Southern Alberta Landscapes: Meeting the Challenges Ahead

Modeling Wildlife and Biodiversity

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Summary

As part of the regional resource overview for *Southern Alberta Landscapes: Meeting the Challenges Ahead* (SAL), I facilitated obtaining input from wildlife professionals throughout Alberta and the other prairie provinces. More than 40 biologists from the provincial government, federal government, universities, consulting organizations, and other organizations participated in a series of 15 meetings/workshops. In these discussions we: i) determined which of species and species groups should be modeled in ALCES for SAL, ii) decided how modeling of species and species groups should be conducted in ALCES, and iii) used a Delphi (or expert opinion) process to reach consensus on the parameters and coefficients for those parameters that would be included in the ALCES models. A Delphi process was used because this was faster and more cost effective than literature surveys or research.

No attempt was made to model changes to all wildlife and biodiversity that occur in the SAL study area. Rather, to highlight some of the potential changes to wildlife that may be caused by increased human activity and a larger human footprint in the SAL study area, a series of "flagship" species and species groups were chosen. These species and species groups were: a) from a wide diversity of habitats, b) from a diversity of taxonomic groups, c) easily recognized by the general public, d) known to have diverse resource needs, e) thought to have great potential to be affected by predicted changes in the SAL study area, and e) could be modeled well in ALCES. The four species chosen for modeling were Ferruginous Hawk, Prairie Rattlesnake, Sharp-tailed Grouse, and Grizzly Bear. In addition, to evaluate the effects of environmental change on biodiversity, two species groups were modeled - Grassland Specialists, and Anthropogenic Generalists. Modeling additional species and species groups could proceed at a later date if more time and funds become available. Since only a few species and species groups could be modeled, coarse filter modeling of wildlife/biodiversity habitats was also conducted. Habitats modeled as part of the coarse filter included: grassland habitats, forest habitats, and wetlands/riparian habitats.

For each species, biologists most knowledgeable with the species in question were invited to a workshop, and developed modeling coefficients and constraints using a Delphi process. It required a one-day workshop, plus many follow-up emails, to develop and refine the required information for each species. For each species group, two workshops were required (one workshop involving biologists that were experts on birds, and one workshop were the biologists were experts on mammals and herpitles) plus many email communications to develop the ratings. To ensure that all coefficients and constraints for the species groups could be completed quickly, we kept the models for species groups general.

The experts involved in the workshops and discussions were comfortable using the modeling coefficients and discounting factors they developed to predict change in abundance, if that change was two-fold or greater and occurred throughout the SAL study area. However, the models were thought to be too general to highlight very small changes, or changes within small portions of the SAL study area. The modeling coefficients and discounting factors were based on expert opinions, and these opinions may change as new information is gathered. To remain current, the expert driven process will need to be repeated every few years.

Changes in indices of abundance for species and species groups between pre-European settlement and 2000 were simulated in the SAL study area using ALCES. The amount and quality of each vegetation type presently occurring in the SAL study area, and that present prior to European settlement, were determined from existing maps.

Indices of abundance in the SAL study area were modeled for species and species groups. Percentage change between pre-European settlement (approximately 1700) and 2000 were reported. To avoid implying more accuracy than is possible with the models that were developed, the changes have been rounded to the nearest 5%.

	% Change in Index of Abundance 1700 to 2000
Species Indices	
Ferruginous Hawks Abundance	-80%
Prairie Rattlesnakes Abundance	-60%
Sharp-tailed Grouse Abundance	-80%
Grizzly Bears Exposure	+90%
Species Group Indices	
Abundance of Grassland Specialists	-45%
Abundance of Anthropogenic Generalists	+520%

Indices of abundance for the coarse filter elements in the SAL study area were modeled and are reported as % change in the index from pre-European settlement (1700) to 2000.

	% Change in Index of Abundance 1700 to 2000		% Change in Index of Abundance 1700 to 2000
Grassland Elements		**Forest Elements**	
Area of		Area Including All Ages	
Dry Mixed Grass (Sand Grass)	-45%	Deciduous	-5%
Dry Mixed Grass (Northern Wheatgrass)	-55%	Mixed Deciduous & Coniferous	-5%
Dry Mixed Grass (Needle & Thread Grass)	-65%	Spruce	-5%
Mixed Grass	-80%	Pine	-5%
Fescue Grassland	-80%	Fir	-5%
Fescue Parkland	-65%	Forest Shrubs	-1%
Prairie/Parkland Shrubs	-35%	ALL Forest Types Combined	-5%
Prairie/Parkland Trees	-70%	Area Of Forest >140 yrs Old	
Badlands	-35%	Deciduous	-85%
ALL Native Grassland/Parkland Combined	-65%	Mixed Deciduous & Coniferous	-60%
% Native Grassland/Parkland Invaded by Weeds	-75%	Spruce	-50%
Vegetation Structure Of Native Grassland/Parkland	+10%	Pine	-75%
		Fir	-45%
		ALL Forest Types Combined	-60%
		Density of Anthropogenic Edge	All Created Since 1700
Aquatic Elements			
Flowing Water			
Area	-25%		
% Natural	-15%		
Standing Water			
Area	+15%		
% Natural	-30%		
Index of Sediments in Water	-90%		

A model for "Classic Prairie Fish" was created by Mike Sullivan and Brad Stelfox, using similar processes as for the Grassland Specialists and Anthropogenic Generalists. This fish model is presented in Appendix 1.

The species and species group models, and results from the models, were reviewed by three experts that had many years experience studying wildlife in southern Alberta. In addition, all biologists that participated in the modeling process had the opportunity to review and comment on the results. Overall, the reviewers concluded that the models were reasonably effective at depicting changes in relative abundance of species and species groups. Many experts thought that discussions should be held with wildlife experts every few years to re-evaluate the models and make any changes that are necessary.

1.0 Introduction

As part of the regional resource overview for Southern Alberta Landscapes: Meeting the Challenges Ahead (SAL), it was necessary to describe wildlife and biodiversity that occurred in the area, and develop models of how these would change as environmental conditions changed. Although detailed information on many species could be extracted from existing data sets, a general overview of the required information could be obtained much more quickly and cost effectively from an “expert opinion process”. It was recognized early in this initiative that input would be required from a wide diversity of wildlife practioners to accurately capture the required knowledge. Thus, input from a large group of wildlife experts that had worked extensively in the SAL study area was sought during a series of workshops. Jim Schieck was hired in 2002 to facilitate obtaining this input from wildlife biologists in the provincial government, federal government, universities, and other organizations. The development of species inputs, however, were started prior to Jim Schieck’s involvement - a group chaired by Lorne Fitch began discussions during 2001. The SAL wildlife discussions Jim Schieck facilitated built on those previous discussions.

To facilitate input during 2002, Jim Schieck organized 15 meetings/discussions, plus many phone and email conversations to: i) determine which of species and species groups should be modeled in ALCES for SAL, ii) decide how modeling of species and species groups should be conducted in ALCES, and iii) reach consensus on the parameters and coefficients of those parameters that would be included in the ALCES models. To accomplish the first goal, meetings were held with many wildlife biologists from Alberta Sustainable Resource Development, Canadian Wildlife Service, Alberta Conservation Association, and the University of Alberta (these included Chris Shank, Dale Eslinger, Joel Nickelson, Ron Bjorge, Dave Prescott, Ed Hofman, Grant Neiman, Vance Buchwald, Dom Ruggieri, Pauline Erickson, Garry Trottier, Brenda Dale, Troy Wellicome, Geoff Holroyd, Richard Quinlan, Terry Clayton, Carita Bergman, Phil Lee, Rich Moses, Erin Bayne, Stan Boutin, Ed Korpela, and Jim Schieck). Participants in meetings to develop modeling algorithms (goal two) included Brad Stelfox, Chris Shank, Lana Robinson, Kathy Bennet, Phil Lee, Rich Moses, Erin Bayne, Stan Boutin, and Jim Schieck. Participants in workshops to accomplish goal three included wildlife biologists from federal and provincial governments and private consultants that lived in Alberta or Saskatchewan and were the most knowledgeable on the species in question. For each species, or species group, the participants that participated are listed in the appropriate section below. Many additional researchers were contacted by phone and email to follow up on questions that were raised during the meetings.

Due to fiscal constraints, no attempt was made to model all changes in wildlife and biodiversity that may occur in the SAL study area. Rather, the selection of species and species groups was based on a desire to highlight some of the changes in wildlife that may occur with increased human activity, and a larger human footprint, in the SAL study area. This resulted in the wildlife biologists choosing “flagship” species and species groups that were expected to be affected greatly by human activities. Descriptions of the habitat modeling coefficients and discounting factors for single species are presented in Sections 4-7. Descriptions of the habitat modeling coefficients and discounting factors for species groups are presented in Sections 8 and 9. There is redundancy within Sections 4-9 so that each Section completely describes the information for the species, or species group, in question.

2.0 Which Species and Species Groups To Model

As part of the discussions during July and August 2002 wildlife biologists highlighted the criteria that they thought should be used to select species and species groups to model for SAL. The biologists then developed a list of species and species groups that fit the selection criteria. Finally, they ranked the species and species groups and chose the four highest ranked species and two highest ranked species groups to model for SAL. Wildlife biologists decided to model four single species, and two species groups because they thought they would be asked to defend the output from the ALCES model, and some of the biologists were more comfortable defending the predictions for single species that for species groups.

Criteria Used To Rank/Select Species and Species Groups

1) *The combination of species selected should be from all Natural Regions (Grassland, Parkland, Foothills, Rocky Mountains).*
2) *Species selected should be high profile "flagship" species that the public recognizes.*
3) *Species groups selected should be from habitat types that are expected to be greatly affected by human development in the SAL study area (these are the species groups of greatest conservation concern). Species groups will be used instead of umbrella species.*
4) *Species and species groups selected should include a variety of orders and families.*
5) *A wide variety of resource needs should be represented by the species and species groups that are selected.*
6) *A diversity of spatial and temporal scales should be represented by the species and species groups that are selected.*
7) The habitat needs must be understood for the species and species groups that are selected.
8) The species and species groups must be capable of being modeled in ALCES.
9) If possible, species and species groups that are selected should be consistent with other programs.
10) If possible, species and species groups that are selected should be keystone species.
11) If possible, species and species groups that are selected should be easily monitored.
12) If possible, species and species groups that are selected should have broad distributions.

The first 6 criteria (in italicizes) were deemed to be very important and selection was largely based on these criteria. The next 2 criteria were important for SAL so the species and species groups could be modeled in ALCES. Thus, all species and species groups selected had to "fit" selection criteria 7 and 8. The last 4 criteria, while significant, were deemed to be less important and as such each was superseded by the words "if possible". Note that each species and species group that was selected did not meet all of the criteria, but in total the species and species groups that were selected incorporated all of the important criteria.

Single Species Chosen for Modeling in ALCES

During workshops in the fall of 2002 participants suggested species that fit the selection criteria as potential candidates for modeling. Within the suggested species list, species were ordered based on a combination of their value to the SAL process, and their potential to be modeled in ALCES. Due to constraints on the time and effort available, only the first four species were modeled. Modeling of additional species could proceed at a later date if more funds become available.

Species For Which Modeling Was Conducted For SAL

1) ***Ferruginous Hawk*** (This species is very closely associated with grassland habitats. In addition, Alberta has a relatively large geographic responsibility for this species since a large portion of its' breeding range is inside Alberta. Finally, the species probably relies on ground squirrels for food, and these ground squirrels may be a key-stone prey species on the prairies.

However, there was concern population changes in this species may be due to factors on the wintering ground, and that we may not be able to model this species well in ALCES.)

2) ***Prairie Rattlesnake*** (This species is widely distributed on the prairies [although only near river valleys where denning habitat occurs], it is expected to be greatly affected by changes that are predicted to occur in southern Alberta, and experts thought its abundance could be modeled well within ALCES. The species, however, may have negative connotations to some people and that may reduce its' profile as a flagship species.)

3) ***Sharp-tailed Grouse*** (This species is widely distributed within southern Alberta, it is expected to be greatly affected by changes that are predicted to occur in southern Alberta, and experts thought its abundance could be modeled within ALCES.)

4) ***Grizzly Bear*** (This species is widely distributed on the mountains and present within the foothills parkland in southern Alberta, it is expected to be greatly affected by changes that are predicted to occur in southern Alberta, and experts thought its abundance could be modeled within ALCES. Experts thought that the SAL Grizzly Bear model could be an extension of the model developed for grizzly bear in the NE Slopes near Hinton Alberta.)

Species That Fit The Selection Criteria, But For Which Modeling Was NOT Conducted For SAL
(Note: these species could be modeled in the future if additional funding become available.)

5) Pronghorn (This species was a high profile species in the SAL study area, but there was concern that the winter range of this species could not be modeled since the complete distribution of silver sage has not been mapped.)
6) Rough Fescue (This species is expected to be modeled in ALCES as part of the vegetation dynamics (grazing and drought/fire) portion of the ALCES program. Thus, it was not modeled as part of the Wildlife component.)
7) Great Plains Toad (The habitat requirements of this species are not well understood, and thus it cannot be modeled accurately in ALCES.)
8) Sprague's Pipit (There was concern that the density of this species is affected by events on their winter range outside the Canadian Prairies. However, Alberta has a relatively large geographic responsibility for this species since a large portion of its' range is inside Alberta.)
9) Burrowing Owl (There was concern that the density of this species is affected by events on their winter range outside the Canadian Prairies. In addition, Alberta has a relatively small geographic responsibility for this species since most of its' range is outside Alberta.)
10) Richardson's Ground Squirrel (This is possibly a keystone species. However, the profile of ground squirrels is not high making it a lower priority to model. Modeling Ferruginous Hawks was thought to be a substitute for modeling Richardson's Ground Squirrel.)
11) Pileated Woodpecker (Although this species will respond to reduction in the amount of old forest in the SAL study area, there was concern that it may not respond greatly to other human caused changes in the landscape.)
12) Mule Deer (There was concern that this species may not respond greatly to human caused changes in the SAL study area.)
13) Sage Grouse (There was concern that this species will decline regardless of how we change management activities. In addition, Alberta has a relatively small geographic responsibility for this species since most of its' range is outside Alberta.)
14) Long-billed Curlew (There was concern that the density of this species is affected by events on their winter range outside the Canadian Prairies.)
15) Swift Fox (This species has a very local distribution.)
16) Short-eared Owl (There was concern that the density of this species is affected by events on their winter range outside the Canadian Prairies.)
17) Cottonwood (The distribution of this species will be mapped and followed explicitly as part of SAL and thus the species does not need to be modeled based on other habitats.)
18) Silver Sage (There was concern that this species could not be modeled effectively in ALCES.)

