregions with the highest percent cover of ESAs (e.g. Alpine in the Rocky Mountain Natural Region, Peace-Athabasca Delta in the Boreal Natural Region) have a large proportion of their area in protected areas and/or are largely intact. The areal extent of ESAs is generally quite low (<20%) in the Grassland and Parkland Natural Regions (and corresponding subregions) because protected areas are smaller and human disturbance is greater. A gap analysis is required to identify underrepresented ecosystems in the ESA network to more fully understand management concerns at a coarse-filter level.

The total area identified as environmentally significant increased modestly compared to the previous ESA compilation (Sweetgrass 1997; Timoney 1998) and, in general, the spatial distribution of ESAs is similar between the two products (Figure 5), but with additional areas also identified in this latest iteration. The main factors that account for differences in ESA area, number and boundaries between the 1998 and 2009 analysis was the selection and application of well-defined criteria to delineate ESAs as well as the use of updated information. The inclusion of new criteria (e.g. Criterion 3 – Important habitat for focal species) not specifically considered in the previous analysis identified new areas in this most recent ESA update that were not identified as environmentally significant in the 1998 compilation. The application of specific criteria based on improved information (databases) resulted in a more accurate delineation of existing ESAs, and the addition of new ESAs where there were none previously. For example, although there are still areas of the province that have little biological survey information, there is more data than ever before on the occurrence and distribution of elements of conservation concern; many of the new small ESAs identified result from this new occurrence information. Finally, the inclusion of legislated protected areas and other sites of recognized significance (Criterion 7) as part of the rationale for identifying ESAs contributed to the overal increase in area of ESAs in the province. A clear example is Jasper National Park, which was included as part of the current analysis but not considered in the previous ESA compilation.

FIGURE 4

Environmentally Significant Areas (ESAs) in Alberta. The shaded black areas represent Areas of Recognized Significance (Criterion 7), which override the boundaries identified using quarter-sections (in red).

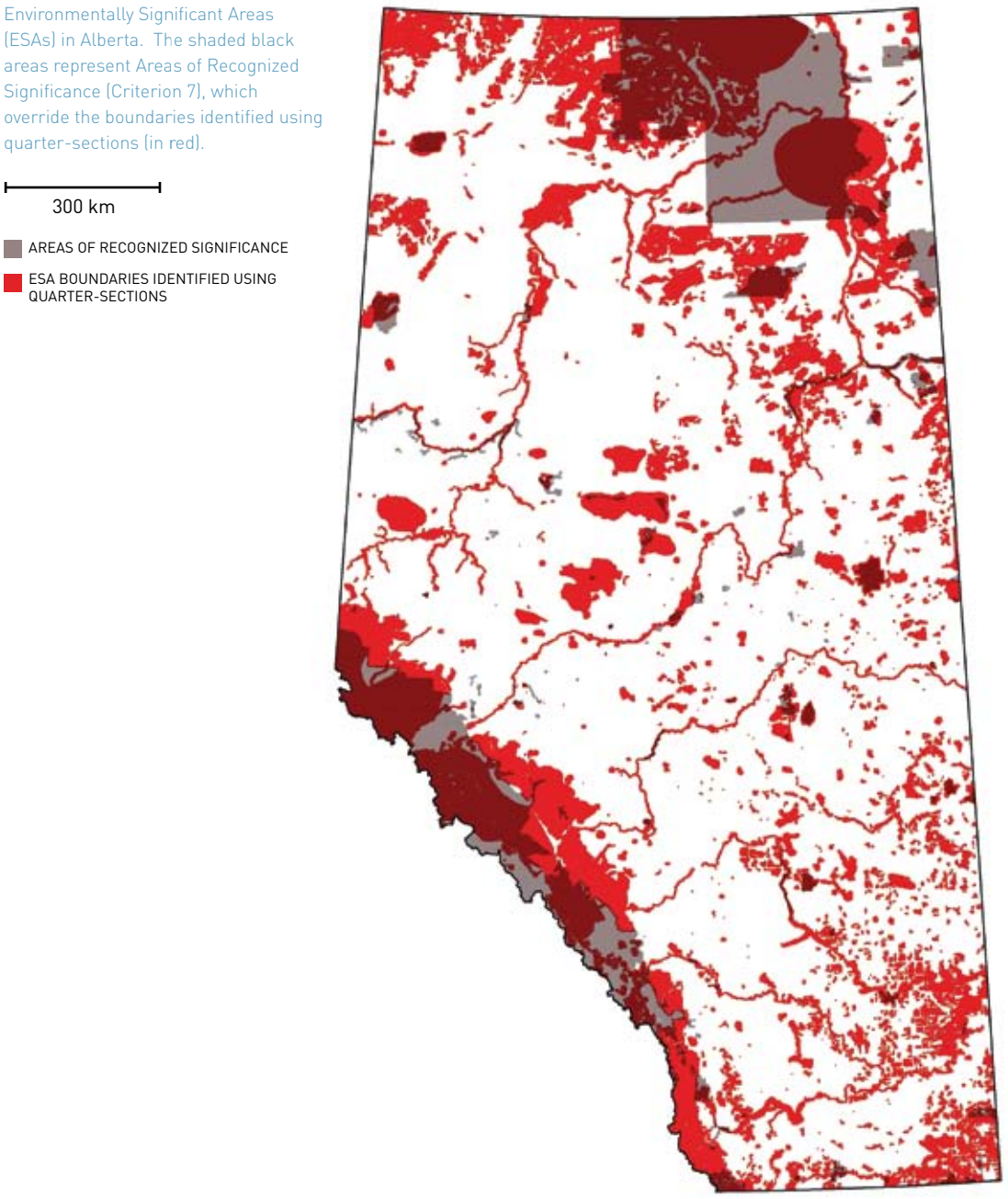


FIGURE 5

Comparison of original ESAs (Sweetgrass 1997, Timoney 1998) with updated ESAs (current analysis - 2009).