19) Barred Owl (This species was a lower priority than species noted above, and thus was not discussed.)
20) Varied Thrush (This species was a lower priority than species noted above, and thus was not discussed.)
21) Prairie Falcon (This species was a lower priority than species noted above, and thus was not discussed.)

Species Groups Selected for Modeling in ALCES

To evaluate the effects of environmental change on biodiversity as a whole, groups of species that forage and/or breed in specific habitats were modeled instead of trying to select individual "umbrella" or "indicator" species" for each of the habitats. There are many different ecosystems in Southern Alberta, with the result that many potential species groups were evaluated for modeling. Due to constraints on the time and effort available within SAL, only the first two species groups were modeled. Modeling of additional species groups could proceed at a later date if more funds become available.

Species Groups For Which Modeling Was Conducted

1) ***Native Grasslands Specialists***. Species in this group live and forage in native or semi-native grasslands. From a conservation perspective it is this loss of these native biota that is of most concern to wildlife biologists. The increases in diversity and abundance of generalist biota, as humans activity increases, often results in the slow reduction in abundance and richness of species associated with native habitats. With the broad scale modeling information used within ALCES, dramatic changes within this species group were expected. However, due to complex interactions between these specialists in their environment, changes in the abundance and richness of native specialists may occur slowly.
2) ***Anthropogenic Generalists***. This species group included species that are positively associated with human activities. Virtually all of these species are generalists, and many are species that were introduced by humans for one reason or another. Introduced species, and native species that do well in human modified landscapes often respond quickly to changes in the human "footprint". Thus, changes to this species group should be very obvious within the ALCES modeling of the SAL study area. Note that the invasion of weedy plants was modeled as a different component of ALCES because the mechanism of their response to human disturbance was expected to be very different from the response by animals (i.e., modeling weedy species response involves modeling soil disturbance and the spread of plants from these disturbance sites).

Species Groups Which Fit The Selection Criteria, But For Which Modeling Was NOT Conducted For SAL (Note: these species groups could be modeled in the future if additional funding becomes available.)

3) Old Forest Specialists. – These species were expected to be negatively affected by human activities that increase forest fragmentation, and by logging activities that reduce the amount of old forest in the SAL study area. This species group received lower priority that the grassland group, however, because there is more grassland than forest in the SAL study area.
4) Aquatic Species. – Modeling this species group was deemed very important by many biologists because the species integrate the many human activities that affect water and water quality in the SAL study area. In addition, water resources are a major concern in the SAL study area. However, at present the wildlife biologists did not think ALCES could be used to effectively predict the important changes to water flow and water quality (ALCES has ability to include the required algorithms, but the numerical values describing how water temperature, water nutrients, and water flow are affected by each of the many different human land uses that are predicted to occur in the SAL study area had not been determined. Note that during 2004, Mike Sulliven facilitated modeling for this group, using information that was available in the ALCES models.)
5) Riparian and/or Wetland Species. – This is a very divers group of species, some of which are associated with specific habitats, and others that are found in areas influenced by a high water table. Given the diversity of species that were present in this group, there was concern that the

response of some species would probably mask an opposite response by other species. As such, modeling the response of the "group-as-a-whole" in ALCES was thought to be not be very informative.

6) Species Associated With the Southern Rocky Mountains (e.g., Columbia Spotted Frog, Red-tailed Chipmunk, Harlequin Duck, etc.) – This is a very small group of species that are restricted to the southern mountains in Alberta.

Although participants at the discussions thought that both plants and animals should be included within the species groups, botanists were uncomfortable assigning ratings for each habitat type for plants especially since many of the habitat types were described based on the plants communities. In addition, often there were complex interactions between soils, landforms, and disturbances (both human and natural) that determine the make-up of plant communities. Thus, we decided to include only vertebrates in the species groups. Changes to plant communities were modeled as part of the vegetation dynamics and structure in ALCES. In addition, the spread of weedy plants into native grassland was modeled by a different sub-routine in ALCES.

Due to time and financial constraints, only some of the vertebrates that occur in the selected species groups were included within the SAL models. When selecting species to include in the species groups biologists: i) used many of the same selection criteria that were used when choosing single species, ii) included species from a wide diversity of regions and habitat types [with emphases on species associated with the most common habitat types], iii) included listed species [species classified as at risk, may be at risk, or sensitive, with emphases on species having a high proportion of their population in Alberta], and iv) included species from a diversity of vertebrate taxa. In addition, the biologists kept the modeling simple for each species within the groups so that the habitat ratings for all of the 20-30 species chosen could be modeled within two workshops. Note that many species associated with Mixed Grassland were included in the Native Grassland Specialists because: a) Mixed Grassland occupies the largest area on the Alberta prairies, b) this habitat type has been modified greatly by agriculture and other human activities, and c) Alberta has a strong responsibility for managing biota within the Mixed Grassland because a large proportion of the Mixed Grassland in North America occurs in Alberta.

Coarse Filter Modeling of Habitats and Habitat Quality

Based on funding constraints in SAL, it was not possible to model all the species and species groups that biologists thought may be affected by human caused changes in the SAL study area. Thus models were developed for only the four species, and the two species groups that were rated as highest priority (see above). However, since many more species and species groups had been identified as "being important to model", managers from Alberta Sustainable Resource Development suggested that coarse filter modeling be conducted to fill the gap.

Coarse filter modeling was designed to describe changes over time in the "amounts" and "qualities" of each habitat type within the SAL study area. In addition, since the ecology of many species that live in the SAL study area was incompletely understood, it will be necessary to retain some areas that are not influenced by human development, or only lightly influenced by human development. These "unmanaged" areas will ensure that at natural process continue to occur on part of the SAL landscape and will help to maintain the many native species. Thus, coarse filter modeling in the SAL study area should be stratified by amounts of human disturbance, and within each of the strata the "amounts" and "qualities" of each cover type modeled. Due to constraints within ALCES, stratification based on intensity of human disturbance was not done.

Spatial scale greatly influences the types of measurements that are possible, and the characteristics included in coarse filter modeling. As such, the coarse filter modeling is discussed at two scales – landscape scale for characteristics that must be evaluated by considering the whole SAL study area, and patch scale for characteristics that can be measured and tracked at scales of 1-100 ha. Results have been presented for both that expected prior to European settlement, and that predicted for the next 50 years.

It is important to recognize that coarse filter modeling is not a substitute for modeling actual species and species groups, but allows planners to obtain rough estimates of potential changes to a much wider group of species than could otherwise be accommodated on a limited budget. If additional funding becomes available in SAL, the coarse filter modeling should be replaced with the more detailed modeling of additional species and species groups. In addition, studies should be conducted to evaluate whether the biotic species (and species groups) remain if the coarse filter modeling indicates that the habitat is maintained.

Coarse Filter Modeling at the Landscape Scale

Coarse filter modeling at the landscape scale is used to assess changes over time in: i) the amounts of each cover type, ii) the pattern in which patches of these cover types are distributed across the landscape, and iii) the size distributions of the patches for each cover type (Table 2.1). It is important to also evaluate the degree to which the patches are affected by human development, because these is a negative relationship between amount of human disturbance and the integrity of natural process and the retention of native species. Thus, analyses often are stratified by "areas undisturbed by humans", "areas lightly disturbed by humans", and "areas disturbed by humans" with analyses conducted separately for each strata.

Table 2.1 Potential Landscape Characteristics That Provide Important Information For Coarse Filter Management In The SAL Study Area

Representation of Each Cover Type **In Areas Undisturbed by Humans**
Area of the cover type
Distribution of patch sizes of the cover type
Proportion of protected areas containing the cover type
Quality (productivity, edge-interior ratio, age distribution, patch neighbor diversity, connectivity) of the cover type
Geographic dispersion across the landscapes of protected areas/reserves
Representation of Each Cover Type **In Areas Lightly Disturbed by Humans**
Area of the cover type
Distribution of patch sizes of the cover type
Proportion of lightly disturbed areas containing the cover type
Quality (productivity, edge-interior ratio, age distribution, patch neighbor diversity, connectivity) of the cover type
Geographic spread across the landscapes of lightly disturbed areas
Density of human created edge in the cover type
Density of stream crossings by type of crossing
Amount of human access
Representation of Each Cover Type **In Areas Disturbed by Humans**
Area of the cover type
Distribution of patch sizes of the cover type
Quality (productivity, edge-interior ratio, age distribution, patch neighbor diversity, connectivity) of the cover type
Geographic spread across the landscapes of the cover type
Density of human created edge in the cover type
Density of stream crossings by type of crossing
Amount of human access: length of road/trail accessible by motorized vehicle and walking, amount of area >500 m and >1000 m from roads, trails, pipelines, seismic lines

ALCES is a non-spatial modeling tool, and thus has limited potential to model some of these potential landscape characteristics. As a further complication, the SAL landscape was not subdivided into "areas undisturbed by humans", "areas lightly disturbed by humans", and "areas disturbed by humans". As such these levels of human disturbance cannot be modeled separately in ALCES. The only landscape characteristics that were modeled for SAL were:

- Total area for each natural cover type
- Density of human created edge (Note that information was presented for the forested areas[1] only because these were deemed to be the cover types where edge had the greatest potential to affect wildlife)
- Proportion of native habitat invaded by weeds, exotic species, and agronomic species (Note that information was presented for the native grassland[1] only because these were deemed to be the cover types where weed invasion had the greatest potential to affect wildlife)
- Age distribution (in 20 year categories) for forest cover types (Note that although ALCES modeling was done for all age classes, information was presented only for the age-class >140 years because this was deemed to be the age-class of greatest management concern by wildlife biologists)
- Total area of flowing water (streams, rivers, canals) and standing water (lakes, ponds, wetlands), and the proportion of flowing and standing water that are natural versus man-made

Modeling was done individually for each of the cover types, and then for three broad groups of cover types: native grassland cover types[1], forest cover types[2], and riparian/wetland cover types[3].

1 – Native Grassland Cover Types Included: Dry Mixedgrass Sandy Soils (sand grass), Dry Mixedgrass Moderate Drainage/Blowout Soils (needle & thread grass), Dry Mixedgrass Well Drained Loamy Soils (wheat grass), Mixedgrass (wheat grass, needle & thread grass), Foothills & Northern Fescue (fescue grass), Central Parkland & Foothills Parkland (fescue parkland), Shrubs (in grassland areas), Breaks & Badlands (valleys & coulees).
2 – Forest Cover Types Included: Deciduous, Mixedwood (deciduous & coniferous), White/ Engelmann Spruce, Douglas Fir, Pine, Shrubs (in forestland), Wetlands, Bogs, Meadows, Floodplains.
3 – Riparian/wetland cover types included: all reservoirs, lakes, ponds, cannels, rivers, and streams. .

Coarse Filter Modeling at the Patch Scale

Coarse filter modeling at the patch scale is used to assess changes over time in the amounts and qualities of structures/characteristics that are present within patches. A wide diversity of structures and characteristics influence whether biota use, or do not use, a patch (Table 2.2).

Table 2.2 Potential Structures/Characteristics That May Influence Whether Biota Use A Patch. These Structures/Characteristics Provide Important Information For Coarse Filter Management In The SAL Study Area

Potential Soil Characteristics Include:

- Soil characteristics: density, moisture content, dissolved oxygen content, temperature, carbon content, nitrogen content, potassium content, organic decay rates
- Number and size of areas with bare ground: classified as natural or human-caused, and by the process by which they were created
- Number and size of rocky outcrops
- Amount and pattern of topographical variation: classified as natural or human-caused, and by the process by which they were created
- Number and depth of soil layers

Potential Riparian, Wetland, and Watershed Characteristics Include:

- Water characteristics: sediment load, turbidity, dissolved oxygen, dissolved nutrients, pH, temperature, salinity
- Watershed characteristics

Number and length of streams classified by: presence of water throughout the year (e.g., ephemeral, temporary, permanent), width of stream channel, stream bank shape and stability, number and size of areas with erosion (classified as natural or human-caused, and by the process by which they were created), area and shape of saturated soils along the bank, type of substrate within stream and bank, species of woody vegetation present, canopy cover, and width of woody vegetation along the stream (both within saturated soils along the stream, and adjacent to saturated soils along the stream), species of submergent and emergent vegetation present, and width of submergent and emergent vegetation within the stream

Number and area of wetlands/water bodies classified by: presence of water throughout the year (e.g., ephemeral, temporary, permanent), depth of water, area and shape of wetland/water body, area and shape of saturated soils around the wetland/water body, type of substrate within and around the wetland/water body, number and size of areas with erosion (classified as natural or human-caused, and by the process by which they were created), species of woody vegetation present, canopy cover, and width of woody vegetation around the wetland/water body (within saturated soils around the wetland/water body, and adjacent to saturated soils around the wetland/water body), species of submergent and emergent vegetation present, and width of submergent and emergent vegetation within the wetland/water body

Number, size, and pattern of water source areas
Number, size, and pattern of groundwater recharge areas
Number, size, and pattern of areas prone to flooding
Volume, rate, and timing of water flow
Connectivity and pattern (sinuosity) of wetlands, watercourses, and other aquatic elements
Precipitation and runoff relationships

Potential Structures/Characteristics Within Forest Habitat Include:

- Number, height, and depth of canopy layers
- Percent canopy cover and basal area for each tree species in each canopy layer
- Dominant age (and age range) of each canopy layer
- Patchiness of canopy cover
- Density and size distribution of canopy gaps
- Canopy transparency / understory light availability
- Percent understory cover for each species
- Number and height of understory vegetation layers (tall shrub, low shrub, herbs, and grasses)
- Patchiness of understory vegetation
- Vertical structure variability
- Density and size (dbh) of trees for each species
- Density of large (>20 cm diameter), and very large (>50 cm diameter) trees for each species
- Density and size (dbh) of snags for each species
- Density of large (>20 cm diameter), and very large (>50 cm diameter) snags for each species, classified by decay
- Volume of downed logs classified by size classes (<10, 10-20, 20-50, >50 cm diameter) and decay categories

Potential Structures/Characteristics Within Shrubland, Grassland, And Herbaceous Habitat Include:

- Number and height of vegetation layers (tall shrub, low shrub, herbs, and grasses, moss, lichen, etc.)
- Percent cover, biomass, and maximum height of live vegetation for each species
- Percent cover and biomass of standing dead vegetation (in two or more height categories)
- Patchiness of shrubby and herbaceous vegetation
- Depth of vegetation litter

Potential Human Disturbance Characteristics Include:

- Amount/proportion of human-created habitats and structures
- Degree to which human created vegetation, habitats, and structures differ from those found naturally
- Amount of pesticides and pollution: concentration of pesticides and other human-created compounds in the soil, groundwater, streams, wetlands, lakes
- Density and distribution of non-native and weedy species

There are many structures/characteristics at the patch scale that could influence biota. Although ALCES has been programmed to track some of these structures/characteristics, most of these the rates were not "fine-tuned" for the SAL study area. As such, only a few of the potential characteristics were modeled for SAL wildlife/biodiversity:

- Average amount of vegetation structure in native grassland / parkland (structure was measured as a combination of vegetation height diversity, spatial diversity, and species composition). Native Grassland / Parkland Cover Types Included: Dry Mixedgrass Sandy Soils (sand grass), Dry Mixedgrass Moderate Drainage/Blowout Soils (needle & thread grass), Dry Mixedgrass Well Drained Loamy Soils (wheat grass), Mixedgrass (wheat grass, needle & thread grass), Foothills & Northern Fescue (fescue grass), Central Parkland & Foothills Parkland (fescue parkland).
- Water quality as measured by sediment load

3.0 Monitoring to Assess the Effectiveness of the SAL Strategy

Four species (Ferruginous Hawk, Prairie Rattlesnake, Sharp-tailed Grouse, Grizzly Bear), two species groups (Grassland Specialists, Anthropogenic Generalists), and a set of coarse filter elements (habitat amounts/qualities) were modeled within the SAL to highlight expected changes in wildlife and biodiversity under a variety of potential development scenarios in the SAL study area. Although there was extensive input from many biologists when developing the models, all experts recognized that their knowledge of species and natural ecosystems was rudimentary. Thus, many species and biotic communities may not be sustained even if targets for amounts and qualities of habitats are achieved. Only by monitoring how the actual environments/habitats change, and how species and species groups respond to those changes will it be possible to determine whether the models are accurate. As such, it is critical for a monitoring program to be implemented in the SAL area.

To be effective, the monitoring program must:

- provide information on a wide variety of biota so that changes in species and species groups can be evaluated,
- provide information on long-term changes to cover types, a wide variety of habitat structures, soil characteristics, hydrological regimes, and other elements,
- provide information at multiple spatial scales,
- be rigorous enough to provide early warning by detecting small changes in vegetation and biota that occur slowly over time,
- have sufficient intensity to document spatial and temporal variation in highly manipulated systems so that these can be compared to variation in natural/benchmark systems, and
- be more intensive in areas where “risky” strategies have been implemented.

Establishing and maintaining such an effective long-term and broad-scale wildlife/biodiversity monitoring program will require a significant funding commitment. In addition, maintaining the momentum of an effective monitoring program will be difficult due to the financial constraints that all organizations periodically experience. However, without this monitoring program, it will not be possible to assess the effectiveness on wildlife and biodiversity of the management strategies employed within the SAL study area.

All of the single species that were modeled in SAL are flagship species and presently have monitoring programs in place. Due to financial constraints, however, these existing monitoring programs have localized focal areas, and it is difficult to extrapolate those local results to the complete SAL study area. To make these single species monitoring programs effective for SAL, it will be necessary to provide additional support to the existing programs so they can broaden their geographic scope and increase the intensity of their surveys. In addition, if SAL becomes a long-term management strategy for Southern Alberta, then additional single species will be added to the SAL models over time. As such, it would be prudent to include other high priority species in monitoring programs at this time so that reliable and effective data are available when they are needed.

Broad-scale monitoring for biodiversity and habitats/vegetation has not yet been well developed for Southern Alberta. However, both the Alberta and Canadian governments have explored biodiversity monitoring programs, and a combined provincial/federal biodiversity monitoring program (the Alberta Biodiversity Monitoring Program; ABMP) is presently being tested in central Alberta. Due to ecological characteristics of southern Alberta, however, the ABMP may require some refinements to meet all of SAL’s needs. In addition, monitoring programs for specific taxa (eg., Breeding Bird Survey, Amphibian Monitoring Program) have some sites within the SAL study area. In all likelihood it will be more cost effective and expedient to revise and expand on these existing programs than to develop a new biodiversity monitoring programs.

To maximize the value of monitoring that is conducted in the SAL study area, all monitoring protocols should be compatible with ongoing provincial and federal monitoring programs. In addition, the data should be stored in centralized databases so that it is does not “disappear” over time. Finally, results from the monitoring program will be most meaningful if they are compared with results from other management areas. To accomplish this, an adaptive management approach is needed in the SAL study area so that managers can compare and contrast the successes and failures of management in this area with resource management strategies in other areas.

4.0 Ferruginous Hawks

Background

Based on discussions during August 2002, Ferruginous Hawks were selected for modeling in the Southern Alberta Landscapes: Meeting the Challenges Ahead. This species is closely associated with grassland habitats, and Alberta has a relatively large geographic responsibility for maintaining its breeding population since a large portion of its' breeding range is inside Alberta. In addition, Ferruginous Hawks rely on ground squirrels for food, and these ground squirrels may be a key-stone prey species on the prairies.

Participants

Modeling of Ferruginous Hawks for the SAL occurred in Brooks AB, on September 30, 2002. Jim Schieck and Brad Stelfox facilitated the discussions in which "Ferruginous Hawk experts" experts Reg Russell, Brad Taylor, Joe Schmutz, Cleve Wershler, Dave Scobie, and Leo Dube participated. Based on expert opinion and discussion, the participants arrived at a common agreement of habitat requirements for Ferruginous Hawks and the expected responses of these hawks to human caused changes to the habitats. The ratings developed by these experts, however, are based on their opinions and due to incomplete knowledge, these opinions may change as new information is gathered. To remain current, this expert driven process will need to be repeated every few years.

Habitat Value Based on Expert Opinion

The wildlife experts classified the importance of each habitat tracked within ALCES as being Primary, OK, Marginal, or Not Important to Ferruginous Hawks. They then arrived at agreed upon numerical ratings for each habitat type with a rating of 1.0 for the most important habitat type, and a rating of 0.0 for habitat types that are not used by the Ferruginous Hawks (see Table 4.1 below). Finally they determined the % of each habitat that was extra-limital to Ferruginous Hawks. Note that scattered single trees (or even small clumps of trees) surrounded by native grassland are included as "grassland" because single trees were not mapped in the GIS layers from which the habitat data were extracted.

Discounting of Habitat Value Based on Habitat Degradation

The experts thought that three types of human activities would have great affects on the habitat qualities for Ferruginous Hawks. As such, they developed discounting factors that were applied to each habitat. Habitat ratings in the table were multiplied by these discounting factors to arrive at an adjusted rating of the habitat for Ferruginous Hawks.

1) *Grazing intensity* – Ground squirrels are the major prey for the Ferruginous Hawks. Livestock grazing affects vegetation structure which in turn affects the habitat quality for ground squirrels. A limited amount of grazing is beneficial to ground squirrels because it creates vertical and horizontal heterogeneity in the vegetation thus providing food and habitat resources for them. However, the benefits to Ferruginous Hawks peak at relatively low levels of grazing (i.e., the stocking density recommended by Alberta Public Lands), because at that point the availability of food for ground squirrels decreases. The amount that habitat ratings must be discounted due to sub-optimal grazing/vegetation structure is depicted in Figure 4.1.
2) *Amount of cultivation in the landscape* - At low levels of cultivation, the mix of native grassland and crops [with fence rows] creates good habitat for ground squirrels, and thus abundant food for Ferruginous Hawks. But at moderate and high levels of cultivation in the landscape, the hawks must travel far to find food. In addition, disturbance caused by people and machines being present to plant and harvest crops decreases the foraging success of Ferruginous Hawks. The amount that habitat ratings must be discounted due to cultivation is depicted in Figure 4.2.
3) *Amount of area disturbed by the energy industry* - In the process of exploring and extracting energy, many vehicles travel through Ferruginous Hawk habitat. Disturbance caused by vehicle noise/travel decreases foraging success of Ferruginous Hawks, and may make them abandon their

nests. In addition, disturbance from all types of energy exploration, development and production (including disturbance from active pump jacks, compressor stations, batteries, servicing wells) decreases the foraging success of Ferruginous Hawks, especially during the nesting period. The amount that habitat ratings must be discounted due to disturbance by the energy industry is depicted in Figure 4.3.

4) *Native Grassland that has been invaded by weeds and agronomic species* – Weedy plants and species introduced for agriculture often become established in areas with disturbed soils. Over time, these weedy/agronomic species then invade the surrounding native grassland, thus reducing the quality of that grassland for Ferruginous Hawks. To compensate for this reduction in habitat quality in native grassland, invasion of weed/agronomic species was modeled in ALCES based on known rates of invasion from human disturbances in the grassland of Alberta. Then in the habitat model for Ferruginous Hawks, the invaded areas were assigned a habitat rating similar to that for tame pasture.

Algorithms Used for Modeling Ferruginous Hawks in the SAL Study Area

Habitats and habitat characteristics that are used within ALCES models were developed by a very broad group of people between 1995 and 2003. The habitats that were included in the SAL ALCES model are based on the combination of information available for the SAL study area and the habitat types that ALCES can incorporate into SAL models.

Algorithms for combining ratings among habitats, and for incorporating discounting factors for these habitats were developed by Brad Stelfox and Jim Schieck. In these algorithms, habitat ratings developed by the wildlife experts were multiplied by the discounting factor to arrive at an adjusted rating for each habitat. Adjusted ratings were then multiplied by the area of that habitat in the SAL study area that is not extra limital to the species, and summed across all habitat types. To produce an index that relates present/future conditions in the SAL study area to pre-European settlement conditions, the sum of the adjusted ratings was divided by the sum obtained assuming habitats were similar to those present prior to European settlement.

$$\text{IofA} = \frac{\sum^{j} (\text{HR x (DMA}_{p/f} \text{ x DMB}_{p/f} \text{ x DMC}_{p/f}) \text{ x Area}_{p/f})}{\sum^{k} (\text{HR x (DMA}_{n} \text{ x DMB}_{n} \text{ x DMC}_{n}) \text{ x Area}_{n})}$$

Where: "IofA" is the Index of Abundance for the species in the SAL study area; this index was created as the habitat suitability for the species at any time period divided by the habitat suitability expected under natural conditions

"HR" is the habitat rating developed by experts for the habitat in question

"DMA" is the discounting multiplier based on the grazing intensity in the habitat

"DMB" is the discounting multiplier based on the amount of cultivation in the landscape

"DMC" is the discounting multiplier based on the amount of disturbance by the energy industry in the habitat

"Area" is the area of the habitat available to the species within the study area (i.e., the area of the habitat in question in the SAL study area multiplied by the proportion of the habitat that occurs within the species range)

"j" is the number of habitats found at present (or in the future)

"k" is the number of habitats found prior to European settlement

"p/f" refers to the conditions when the present (or future) time periods are being modeled

"n" refers to the conditions prior to European settlement

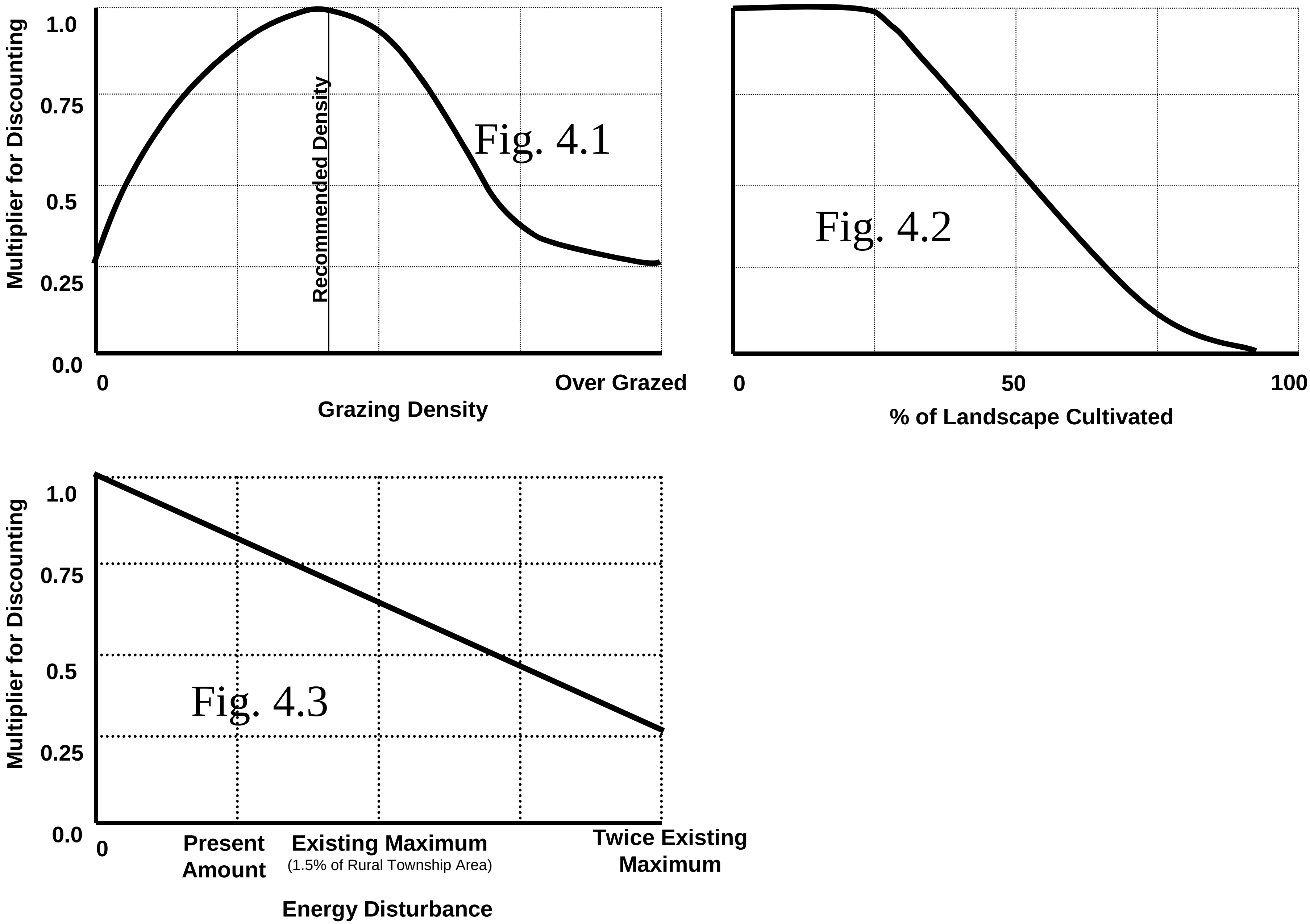
Table 4.1 Habitat Ratings For Ferruginous Hawks