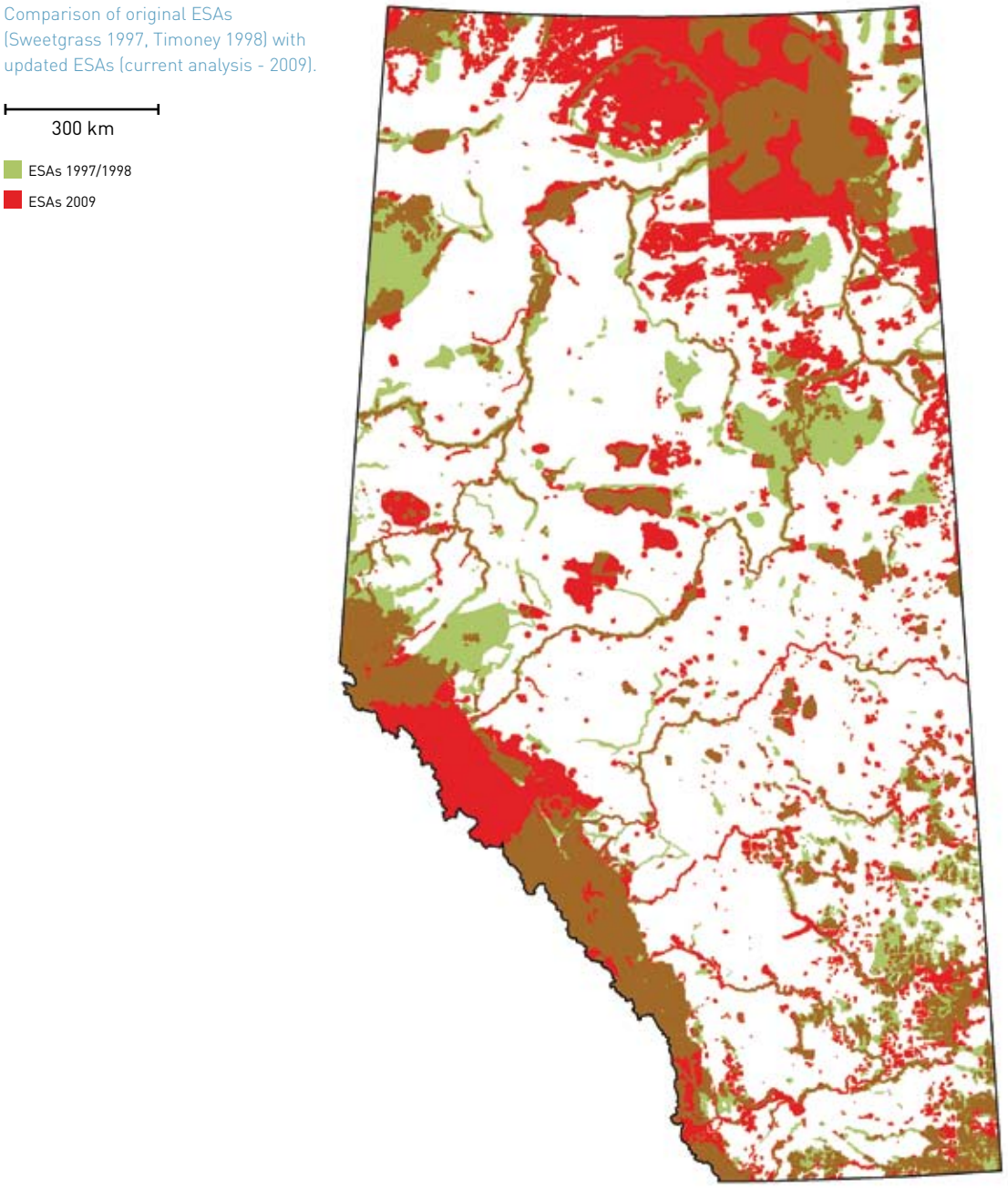
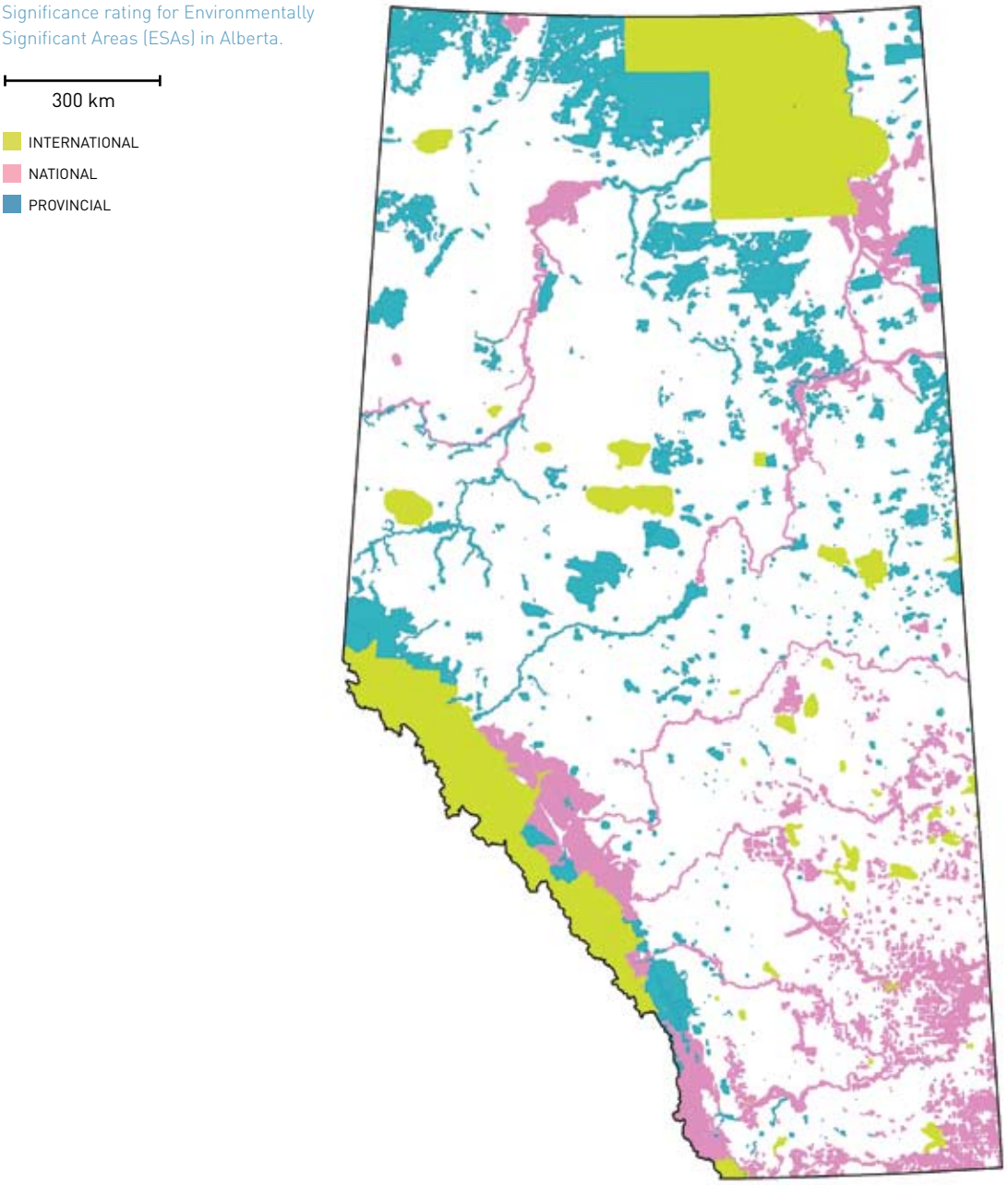