Habitat Type	Category Rating[1]	Rating[2]	% Extra-Limital[3]
Grassland Habitat Types[4]			
Dry Mixed Grass			
Sandy Soils (sand grass)	OK	0.4	0.00
Moderate Drainage/Blowout Soils (WG)	Primary	1.0	0.00
Well Drained Loamy Soils (NTG)	Primary	1.0	0.00
Mixedgrass (wheat grass, needle & thread)	Primary	0.8	0.00
Foothills & Northern Fescue (fescue grass)	OK	0.5	0.50
Central/Foothills Parkland (fescue parkland)			
Shrubs (in grassland)			
Prairie treed	OK	0.4	0.25
Breaks & Badlands (valleys & coulees)	Primary	0.9	0.25
Riparian (floodplain/wetland margins)	Marginal	0.1	0.10
Agricultural Habitat Types			
Cereal Crops			
Oilseeds			
Legume crops			
Specialty Crops			
Forage Crops	Marginal	0.1	0.25
Tame Pasture	OK	0.3	0.25
Forest Habitat Types[5]			
Deciduous (hardwood)			
Mixedwood (Deciduous/Coniferous)			
White Spruce			
Engelmann Spruce			
Douglas Fir			
Pine			
Shrubs (in forestland)			
Wetlands, Bogs, Meadows, Floodplains			

Habitat Type	Category Rating[1]	Rating[2]	% Extra-Limital[3]
Water Habitat Types			
Lentic (Lakes, Ponds)			
Small			
Large			
Artificial Pond/Lake			
Lotic (Streams, Rivers)			
Small			
Large			
Canals			
Other Habitat Types			
Alpine, Rock, Ice, Bare Inorganic Soil			
Industrial Habitat Types			
Seismic Lines	OK	0.2	0.25
Well sites			
Wellsite Roads			
Pipelines	Marginal	0.1	0.20
Industrial Plants	Marginal	0.1	0.10
Coal Mines			
Gravel Mines			
Feedlots			
Other Anthropogenic Habitat Types			
Major Roads			
Minor Roads			
Trails			
Rail Network			
Towns/Cities			
Rural Residential			
Acreage Residential			
Recreational (campgrounds, accommodation)			

1 – Classified as Primary, OK, Marginal, and left Blank if of no value
2 – The natural habitat type where the species reaches it's highest density is rated as 1.0. All other habitat types are rated in relation to this habitat (i. e., a habitat type where the species has 75% of the density of the best natural habitat type is rated as 0.75.)
3 - % of the habitat type in the SAL study area that is outside the Ferruginous Hawks species range.
4 – These habitats occur within the Grassland and Parkland Natural Regions only.
5 – These habitats occur within the Foothills and Rocky Mountain Natural Regions only.

Figure 4.1-4.3 Factors Used to Discount Habitat Ratings for Ferruginous Hawks



Changes In Ferruginous Hawks Over Time

ALCES was used to model changes in the amount and quality of each cover type in the SAL study area, and how these changes affected Ferruginous Hawks between pre-European settlement (approximately 1700) and the present. During this period agriculture, forestry, energy, transportation, and tourism reduced the amount of habitat available for Ferruginous Hawks by converting native cover types into “anthropogenic” cover types. In addition, human activities associated with population growth and resource use/extraction affected the quality of the remaining native habitat.

Three types of information were determined for Ferruginous Hawks:

i) *Predicted Historic Index of Abundance for Ferruginous Hawks* – This was the index of expected abundance for Ferruginous Hawks prior to European settlement. Abundance was converted to an index so that the average abundance in 1700 had a value of 1.0 (note that this index would have had a value of 0.0 if no Ferruginous Hawks were present, and would be greater that 1.0 if Ferruginous Hawk abundance was greater than that present in 1700). Natural variation in moisture and fire were used to estimate the “range of natural variation” in Ferruginous Hawk abundance. This range of variation may be an underestimate because other factors (e.g. inter- and intra-specific interactions) may affect Ferruginous Hawk abundance.

ii) *Predicted Present Index of Abundance for Ferruginous Hawks Assuming the Habitat in the SAL Study Area was in Optimum Condition* – This was the predicted index of abundance for Ferruginous Hawks in 2000 based on the conversion of natural habitats to anthropogenic habitats, and assuming there was no degradation in the remaining natural habitats. This index of abundance was standardized as a proportion of the historical index.

iii) *Predicted Present Index of Abundance for Ferruginous Hawks After Accounting For Habitat Degradation* – This was the predicted index of abundance for Ferruginous Hawks in 2000 after accounting for conversion of natural habitats to anthropogenic habitats and the human uses/activities that degrade the value of the remaining habitat for Ferruginous Hawks. This index of abundance was standardized as a proportion of the historical index.

Index of Abundance Prior to European Settlement	**Historic Range of Variation (Natural Variation)**	**Index of Abundance in 2000 (% of Historic Index)**	
		Index of Abundance Assuming Optimum Habitat	**Index of Abundance After Accounting for Habitat Degradation**
1.0	15% of Historic Abundance	40% of Historic Abundance	20% of Historic Abundance

5.0 Prairie Rattlesnakes

Background
Based on discussions during August 2002, Prairie Rattlesnakes were selected for modeling for SAL. This species is widely distributed across the prairies, in and around badlands and river breaks where denning habitat occurs. Wildlife biologists thought Rattlesnake abundance could be modeled within ALCES, and that it would be greatly affected by human caused changes that are predicted to occur in southern Alberta during the next 50 years.

Participants
Modeling of Rattlesnakes for the Southern Alberta Landscapes: Meeting the Challenges Ahead occurred in Medicine Hat AB, on October 1, 2002. Jim Schieck facilitated the discussions in which Rattlesnake experts Ed Hofman, Kelley Kissner, Reg Ernst, and Andy Didiuk participated. Joel Nickelson reviewed the ratings and the whole group finalized them based on email communication during October 2002. The participants arrived at a common agreement of habitat requirements for Rattlesnakes, and responses of Rattlesnakes to human disturbances in the SAL habitats. These ratings are based on expert opinions and due to incomplete knowledge, these opinions may change as new information is gathered. To remain current, this expert driven process will need to be repeated every few years.

Habitat Value Based on Expert Opinion
The experts at the Rattlesnake Workshop classified the importance each habitat type as being Primary, OK, Marginal, or Not Important to Rattlesnakes. They then arrived at agreed upon numerical ratings for each habitat type with a rating of 1.0 for the most preferred habitat, and a rating of 0.0 for habitats that are not used by the Rattlesnakes (see Table 5.1 below). Finally a GIS exercise was used to determine the % of each habitat type that was extra-limital to Rattlesnakes. All habitat greater than 25 km from the major river valleys of the Red Deer River, South Saskatchewan River, Old Man River, Bow River, Milk River, Chin Coulee, and St. Mary's River were assumed to be extra-limital, because based on radio-telemetry data it is unlikely that many Rattlesnakes travel > 25 km from their den sites which only occur in these major river valleys. Within each of the noted drainages, recent observations of Rattlesnakes were used to determine the upstream limit of the Rattlesnake distribution.

Discounting of Habitat Value Based on Habitat Degradation
The Rattlesnake experts thought that three types of human activities (density of roads, amount of cultivation, and human population size), and the spread of non-native weeds would greatly affect habitat quality for Rattlesnakes. As such, they developed discounting factors that were applied to the habitat ratings. Habitat ratings in the table are multiplied by these discounting factors to arrive at an adjusted rating for Rattlesnakes in each habitat.

1) *Density of roads* - Vehicle traffic on all types of roads [including major and minor roads, roads along pipelines and transmission lines, roads to access well sites, access roads to residents, and railways] kills Rattlesnakes that are either crossing the roads, or sunning themselves on roads. Thus, roads are detrimental to Rattlesnakes and habitat ratings need to be discounted based on density of roads in the habitat. The amount that habitat ratings must be discounted due to road density is depicted in Figure 5.1.
2) *Amount of cultivation in the landscape* - Cultivation in the landscape is detrimental to Rattlesnakes because snakes that are foraging in the cultivated areas, or that are dispersing through the cultivated areas, get killed by machinery when the land in being worked, and the crops are being harvested. In addition, pesticides in agriculture landscapes may contaminate the food of Rattlesnakes. The amount that habitat ratings must be discounted due to cultivation is depicted in Figure 5.2.
3) *Total amount of humans in the landscape* - Many people kill, or otherwise harass Rattlesnakes because they dislike them. As the density of people increases, more and more of the landscape [especially the rough country] will be used by people for recreation and hunting, and that will result in more encounters between people and Rattlesnakes. In addition, the amount of off-road vehicle traffic, and the amount of traffic on all types of roads will increase as the human population increases, and that will result in more

snakes being run over and killed. The amount that habitat ratings must be discounted due to increases in human density is depicted in Figure 5.3.

4) *Native Grassland that has been invaded by weeds and agronomic species* – Weedy plants and species introduced for agriculture often become established in areas with disturbed soils. Over time, these weedy/agronomic species then invade the surrounding native grassland, thus reducing the quality of that grassland for Rattlesnakes. To compensate for the reduction in habitat quality in native grassland, invasion of weed/agronomic species was modeled in ALCES based on known rates of invasion from human disturbances in the grassland of Alberta. Then, in the habitat model for Rattlesnakes, the invaded areas were assigned a habitat rating similar to that for tame pasture.

Algorithms Used for Modeling Prairie Rattlesnakes in the SAL Study Area

Habitats and habitat characteristics that are used within the ALCES model were developed by a very broad group of people between 1995 and 2003. The habitats that were included in the SAL ALCES model are based on the combination of information available for the SAL study area and the habitat types that ALCES can incorporate into SAL models.

Algorithms for combining ratings among habitats, and for incorporating discounting factors for these habitats were developed by Brad Stelfox and Jim Schieck. In these algorithms, habitat ratings developed by the wildlife experts were multiplied by the discounting factors to arrive at an adjusted rating for each habitat. Adjusted ratings were then multiplied by the area of that habitat in the SAL study area that is not extra limital to the species, and summed across all habitat types. To produce an index that relates present/future conditions in the SAL study area to pre-European settlement conditions, the sum of the adjusted ratings was divided by the sum obtained assuming habitats were similar to those present prior to European settlement.

$$\text{IofA} = \frac{\sum^{j} (\text{HR x } (\text{DMA}_{p/f} \text{ x DMB}_{p/f} \text{ x DMC}_{p/f}) \text{ x Area}_{p/f})}{\sum^{k} (\text{HR x } (\text{DMA}_{n} \text{ x DMB}_{n} \text{ x DMC}_{n}) \text{ x Area}_{n})}$$

Where: "IofA" is the Index of Abundance for the species in the SAL study area; this index was created as the habitat suitability for the species at any time period divided by the habitat suitability expected under natural conditions

"HR" is the habitat rating developed by experts for the habitat in question

"DMA" is the discounting multiplier based on the density of roads in the habitat

"DMB" is the discounting multiplier based on the amount of cultivation in the landscape

"DMC" is the discounting multiplier based on the human population density in the SAL study area

"Area" is the area of the habitat available to the species within the study area (i.e., the area of the habitat in the study area multiplied by the proportion of the habitat in question that occurs within the species range)

"j" is the number of habitats found at present or in the future

"k" is the number of habitats found prior to European settlement

"p/f" refers to the conditions when the present (or future) time periods are being modeled