FIGURE 6

Significance rating for Environmentally Significant Areas (ESAs) in Alberta.



Due to the fact that ESAs mapped in 1998 were not identified using consistently applied criteria, specific comparisons between old and new ESAs could not be made. For example, some ESAs appear to be reduced in size compared to old ESA boundaries (Figure 5); this is likely the result of industrial activities (e.g. oil and gas, forestry) on the landbase. Certainly, existing ESAs have been impacted by industrial activities over the past 10 years; however, it is unclear how much of the area was intact originally because a consistent criterion for large natural areas across the province was not included in the first analysis, and therefore, loss of area for specific ESAs could not be absolutely determined.

From the 754 ESAs identified during the current analysis, 56 are of international significance, 227 of national significance, and 471 are of provincial significance (Figure 6). This significance rating provides a rough estimate of the importance of the environmental values within each of the ESAs. However, this superficial examination should be complemented by more in depth analyses prioritizing or ranking these sites in terms of their irrepleacibility, representativeness and vulnerability to surrounding threats.

In general, the application of systematic conservation area design principles using seven well-defined criteria resulted in a scientifically defensible portfolio of ESAs in the province of Alberta. Further, the methodology for delineating ESAs was transparent and repeatable resulting in an ESA network which can be easily updated incorporating new information (e.g. updates on listings of elements of concern) as well as new criteria (e.g. human disturbance) as this information becomes available. The consistent application of this methodology ensures the relevancy of ESAs as a decision support tool for land-use planning and implementation in the province of Alberta over the longterm. Overall, the vast majority of ESAs contain multiple environmental values representing outstanding biological and physical resources provincially. While further analysis will be required at the regional scales to further refine ESA boundaries, prioritize ESAs for management, and develop ESA-specific management strategies, this analysis identified areas that should be given closer scrutiny by land managers and stakeholders in the land-use planning process.

Caveats for Analysis and Recommendations

There are several limitations to this analysis that should be considered when using this product, as well as recommendations for future updates.

1. Identification of ESAs occurred at a very large scale (provincial) using quarter-sections as the unit of analysis to highlight general areas in the province where environmental values may require special management consideration. This should be considered a coarse-scale assessment of environmental values in the province. The boundaries of ESAs should be refined at regional scales based on ecological criteria to specifically delineate ESAs and develop ESA-specific management strategies to maintain or improve the ecological condition of the environmental values contained therein, and abate threats to these values (Groves et al. 2000).
2. While this process identified ESAs across the province, neither the designation of an ESA for a particular area, nor its rating should be considered synonymous with pristine or undisturbed habitat. As noted above, even criteria that might imply intactness, such as Criterion 6 (large natural areas) or Criterion 7 (sites with recognized significance), cannot be assumed to be intact. The intactness and ecological integrity of many of the ESAs have been compromised by different land-use activities. For example, seismic lines, pipelines and well sites were considered to some extent under Criterion 6 (but only for the forested regions of the province); however, given the fast rate of development of such features, the data that we used is likely out-of-date. Further, edge effects associated with roads were only considered very coarsely under Criterion 6 and 7. Restoration measures may be required in many ESAs to ensure environmental values contained within these sites are maintained. Future updates should include criterion to measure intactness of ESAs to better account for human footprint on the landbase and the vulnerability of ESAs to current and future developments. This information would inform decision-makers about threats to individual ESAs and management actions that may be required to maintain or restore their environmental values.

3. While large areas of the province were identified as environmentally significant based on Criterion 6 (large areas of native vegetation) and Criterion 7 (sites of recognized significance), and in combination with other criteria, it is unknown how representative these areas are of ecosystems within the Natural Regions of the province. Currently, there are no province-wide GIS data layers available which define ecosystems based on common ecosystem-based units (e.g. geomorphology, climate, vegetation communities). This would include seral stage distribution of forest ecosystems. The addition of a criterion that includes representation of ecosystems to identify ESAs would increase the probability that the portfolio of ESAs identified across the province include poorly known or unidentified components of biodiversity which cannot be actively managed for (Belbin 1993; O'Neil et al. 1995; Johnson 1999; Noss 1999b; Schwartz 1999).
4. ESAs were rated as international, national, or provincially significant based on environmental values contained within their boundaries or because these areas had previously been recognized by other sources. No further attempt was made to prioritize or rank these sites in a systematic fashion to identify conservation priorities for Alberta (e.g. irreplaceable ESAs that contain unique environmental elements or conditions unlike other sites in the province). Ranking ESAs using more refined criteria such as irreplaceability, representativeness, and vulnerability could be used to establish ESA management priorities in support of land-use planning processes regionally (Margules and Pressey 2000; Noss 2003; Pressey and Bottrill 2008).

CRITERION 1:
Areas that contain elements of conservation concern

Data availability inevitably limits identification of environmentally significant areas. Specific recommendations for refinement of the defined set of criteria include:

Species status rankings are constantly being updated based on new information; ESAs should be updated at regular intervals to include these updates, particularly as information in undersampled regions of the province and data on undersampled taxa (e.g. lichens, invertebrates) become available.

CRITERION 2:
Areas that contain rare or unique landforms

Unique landforms should be analyzed for their level of ecological integrity, vulnerability, and/or human footprint to inform the management of these areas. Also, they should be mapped with more precision than what is currently available.

CRITERION 3:
Areas that contain habitat for focal species

Critical habitat mapping of identified focal species should be updated as key habitat models are improved and refined.

Additional focal species could be added depending on priorities of decision-makers and availability of mapped data layers to identify important habitat.

CRITERION 4:
Areas that contain important wildlife habitat

Additional critical wildlife habitat could be added (e.g. ungulate winter range) depending on priorities of decision-makers and availability of mapped data layers.