"n" refers to the conditions prior to European settlement

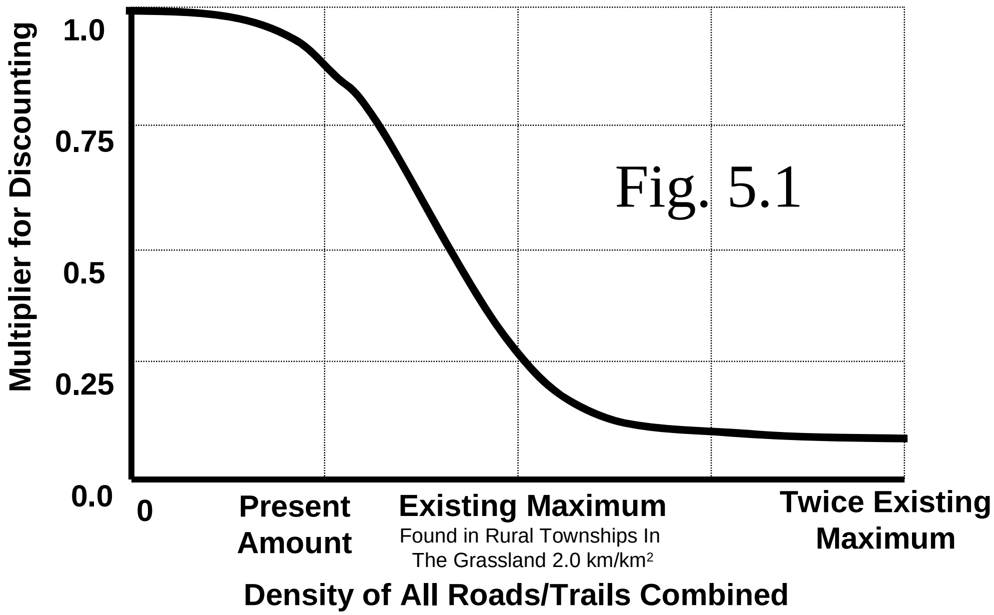
Table 5.1 Habitat Ratings For Rattlesnakes

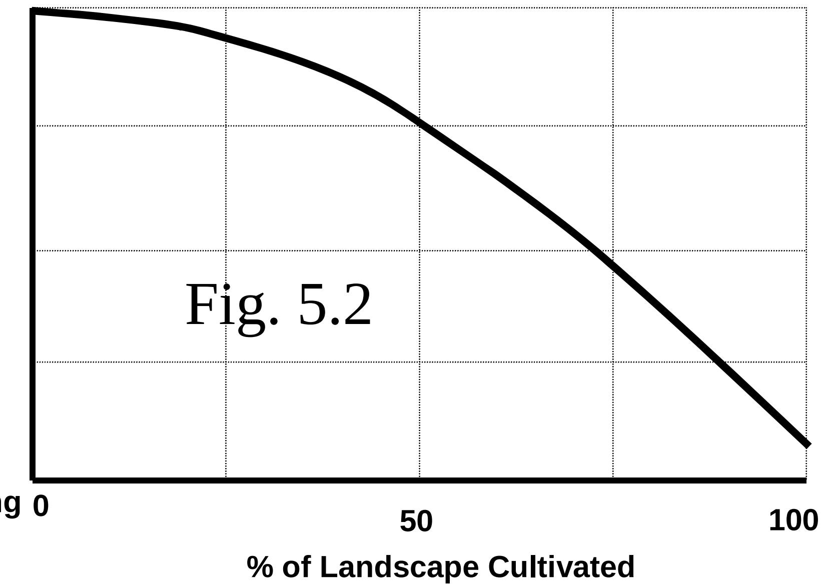
Habitat Type	Category Rating[1]	Rating[2]	% Extra-Limital[3]
Grassland Habitat Types[4]			
Dry Mixed Grass			
Sandy Soils (sand grass)	Primary	0.50	0.84
Moderate Drainage/Blowout Soils (WG)	Primary	0.75	0.49
Well Drained Loamy Soils (NTG)	Primary	0.75	0.73
Mixedgrass (wheat grass, needle & thread)	Primary	0.65	0.95
Foothills & Northern Fescue (fescue grass)			
Central/Foothills Parkland (fescue parkland)			
Shrubs (in grassland)	OK	0.25	0.35
Prairie treed	Marginal	0.10	0.10
Breaks & Badlands (valleys & coulees)	Primary	1.00	0.68
Riparian (floodplain/wetland margins)	OK	0.10	0.27
Agricultural Habitat Types			
Cereal Crops	Marginal	0.05	0.31
Oilseeds	Marginal	0.05	0.18
Legume crops	Marginal	0.05	0.29
Specialty Crops	Marginal	0.05	0.93
Forage Crops	Marginal	0.07	0.52
Tame Pasture	OK	0.20	0.83
Forest Habitat Types[5]			
Deciduous (hardwood)			
Mixedwood (Deciduous/Coniferous)			
White Spruce			
Engelmann Spruce			
Douglas Fir			
Pine			
Shrubs (in forestland)			
Wetlands, Bogs, Meadows, Floodplains			

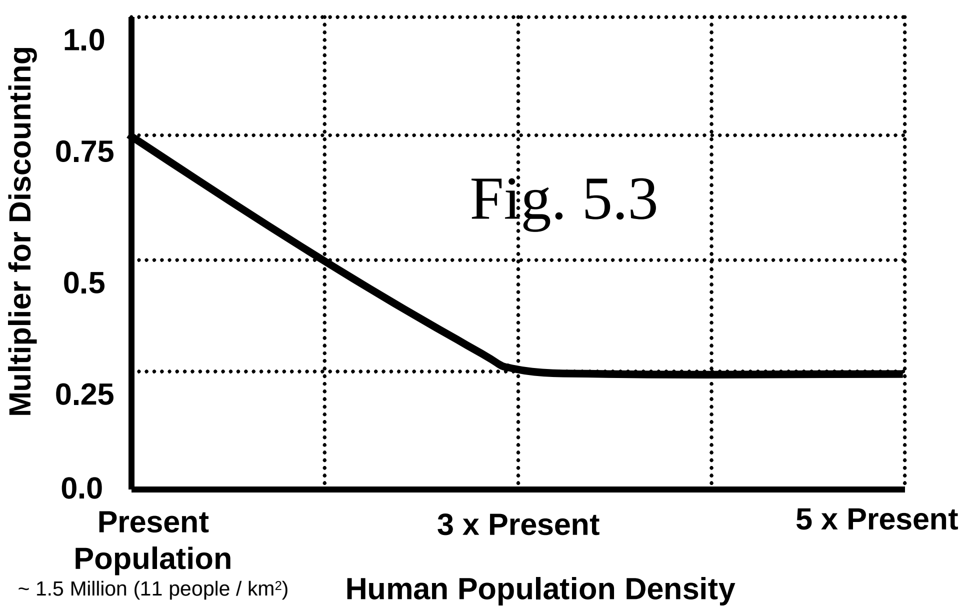
Habitat Type	Category Rating[1]	Rating[2]	% Extra-Limital[3]
Water Habitat Types			
Lentic (Lakes, Ponds)			
Small			
Large			
Artificial Pond/Lake			
Lotic (Streams, Rivers)			
Small			
Large			
Canals			
Other Habitat Types			
Alpine, Rock, Ice, Bare Inorganic Soil			
Industrial Habitat Types			
Seismic Lines	Marginal	0.05	0.20
Well sites	Marginal	0.05	0.20
Wellsite Roads	Marginal	0.05	0.20
Pipelines	Marginal	0.05	0.30
Industrial Plants	Marginal	0.05	0.50
Coal Mines	Marginal	0.05	0.60
Gravel Mines	Marginal	0.05	0.60
Feedlots	Marginal	0.07	0.50
Other Anthropogenic Habitat Types			
Major Roads	Marginal	0.05	0.20
Minor Roads	Marginal	0.05	0.20
Trails	Marginal	0.05	0.20
Rail Network	Marginal	0.05	0.20
Towns/Cities	Marginal	0.05	0.20
Rural Residential	OK-Marginal	0.10	0.10
Acreage Residential	Marginal	0.05	0.20
Recreational (campgrounds, accommodation)	Marginal	0.05	0.20

1 – Classified as Primary, OK, Marginal, and left Blank if of no value
2 – The natural habitat type where the species reaches it's highest density is rated as 1.0. All other habitat types are rated in relation to this habitat (i.e., a habitat type where the species has 75% of the density in the best natural habitat type is rated as 0.75. It is possible for anthropogenic habitat types to have ratings of > 1.0.)
3 - % of the habitat type in the SAL study area that is outside the species range for Rattlesnakes.
4 – These habitats occur within the Grassland and Parkland Natural Regions only.
5 – These habitats occur within the Foothills and Rocky Mountain Natural Regions only.

Figures 5.1-5.3 Factors Used to Discount Habitat Ratings for Rattlesnakes







Changes In Prairie Rattlesnakes Over Time

ALCES was used to model changes in the amount and quality of each cover type in the SAL study area, and how these changes affected Prairie Rattlesnakes between pre-European settlement (approximately 1700) and the present. During this period agriculture, forestry, energy, transportation, and tourism reduced the amount of habitat available for Prairie Rattlesnakes by converting native cover types into "anthropogenic" cover types. In addition, human activities associated with population growth and resource use/extraction affected the quality of the remaining native habitat.

Three types of information were determined for Prairie Rattlesnakes:

i) *Predicted Historic Index of Abundance for Prairie Rattlesnakes* – This was the index of expected abundance for Prairie Rattlesnakes prior to European settlement. Abundance was converted to an index so that the average abundance in 1700 had a value of 1.0 (note that this index would have had a value of 0.0 if no Prairie Rattlesnakes were present, and would be greater that 1.0 if Prairie Rattlesnakes abundance was greater than that present in 1700). Natural variation in moisture and fire were used to estimate the "range of natural variation" in Prairie Rattlesnakes abundance. This range of variation was an underestimate because other factors (eg. inter- and intra-specific interactions) affect Prairie Rattlesnakes abundance.

ii) *Predicted Present Index of Abundance for Prairie Rattlesnakes Assuming the Habitat in the SAL Study Area was in Optimum Condition* – This was the predicted index of abundance for Prairie Rattlesnakes in 2000 based on the conversion of natural habitats to anthropogenic habitats, and assuming there was no degradation in the remaining natural habitats. This index of abundance was standardized as a proportion of the historical index.

iii) *Predicted Present Index of Abundance for Prairie Rattlesnakes After Accounting For Habitat Degradation* – This was the predicted index of abundance for Prairie Rattlesnakes in 2000 after accounting for conversion of natural habitats to anthropogenic habitats and the human uses/activities that degrade the value of the remaining habitat for Prairie Rattlesnakes. This index of abundance was standardized as a proportion of the historical index.

Index of Abundance Prior to European Settlement	**Historic Range of Variation (Natural Variation)**	**Index of Abundance in 2000 (% of Historic Index)**	
		Index of Abundance Assuming Optimum Habitat	**Index of Abundance After Accounting for Habitat Degradation**
1.0	0% of Historic Abundance*	55% of Historic Abundance	40% of Historic Abundance

* - range of natural variation was not calculated because Rattlesnake abundance is not related to variation in precipitation and fire

6.0 Sharp-tailed Grouse

Background

Based on discussions during August 2002, Sharp-tailed Grouse were selected for modeling within SAL. This species is widely distributed within southern Alberta, and is expected to be greatly affected by human changes that are predicted to occur in the SAL study area. Wildlife biologists thought Sharp-tailed Grouse abundance could be modeled within ALCES.

Participants

Modeling of Sharp-tailed Grouse occurred in Edmonton AB, on October 17, 2002. Jim Schieck facilitated the discussions and Sharp-tailed Grouse experts Blair Rippin, Doug Manzer, Paul Jones, Dave Moyles, and Jim Allen participated. The participants arrived at a common agreement of habitat requirements for Sharp-tailed Grouse, and responses to changes in habitat elements by these grouse. Ratings, however, are based on their opinions, and due to incomplete knowledge these opinions may change as new information is gathered. To remain current, this expert driven process will need to be repeated every 1-2 years.

Habitat Value Based on Expert Opinion

The Sharp-tailed Grouse experts classified each habitat modeled within ALCES as being Primary, OK, Marginal, or Not Important to Sharp-tailed Grouse. They then arrived at agreed upon numerical ratings for each habitat with a rating of 1.0 for the most preferred habitat, and a rating of 0.0 for habitats that are not used by the Sharp-tailed Grouse (see Table 6.1 below). Finally they determined the % of each habitat that was extra-limital to Sharp-tailed Grouse (note that none of the SAL study area was considered extra limital to Sharp-tailed Grouse).

Discounting of Habitat Value Based on Habitat Degradation

The experts thought that five types of human use in the habitats would affect habitat quality for Sharp-tailed Grouse. As such, they developed discounting factors that were applied to each of the habitat ratings. Habitat ratings in the table were multiplied by the discounting factors to arrive at an adjusted rating for each habitat for Sharp-tailed Grouse.

1) *Amount of cultivation in the landscape* – Limited amounts of cultivation in the landscape are beneficial to Sharp-tailed Grouse since that results in more open areas where grouse can feed and nest (i.e., especially if treed habitats are converted to crop land). In addition, waste grain may increase the suitability of landscapes to some degree for Sharp-tailed Grouse. However, increases in cultivation above 30% of the landscape is detrimental to Sharp-tailed Grouse because grouse nests in the cultivated areas get destroyed by machinery when the land in being worked, and the crops are being harvested. In addition, generalist predators usually increase in density in cultivated landscapes, and these predators destroy nests and kill adult Sharp-tailed Grouse. Finally, pesticides in cultivated landscapes may contaminate the food of Sharp-tailed Grouse. The amount that habitat ratings must be discounted due to cultivation is depicted in Figure 6.1.
2) *Grazing intensity* – A limited amount of grazing is beneficial to Sharp-tailed Grouse because it creates vertical and horizontal heterogeneity in the vegetation, thus providing food and habitat resources. However, the benefits of grazing peak at about half the stocking density recommended by Alberta Public Lands, because at that point availability of food for Sharp-tailed grouse decreases. In addition, nests and chicks get trampled at high livestock densities. The amount that habitat ratings must be discounted due to grazing is depicted in Figure 6.2.
3) *Density of roads* – All types of roads, pipelines, transmission lines, well site roads, residential roads, and trails facilitate hunter access into Sharp-tailed Grouse habitat, with the consequence that more of the birds are shot legally and illegally. In addition, roads and trails result in more generalist predators moving through Sharp-tailed Grouse habitat and killing grouse. Finally, Sharp-tailed Grouse forage and nest on the edges of roads and trails and some get killed by

vehicle traffic. The amount that habitat ratings must be discounted due to road density is depicted in Figure 6.3.