CRITERION 5:
Riparian areas

Stream and river ecosystems in Alberta are highly connected longitudinally (upstream and downstream), laterally (riparian zones, wetlands, floodplains), and vertically (groundwater) as part of a much larger stream network (Pringle 2001; Linke et al. 2008). However, only the lateral connections of some streams and rivers were included in this ESA update, with riparian buffers applied to small streams and large rivers. In future iterations of ESA identification, aquatic systems require a much more comprehensive assessment including criteria, such as (Linke et al. 2008): condition of basins or sub-basins (i.e. human impacts), in-stream habitat, water quality, and biological elements. These criteria considered in the context of hydrological connectivity (longitudinal, lateral, and vertical) would better incorporate aquatic values in ESAs.

A parallel process is currently occurring in NE Alberta, where healthy aquatic ecosystems are being identified. The results from such analysis should be incorporated as part of the riparian areas criterion.

CRITERION 6:
Large natural areas

For large natural areas in forested Natural Regions (Rocky Mountain, Foothills, Boreal, and Canadian Shield), this criterion should be further refined based on representation targets for ecosystems by Natural Region, including targets for large areas of mature/old seral stages. Human disturbance spatial information also needs to be more comprehensive, including (but not limited to): roads, seismic lines, well sites, mining activities, and harvested sites.

For the Grassland and Parkland Natural Regions, ESAs should be updated based on the updated Grassland Vegetation Inventory (GVI) which is currently in the process of being completed. Like forested Natural Regions, ecosystem representation should be included as a criterion to identify large areas of native grassland, as well as a criterion to account for human disturbance. Given the long history of human use in these two Natural Regions, restoration of large natural areas will likely be required to maintain the ecological integrity of these ecosystems.

CRITERION 7:
Sites of recognized significance

A range of management options apply to sites of recognized significance from multiple use, to low intensity human use, to full legal protection. Given this range, these sites should not be assumed to be fully intact; a criterion to account for human disturbance, vulnerability, and/or ecological integrity would inform strategic management of these areas.

Because many of the sites of recognized significance are legally protected, an analysis of ecosystem representation should be conducted in future ESA updates, or as part of the land-use planning process, to help identify and prioritize ESAs outside protected areas for management consideration (i.e. gap analysis) in the land-use planning process. A gap analysis could also be conducted for other criteria as well.

New criteria to add as information becomes available, for example:

- New spatial layers for environmental values recognized as a priority (e.g. ecological goods and services, healthy aquatic ecosystems).
- Measure of human disturbance within each ESA;
- Measure of ecological integrity or intactness;
- Vulnerability or threat analysis;

Conclusion

Environmental values defined by seven criteria were used to identify and update ESAs in the province of Alberta. The process was based solidly on well-accepted conservation area design principles which identified a portfolio of ESAs in the province using systematic, transparent and repeatable methods. With the advent and roll-out of the Alberta Land-use Framework (Government of Alberta 2008), the early identification of areas with outstanding biological and physical resources in the province represents an important tool to support the regional land-use planning process. While further analysis will be required at the regional scales to further refine the ESAs and develop ESA-specific management strategies for environmental values of concern, the ESAs identified under this process highlight areas that should be given closer scrutiny by land managers and stakeholders in the land-use planning process.

While ESAs are often viewed as static components in the landbase, ESAs do not have to be considered a single result but rather as a dynamic process that can be updated at regular intervals as databases are updated and new information becomes available (Oetting et al. 2006). Of particular concern is the continued development of resources outside protected areas and resulting impacts to ESAs. Underlying data layers should be revised at regular intervals to account for improved data. In particular, any update of provincial ESAs should incorporate measures of human disturbance, and ecological integrity or intactness.

ESAs are not legally protected – they only recognize areas of environmental significance based on currently available information and selected criteria, identifying opportunities for conservation and/or management of environmental values throughout the province. Many of the environmental values occur in legislated protected areas; therefore, values outside the protected areas network should be given priority in land-use planning processes.

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