4) *Total amount of humans in the landscape* – Increased human density in the SAL study area will result in increased recreation (hiking, off-road vehicles, ecotours, etc.) in Sharp-tailed Grouse habitat. These increased human activities will result in Sharp-tailed Grouse spending more time being vigilante, and less time foraging. In addition, the amount of traffic on all types of roads will increase as human population increases, and that will result in more grouse being killed by vehicles. Finally, in areas where acreage development occurs, domestic dogs and cats will become more common and will kill some grouse. The amount that habitat ratings must be discounted due to increases in human density is depicted in Figure 6.4.

5) *Native Grassland that has been invaded by weeds and agronomic species* – Weedy plants and species introduced for agriculture often become established in areas with disturbed soils. Over time, these weedy/agronomic species then invade the surrounding native grassland, thus reducing the quality of that grassland for Sharp-tailed Grouse. Invasion of weed/agronomic species was modeled in ALCES based on known rates of invasion from human disturbances in the grassland of Alberta. To compensate for the reduction in habitat quality caused by weed invasion into native grassland, the invaded areas were assigned a habitat rating similar to that for tame pasture for Sharp-tailed Grouse.

Algorithms Used for Modeling Sharp-tailed Grouse in the SAL Study Area

Habitats and habitat characteristics that are used within ALCES models were developed by a very broad group of people between 1995 and 2003. The habitats that were included in the SAL ALCES model are based on the combination of information available for the SAL study area and the habitat types that ALCES can incorporate into SAL models.

Algorithms for combining ratings among habitats, and for incorporating discounting factors for these habitats were developed by Brad Stelfox and Jim Schieck. In these algorithms, habitat ratings developed by the wildlife experts were multiplied by the discounting factors to arrive at an adjusted rating for each habitat. Adjusted ratings were then multiplied by the area of that habitat in the SAL study area that is not extra limital to the species, and summed across all habitat types. To produce an index that relates present/future conditions in the SAL study area to pre-European settlement conditions, the sum of the adjusted ratings was divided by the sum obtained assuming habitats were similar to those present prior to European settlement.

$$\text{IofA} = \frac{\sum_{k}^{j} (\text{HR} \times (\text{DMA}_{p/f} \times \text{DMB}_{p/f} \times \text{DMC}_{p/f} \times \text{DMD}_{p/f}) \times \text{Area}_{p/f})}{\sum (\text{HR} \times (\text{DMA}_{n} \times \text{DMB}_{n} \times \text{DMC}_{n} \times \text{DMD}_{n}) \times \text{Area}_{n})}$$

Where: “IofA” is the Index of Abundance for the species in the SAL study area; this index was created as the habitat suitability for the species at any time period divided by the habitat suitability expected under natural conditions

“HR” is the habitat rating developed by experts for the habitat type in question

“DMA” is the discounting multiplier based on the amount of cultivation in the landscape

“DMB” is the discounting multiplier based on the intensity of grazing in the habitat

“DMC” is the discounting multiplier based on the amount of roads in the habitat

“DMD” is the discounting multiplier based on the amount of human population in the SAL study area

“Area” is the area of the habitat available to the species within the study area (i.e., the area of the habitat in the study area multiplied by the proportion of the habitat in question that occurs within the species range)

"j" is the number of habitats found at present or in the future
"k" is the number of habitats found prior to European settlement
"p/f" refers to the conditions when the present (or future) time periods are being modeled
"n" refers to the conditions prior to European settlement

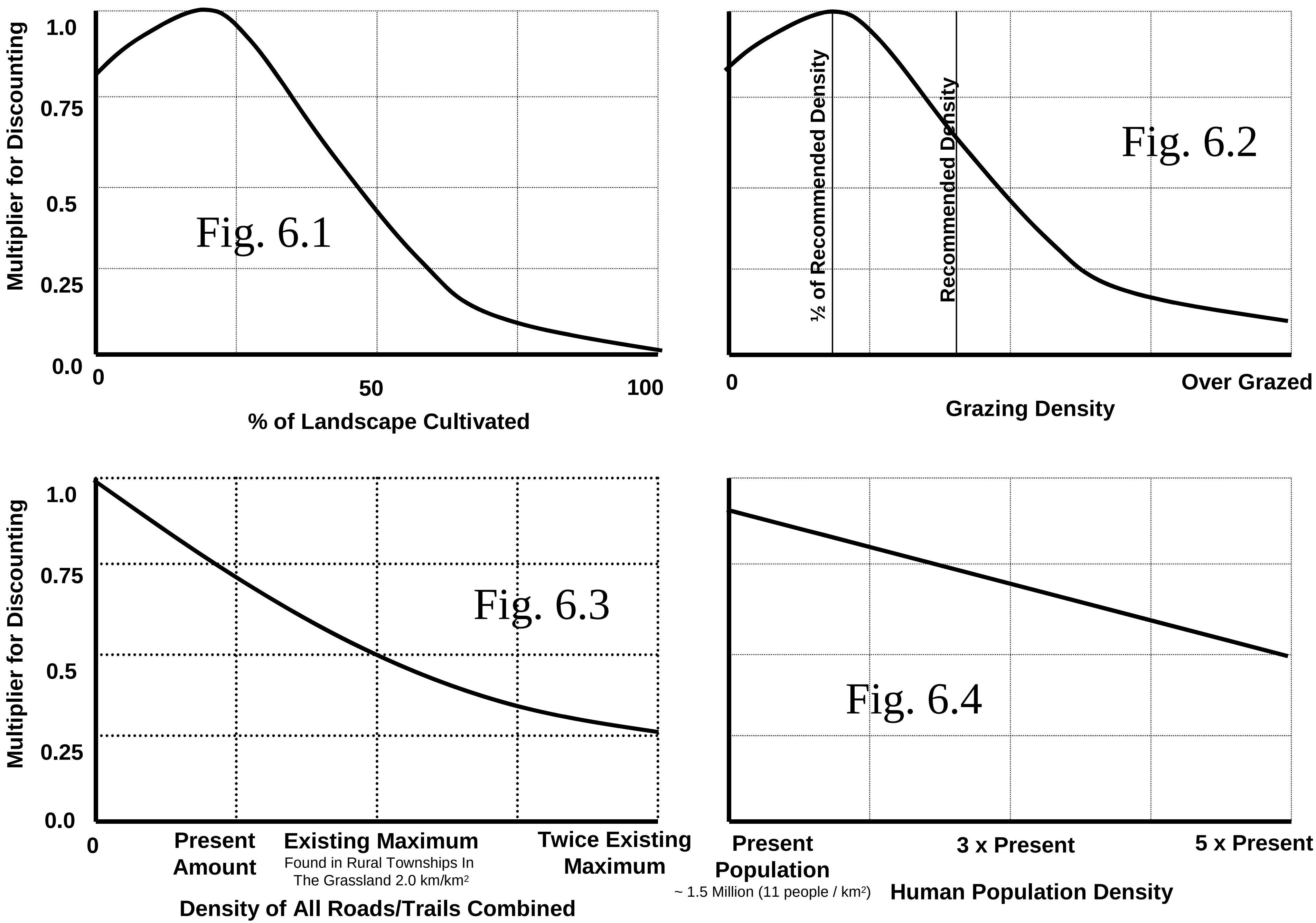
Table 6.1 Habitat Ratings For Sharp-tailed Grouse

Habitat Type	Category Rating[1]	Rating[2]	% Extra-Limital[3]
Grassland Habitat Types[4]			
Dry Mixed Grass			
Sandy Soils (sand grass)	Primary	1.0	0
Moderate Drainage/Blowout Soils (WG)	OK	0.1	0
Well Drained Loamy Soils (NTG)	OK	0.5	0
Mixedgrass (wheat grass, needle & thread)	Primary	1.0	0
Foothills & Northern Fescue (fescue grass)	Primary	1.0	0
Central/Foothills Parkland (fescue parkland)	Primary	1.0	0
Shrubs (in grassland)	OK	0.2	0
Prairie treed			
Breaks & Badlands (valleys & coulees)	OK	0.2	0
Riparian (floodplain/wetland margins)	Primary	0.6	0
Agricultural Habitat Types			
Cereal Crops			
Oilseeds			
Legume crops			
Specialty Crops			
Forage Crops			
Tame Pasture	Marginal	0.05	0
Forest Habitat Types[5]			
Deciduous (hardwood)	Marginal	0.05	0
Mixedwood (Deciduous/Coniferous)	Marginal	0.05	0
White Spruce	Marginal	0.05	0
Engelmann Spruce	Marginal	0.05	0
Douglas Fir			
Pine			
Shrubs (in forestland)	Marginal	0.05	0
Wetlands, Bogs, Meadows, Floodplains	Marginal	0.05	0

Habitat Type	Category Rating[1]	Rating[2]	% Extra-Limital[3]
Water Habitat Types			
Lentic (Lakes, Ponds)			
Small			
Large			
Artificial Pond/Lake			
Lotic (Streams, Rivers)			
Small			
Large			
Canals			
Other Habitat Types			
Alpine, Rock, Ice, Bare Inorganic Soil			
Industrial Habitat Types			
Seismic Lines			
Well sites			
Wellsite Roads			
Pipelines			
Industrial Plants			
Coal Mines			
Gravel Mines			
Feedlots			
Other Anthropogenic Habitat Types			
Major Roads			
Minor Roads			
Trails			
Rail Network			
Towns/Cities			
Rural Residential			
Acreage Residential			
Recreational (campgrounds, accommodation)			

1 – Classified as Primary, OK, Marginal, and left Blank if of no value
2 – The natural habitat type where the species reaches it's highest density is rated as 1.0. All other habitat types are rated in relation to this habitat (i.e., a habitat type where the species has 75% of the density in the best natural habitat type is rated as 0.75. It is possible for anthropogenic habitat types to have ratings of > 1.0.)
3 - % of the habitat type in the SAL study area that was outside the species range for Sharp-tailed Grouse.
4 – These habitats occur within the Grassland and Parkland Natural Regions only.
5 – These habitats occur within the Foothills and Rocky Mountain Natural Regions only.

Figures 6.1-6.4 Factors Used to Discount Habitat Ratings for Sharp-tailed Grouse



Changes In Sharp-tailed Grouse Over Time

ALCES was used to model changes in the amount and quality of each cover type in the SAL study area, and how these changes affected Sharp-tailed Grouse between pre-European settlement (approximately 1700) and the present. During this period agriculture, forestry, energy, transportation, and tourism reduced the amount of habitat available for Sharp-tailed Grouse by converting native cover types into “anthropogenic” cover types. In addition, human activities associated with population growth and resource use/extraction affected the quality of the remaining native habitat.

Three types of information were determined for Sharp-tailed Grouse:

i) *Predicted Historic Index of Abundance for Sharp-tailed Grouse* – This was the index of expected abundance for Sharp-tailed Grouse prior to European settlement. Abundance was converted to an index so that the average abundance in 1700 had a value of 1.0 (note that this index would have had a value of 0.0 if no Sharp-tailed Grouse were present, and would be greater that 1.0 if Sharp-tailed Grouse abundance was greater than that present in 1700). Natural variation in moisture and fire were used to estimate the “range of natural variation” in Sharp-tailed Grouse abundance. This range of variation may be an underestimate because other factors (eg. inter- and intra-specific interactions) may affect Sharp-tailed Grouse abundance.

ii) *Predicted Present Index of Abundance for Sharp-tailed Grouse Assuming the Habitat in the SAL Study Area was in Optimum Condition* – This was the predicted index of abundance for Sharp-tailed Grouse in 2000 based on the conversion of natural habitats to anthropogenic habitats, and assuming there was no degradation in the remaining natural habitats. This index of abundance was standardized as a proportion of the historical index.

iii) *Predicted Present Index of Abundance for Sharp-tailed Grouse After Accounting For Habitat Degradation* – This was the predicted index of abundance for Sharp-tailed Grouse in 2000 after accounting for conversion of natural habitats to anthropogenic habitats and the human uses/activities that degrade the value of the remaining habitat for Sharp-tailed Grouse. This index of abundance was standardized as a proportion of the historical index.

Index of Abundance Prior to European Settlement	**Historic Range of Variation (Natural Variation)**	**Index of Abundance in 2000 (% of Historic Index)**	
		Index of Abundance Assuming Optimum Habitat	**Index of Abundance After Accounting for Habitat Degradation**
1.0	25% of Historic Abundance	25% of Historic Abundance	20% of Historic Abundance

7.0 Grizzly Bears

Background

Based on discussions during August 2002, Grizzly Bears were selected for modeling within SAL. This species is widely distributed on the mountains and present within the parkland in southern Alberta. In addition, it is expected to be greatly affected by changes that are predicted to occur in the SAL study area. Wildlife experts thought that Grizzly Bear abundance could be modeled within ALCES using a similar process as that used to model grizzly bears in the Hinton area.

Participants

A workshop to evaluate how Grizzly Bears should be incorporated into SAL was held October 25, 2002 in Cochrane, AB. Scott Neilson, Jon Jorgenson, Mike Gibeau, Carita Bergman, Chris Shank, Brad Stelfox, and Jim Schieck developed a process to evaluate existing data and create a Grizzly Bear model using resource selection functions. Scott Nielson created the resource selection/mortality/exposure coefficients for the Grizzly Bears.

Habitat Value of the SAL Study Area Based on Resource Selection Functions for Use, Mortality, and Exposure

Grizzly Bears have been studied extensively in Alberta during the past 50 years. Based on studies in the north-east slopes Alberta (near Hinton), models based on empirically calculated resource selection coefficients provided more accurate quantification of habitat use than did models based on expert opinion. There is extensive data available from the SAL study area available to create a data driven habitat use model, and a data driven mortality occurrence model for Grizzly Bears. Thus, wildlife biologists participating in Grizzly Bear discussions for SAL thought it would be easier to defend “data driven” models than an “expert opinion” models for Grizzly Bears. Consequently, three data driven models were developed for Grizzly Bear in the SAL study area: i) a “habitat selection” model based on the comparison of radio-telemetry data of known grizzly bear “use” locations versus random points, ii) a “mortality risk” model based on known mortality locations in relation to random points, and iii) an “exposure risk” model based on the co-occurrence of habitat use (radio-telemetry locations) and mortality locations for grizzly bears. This data-driven modeling required much greater time and funding for many people than did the expert opinion approach used for the previous three species models.

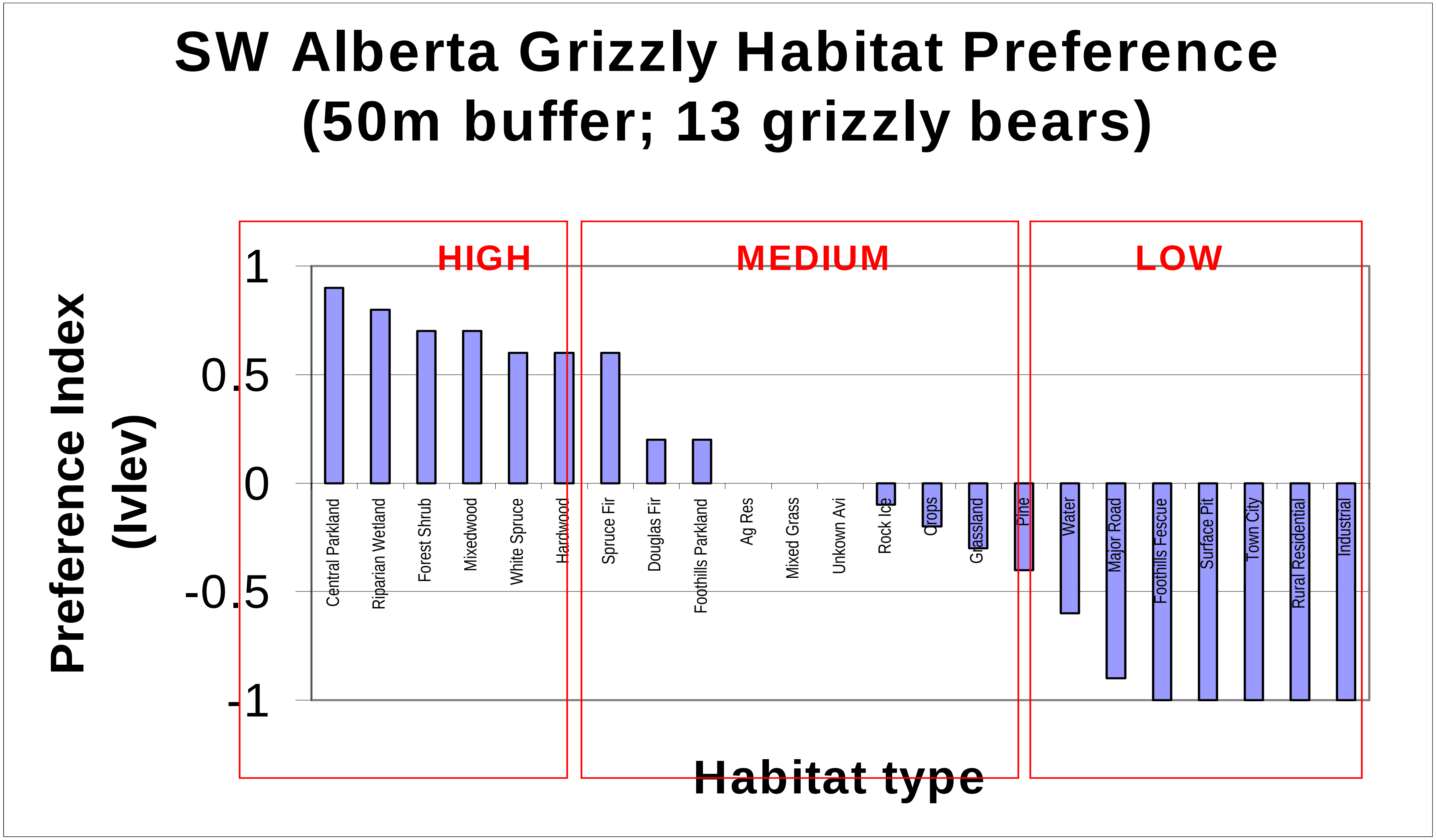
We first obtained permission from the organizations (i.e., East Slope Grizzly Bear Project, National Parks, and Alberta Fish and Wildlife) that had collected data on Grizzly Bear use and mortality to incorporate their data in SAL modeling. In the northern 70% of the Grizzly bear range within the SAL study area, 2,764 radio-telemetry locations from 45 Grizzly Bears were obtained. In addition, mortality locations for 235 locations of Grizzly Bear were obtained. We used this information to construct models of habitat selection, mortality, and exposure for Grizzly Bears.

Spatial GIS data describing the ALCES habitat classes and the location of linear features in the SAL study area were obtained from the spatial data coordinator for the SAL (Lana Robinson, Alberta Environment). The Grizzly Bear radio-telemetry locations and mortality locations were overlaid on the GIS data by Scott Nielson to determine the habitats bears used and the habitats where bears died. As a supplementary data set, 27,022 random points were overlaid on the GIS data in the 45 grizzly bear home ranges to determine the availability of habitats in each of the home ranges.

Scott Neilson conducted the statistical analyses to determine the resource selection functions (see supplementary report; Grizzly Bear Habitat Selection and Mortality Coefficients: Estimates For The Southern Alberta Landscapes: Meeting the Challenges Ahead Project). Scott created three models: i) a Grizzly Bear habitat selection model based on the comparison of radio-telemetry locations of grizzly bears versus random points, ii) a Grizzly Bear mortality risk model based on known mortality locations in relation to random points, and iii) a Grizzly Bear exposure risk model based on the mortality locations in relation the habitats that were used (radio-telemetry locations) by Grizzly Bears. Since the data were binomial (use/occurrence versus random, and mortality versus use), all models were created using logistic regression. 80% of the data was used to construct selection/occurrence coefficients, and 20% (567 radio-telemetry locations, and 50 mortality locations) used to “test” whether the predicted selection/occurrence coefficients discriminated habitats well. The tests indicated that all the models (habitat use, mortality risk, and exposure risk) had predictive value, but that mortality risk and exposure risk models had higher predictive values than did the habitat use model. Coefficients from the models were then used to calculate an index of habitat use in the SAL study area, an index of habitat mortality risk in the SAL study area, and an index of exposure risk in the SAL study area for Grizzly Bears. Although all of three models provide useful information, the SAL planning team relied mainly on the exposure risk when evaluating Grizzly Bears because this had higher predictive value, and described both “use” and “mortality”. Although, historically Grizzly Bears lived throughout the SAL study area, the modeling that occurred for SAL was limited to the “Green Zone”, since it is not anticipated that Grizzly Bears will live outside this area in the future.

Two habitats (Foothills and Parkland Grassland, and Douglas Fir) in SAL study area were not adequately evaluated during Scott’s modeling exercise using data from the East-slopes Grizzly Bear Project because these habitats occur mostly to the south of the data that he had. In addition, Grizzly Bears were thought to use cover types somewhat differently in the Crowsnest Pass area. Carita Bergman (Alberta Sustainable Resource Development) had a limited data set on habitat use by Grizzly Bears that provided additional insights for these more southern habitats. In general Carry found that forest habitats had higher relative use by Grizzly Bears than found by Scott. Grassland had moderate selection in both the north and south parts of the study area. To create a habitat use model that integrated results from both Scott’s and Carry’s analyses (ie., to create a model for the total SAL study area) coefficients found by Scott for forest habitats were increased by 0.1, and for all other cover types coefficients found by Scott were used.

Figure 7.1. Grizzly Bear Habitat Use in the Crowsnest area – from analyses by Carita Bergman.



Algorithms Used for Modeling Grizzly Bears in the SAL Study Area

Grizzly Bear Habitat Use Index

This index was calculated as the resource selection function for Grizzly Bears. To create an index that showed changes since European settlement, the present selection index was divided by the selection index calculated assuming the landscape was similar to what would have been present prior to European settlement.

$$UI = \frac{\left[\begin{array}{l} Deciduous_p + Spruce_p + Mixedwood_p + DouglasFir_p + Forb_p + Shrub_p + \\ Grass_p + Wetland_p + Alpine_p + Rock/Ice_p + Agriculture_p + Human_p + Road_p \end{array}\right]}{\left[\begin{array}{l} Deciduous_n + Spruce_n + Mixedwood_n + DouglasFir_n + Forb_n + Shrub_n + \\ Grass_n + Wetland_n + Alpine_n + Rock/Ice_n + Agriculture_n + Human_n + Road_n \end{array}\right]}$$

where:
UI = the resource selection index for all cover types in the SAL landscape for Grizzly Bears
p = calculations are based on present conditions
n = calculations are based on conditions prior to European settlement
RoadDensity = the average density of major plus minor roads (expressed as km/km^2) in the foothills and mountains,
LinearDensity = the average density of other linear features (pipelines plus transmission lines plus seismic lines plus railway lines plus trails; expressed as km/km^2) in the foothills and mountains,
Deciduous = {exponent[(0.045 x LinearDensity) - (0.009 x RoadDensity) + (0.983 x 1)]} x $Area_{de}$ where $Area_{de}$ is the total area occupied by "Hardwood" within the foothills and mountains,
Spruce = {exponent[(0.045 x LinearDensity) - (0.009 x RoadDensity) + (0.294 x 1)]} x $Area_{sp}$ and where $Area_{sp}$ is the total area occupied by "Black Spruce and White Spruce" within the foothills and mountains,
Mixedwood = {exponent[(0.045 x LinearDensity) - (0.009 x RoadDensity) = (0.924 x 1)]} x $Area_{mx}$ and where $Area_{mx}$ is the total area occupied by "Mixedwood" within the foothills and mountains,
DouglasFir = {exponent[(0.045 x LinearDensity) - (0.009 x RoadDensity) - (0.187 x 1)]} x $Area_{df}$ and where $Area_{df}$ is the total area occupied by "Douglas Fir" within the foothills and mountains,
Forb = {exponent[(0.045 x LinearDensity) - (0.009 x RoadDensity) + (0.920 x 1)]} x $Area_{fo}$ and where $Area_{fo}$ is the total area occupied by "Forb" within the foothills and mountains,
Shrub = {exponent[(0.045 x LinearDensity) - (0.009 x RoadDensity) + (0.502 x 1)]} x $Area_{sh}$ and where $Area_{sh}$ is the total area occupied by "Forest Shrub" within the foothills and mountains,
Grass = {exponent[(0.045 x LinearDensity) - (0.009 x RoadDensity) + (0.357 x 1)]} x $Area_{gr}$ and where $Area_{gr}$ is the total area occupied by "Grassland" within the foothills and mountains,
Wetland = {exponent[(0.045 x LinearDensity) - (0.009 x RoadDensity) - (0.777 x 1)]} x $Area_{we}$ and where $Area_{we}$ is the total area occupied by "Lotic and Lentic Large, Lentic Medium, and Lentic Small" within the foothills and mountains,
Alpine = {exponent[(0.045 x LinearDensity) - (0.009 x RoadDensity) - (0.369 x 1)]} x $Area_{al}$ and where $Area_{al}$ is the total area occupied by "Alpine",
Rock/Ice = {exponent[(0.045 x LinearDensity) - (0.009 x RoadDensity) - (1.249 x 1)]} x $Area_{ri}$ and where $Area_{ri}$ is the total area occupied by "Rock/Ice" within the foothills and mountains,
Agriculture = {exponent[(0.045 x LinearDensity) - (0.009 x RoadDensity) - (1.510 x 1)]} x $Area_{ag}$ and where $Area_{ag}$ is the total area occupied by "Annual Crop, Forage Crop, and Rural Residence" within the foothills and mountains,
Human = {exponent[(0.045 x LinearDensity) - (0.009 x RoadDensity) - (0.990 x 1)]} x $Area_{hu}$ and where $Area_{hu}$ is the total area occupied by "Industrial Plants, Pipelines, Recreational Areas, Surface Mines, and Wellsites" within the foothills and mountains,

Road = {exponent[(0.045 x LinearDensity) - (0.009 x RoadDensity) + (0.347 x 1)]} x $Area_{ro}$
and where $Area_{ro}$ is the total area occupied by "Major Roads" within the foothills and mountains,
All other cover types were excluded from the calculation of the Selection index.

Grizzly Bear Habitat Mortality Index
This index was calculated as the mortality function for Grizzly Bears. To create an index that showed changes since European settlement, the present mortality index was divided by the mortality index calculated assuming the landscape was in conditions that would have been present prior to European settlement.

$$MI = \frac{\left[\begin{array}{l} Deciduous_p + Spruce_p + Mixedwood_p + Forb_p + Shrub_p + Grass_p + Wetland_p + \\ Alpine_p + Rock/Ice_p + Agriculture_p + Human_p + Road_p \end{array}\right]}{\left[\begin{array}{l} Deciduous_n + Spruce_n + Mixedwood_n + Forb_n + Shrub_n + Grass_n + Wetland_n + \\ Alpine_n + Rock/Ice_n + Agriculture_n + Human_n + Road_n \end{array}\right]}$$

where:
MI = the risk of mortality in the SAL landscape for Grizzly Bear across all cover types
p = calculations are based on present conditions
n = calculations are based on conditions prior to European settlement
RoadDensity = the average density of major and minor roads (expressed as km/km^2) within the foothills and mountains,
LinearDensity = the average density of other linear features (pipelines plus transmission lines plus seismic lines plus railway lines plus trails; expressed as km/km^2) within the foothills and mountains,
Deciduous = {exponent[(0.495 x RoadDensity) + (0.543 x LinearDensity) - (2.186 x 1)]} x $Area_{de}$
where $Area_{de}$ is the total area occupied by "Hardwood" within the foothills and mountains,
Spruce = {exponent[(0.495 x RoadDensity) + (0.543 x LinearDensity) - (0.039 x 1)]} x $Area_{sp}$
and where $Area_{sp}$ is the total area occupied by "Black Spruce, White Spruce, Douglas Fir, plus any other Coniferous forest type except Pine" within the foothills and mountains,
Mixedwood = {exponent[(0.495 x RoadDensity) + (0.543 x LinearDensity) - (0.093 x 1)]} x $Area_{mx}$
and where $Area_{mx}$ is the total area occupied by "Mixedwood" within the foothills and mountains,
Forb = {exponent[(0.495 x RoadDensity) + (0.543 x LinearDensity) + (0.494 x 1)]} x $Area_{fo}$
and where $Area_{fo}$ is the total area occupied by "Forb" within the foothills and mountains,
Shrub = {exponent[(0.495 x RoadDensity) + (0.543 x LinearDensity) + (0.952 x 1)]} x $Area_{sh}$
and where $Area_{sh}$ is the total area occupied by "Forest Shrub" within the foothills and mountains,
Grass = {exponent[(0.495 x RoadDensity) + (0.543 x LinearDensity) + (0.111 x 1)]} x $Area_{gr}$
and where $Area_{gr}$ is the total area occupied by "Grassland" within the foothills and mountains,
Wetland = {exponent[(0.495 x RoadDensity) + (0.543 x LinearDensity) + (1.042 x 1)]} x $Area_{we}$
and where $Area_{we}$ is the total area occupied by "Lotic and Lentic Large, Lentic Medium, and Lentic Small" within the foothills and mountains,
Alpine = {exponent[(0.495 x RoadDensity) + (0.543 x LinearDensity) - (13.850 x 1)]} x $Area_{al}$
and where $Area_{al}$ is the total area occupied by "Alpine" within the foothills and mountains,
Rock/Ice = {exponent[(0.495 x RoadDensity) + (0.543 x LinearDensity) - (1.149 x 1)]} x $Area_{ri}$
and where $Area_{ri}$ is the total area occupied by "Rock/Ice" within the foothills and mountains,
Agriculture = {exponent[(0.495 x RoadDensity) + (0.543 x LinearDensity) - (0.445 x 1)]} x $Area_{ag}$
and where $Area_{ag}$ is the total area occupied by "Annual Crop, Forage Crop, and Rural Residence" within the foothills and mountains,
Human = {exponent[(0.495 x RoadDensity) + (0.543 x LinearDensity) + (0.558 x 1)]} x $Area_{hu}$
and where $Area_{hu}$ is the total area occupied by "Industrial Plants, Pipelines, Recreational Areas, Surface Mines, and Wellsites" within the foothills and mountains,
Road = {exponent[(0.495 x RoadDensity) + (0.543 x LinearDensity) + (1.379 x 1)]} x $Area_{ro}$
and where $Area_{ro}$ is the total area occupied by "Major Roads" within the foothills and mountains,

All other cover types were excluded from the calculation of the Mortality index.

Grizzly Bear Habitat Exposure Index
This index was calculated as the exposure function for Grizzly Bears. To create an index that showed changes since European settlement, the present exposure index was divided by the exposure index calculated assuming the landscape was in conditions that would have been present prior to European settlement.

$$\mathbf{EI} = \frac{\left[\begin{array}{l}\text{Deciduous}_p + \text{Spruce}_p + \text{Mixedwood}_p + \text{DouglasFir}_p + \text{Forb}_p + \text{Shrub}_p + \\ \text{Grass}_p + \text{Wetland}_p + \text{Alpine}_p + \text{Rock/Ice}_p + \text{Agriculture}_p + \text{Human}_p + \text{Road}_p\end{array}\right]}{\left[\begin{array}{l}\text{Deciduous}_n + \text{Spruce}_n + \text{Mixedwood}_n + \text{DouglasFir}_n + \text{Forb}_n + \text{Shrub}_n + \\ \text{Grass}_n + \text{Wetland}_n + \text{Alpine}_n + \text{Rock/Ice}_n + \text{Agriculture}_n + \text{Human}_n + \text{Road}_n\end{array}\right]}$$

where:
EI = the exposure risk in the SAL landscape for Grizzly Bear including all cover types
p = calculations are based on present conditions
n = calculations are based on conditions prior to European settlement
RoadDensity = the average density of major and minor roads (expressed as km/km^2) within the foothills and mountains,
LinearDensity = the average density of other linear features (pipelines plus transmission lines plus seismic lines plus railway lines plus trails; expressed as km/km^2) within the foothills and mountains,
Deciduous = {exponent[(0.681 x RoadDensity) + (0.314 x LinearDensity) - (0.293 x 1)]} x $Area_{de}$
where $Area_{de}$ is the total area occupied by “Hardwood” within the foothills and mountains,
Spruce = {exponent[(0.681 x RoadDensity) + (0.314 x LinearDensity) - (0.261 x 1)]} x $Area_{sp}$
and where $Area_{sp}$ is the total area occupied by “Black Spruce, White Spruce, Douglas Fir, plus any other Coniferous forest type except Pine” within the foothills and mountains,
Mixedwood = {exponent[(0.681 x RoadDensity) + (0.314 x LinearDensity) + (0.441 x 1)]} x $Area_{mx}$
and where $Area_{mx}$ is the total area occupied by “Mixedwood” within the foothills and mountains,
Forb = (0.681 x RoadDensity) + (0.314 x LinearDensity) + (1.339 x 1)]} x $Area_{fo}$
and where $Area_{fo}$ is the total area occupied by “Forb” w within the foothills and mountains,
Shrub = {exponent[(0.681 x RoadDensity) + (0.314 x LinearDensity) + (0.985 x 1)]} x $Area_{sh}$
and where $Area_{sh}$ is the total area occupied by “Forest Shrub” within the foothills and mountains,
Grass = {exponent[(0.681 x RoadDensity) + (0.314 x LinearDensity) + (1.045 x 1)]} x $Area_{gr}$
and where $Area_{gr}$ is the total area occupied by “Grassland” within the foothills and mountains,
Wetland = {exponent[(0.681 x RoadDensity) + (0.314 x LinearDensity) + (1.229 x 1)]} x $Area_{we}$
and where $Area_{we}$ is the total area occupied by “Lotic and Lentic Large, Lentic Medium, and Lentic Small” within the foothills and mountains,
Alpine = {exponent[(0.681 x RoadDensity) + (0.314 x LinearDensity) - (13.971 x 1)]} x $Area_{al}$
and where $Area_{al}$ is the total area occupied by “Alpine” within the foothills and mountains,
Rock/Ice = {exponent[(0.681 x RoadDensity) + (0.314 x LinearDensity) - (0.123 x 1)]} x $Area_{ri}$
and where $Area_{ri}$ is the total area occupied by “Rock/Ice” within the foothills and mountains,
Agriculture = {exponent[(0.681 x RoadDensity) + (0.314 x LinearDensity) + (2.281 x 1)]} x $Area_{ag}$
and where $Area_{ag}$ is the total area occupied by “Annual Crop, Forage Crop, and Rural Residence” within the foothills and mountains,
Human = {exponent[(0.681 x RoadDensity) + (0.314 x LinearDensity) + (2.081 x 1)]} x $Area_{hu}$
and where $Area_{hu}$ is the total area occupied by “Industrial Plants, Pipelines, Recreational Areas, Surface Mines, and Wellsites” within the foothills and mountains,
Road = {exponent[(0.681 x RoadDensity) + (0.314 x LinearDensity) + (0.755 x 1)]} x $Area_{ro}$
and where $Area_{ro}$ is the total area occupied by “Major Roads” within the foothills and mountains,
All other cover types were excluded from the calculation of Exposure index.

Changes In Grizzly Bears Over Time

ALCES was used to model changes in the amount and quality of each cover type in the SAL study area, and how these changes affected Grizzly Bears between pre-European settlement (approximately 1700) and the present (2000). During this period agriculture, forestry, energy, transportation, and tourism affected the amount of habitat available for Grizzly Bears by converting native cover types into "anthropogenic" cover types. In addition, human activities associated with population growth and resource use/extraction affected the quality of the habitats for Grizzly Bears. Finally human access and use of areas affected mortality of Grizzly Bears. Changes in habitat types and human use of the SAL study area were coupled with the Grizzly Bear model to project indices of Grizzly Bear use, mortality, and exposure. Of these three indices, exposure risk is the most informative because it had higher statistical predictive value, and summarized information for both habitat availability and mortality risk.

Two types of information were determined for Grizzly Bears:

i) *Predicted Historic Use/Mortality/Exposure For Grizzly Bears* – These indices were the expected values for Grizzly Bears habitat use, mortality, and exposure prior to European settlement (ie. in approximately 1700). For each of the three indices, the values were standardized to 1.0. Note, that only natural variation in moisture conditions and fire were modeled in ALCES. These factors did not affect the Grizzly Bear models, and as such no "range of natural variation" could be calculated. However, some variation in Grizzly Bear use/mortality/exposure will have occurred historically.

ii) *Predicted Present Use/Mortality/Exposure For Grizzly Bears* – These were the predicted indices of Grizzly Bears habitat use, mortality, and exposure in 2000 based on analyses of data from the study area. These indices were standardized as proportions of the historical values.

Type of Index	**Index Prior to European Settlement**	**Historic Range of Variation (Natural Variation)**	**Index in 2000 (% of Historic Index)**
Habitat Use	1.0	0% of Historic Index*	65% of Historic Index
Mortality	1.0	0% of Historic Index*	175% of Historic Index
Exposure	1.0	0% of Historic Index*	190% of Historic Index

* - range of natural variation was not calculated because Rattlesnake abundance is not related to variation in precipitation and fire

8.0 Grassland Specialist Species Group

Background

Based on discussions during August 2002, two groups of vertebrates (Native Grassland Specialists, and Anthropogenic Generalists) were modeled for SAL. Many of the native grassland specialists do not live outside, or have very low densities outside, native grassland habitats. Thus, loss, or degradation, of native grassland is of great concern to wildlife biologists because this is expected to have devastating effects on native grassland specialists. However, due to complex interactions between grassland specialists in their environment, changes in the abundance and richness for these species may occur slowly.

Participants

Modeling grassland specialist birds occurred in Calgary AB, on October 16, 2002. Jim Schieck facilitated the discussions in which avian experts Brenda Dale, Cleve Wershler, Doug Collister, Dave Scobie, Dave Prescott, and Richard Quinlan participated. Subsequent to the workshop, discussion among participants occurred via email. The ratings and relationships developed by experts (see Table 8.1) are based on these discussions. Modeling the grassland specialist mammals and herptiles occurred in Calgary AB, on October 15, 2002. Jim Schieck facilitated the discussions in which mammal and herptile experts Ed Hofman, David Gummer, Hal Reynolds, Ursula Bannash and Doug Collister participated. Subsequent to the workshop, discussion among participants and with Andy Didiuk, and Dave Scobie occurred via email. The ratings and relationships developed by experts (see Tables 8.2 and 8.3) are based on these discussions. Due to incomplete knowledge, the opinions of bird, mammal, and herptile experts may change as new information is gathered. To remain current, this expert driven process will need to be repeated every 1-2 years.

Habitat Values Based on Expert Opinion

For each of the bird/mammal/herptile species evaluated, the wildlife biologists rated each of the ALCES habitats as:

No Value = the species does not forage or breed in the habitat,
Low Value = the species may be found in the habitat but forages or breeds at very low density there,
Medium Value = the species is often found in the habitat but rarely reaches as high a density as found in their most preferred natural habitat,
High Value = the species is expected to have densities as high as that found in their most preferred natural habitat, or
Very High Value = the species is expected to have densities higher than those found in their most preferred natural habitat.

The categorical ratings that workshop participants assigned to each grassland specialist species are presented in the Tables 8.1-8.3. For modeling within ALCES, these categorical ratings were converted to numerical values (No Value = 0.0, Low Value = 0.1, Medium Value = 0.5, High Value = 1.0, and Very High Value = 1.0).

Discounting Habitat Value Based on Habitat Degradation

For each bird/mammal/herptile species, the workshop participants identified the shape of the relationship used to discount the habitat values based on the amount and type of human activities in the habitat. Human uses that were used for discounting were:

1) *Amount of cultivation in the landscape* - Cultivation intermixed with natural habitats may be detrimental to species that live mainly in natural habitats, because some individuals may nest/burrow and forage in cultivated areas and get killed by machinery when the land in being worked, and the crops are being harvested. In addition, there often is an increase in generalist predators in cultivated habitats and these predators may destroy nests and kill adults in the adjacent natural habitats. Finally, pesticides in cultivated landscapes may contaminate the food for some species. On the positive side, however, waste grain from agriculture provides food for many species, and may increase the suitability of adjacent

habitats. In addition, fragmentation caused by cultivation, buildings, and other structures (e.g., fence rows) associated with cultivation may provide the juxtaposition of nesting and foraging habitats needed by some species.

2) *Density of roads and trails* – Roads, pipelines, transmission lines, and other trails may facilitate the movement of generalist species into native habitats. This use of the native habitats by "new" species may make the native habitats lower value to the grassland specialists that lived there originally. This would occur if: a) the new species were better competitors than the original species, b) the new species prey upon the original species, or c) the new species parasitize the original species. Finally, roads and trails increase human access for recreation and that may result in some species being hunted legally and illegally, and other species being killed by vehicle traffic.

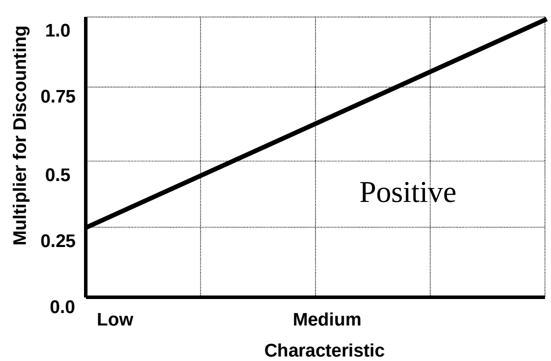
3) *Total number of humans in the SAL study area* – Increased human density will result in increased recreation (hiking, off-road vehicles, ecotours, hunting, etc.) throughout all habitats. These increased human activities will result native grassland specialists spending more time being vigilante, and less time foraging, and may result in the value of native habitats being lower to some species. In addition, the amount of traffic on all types of roads will increase as human population increases, and that will result in more wildlife being killed by vehicles. Finally, generalist predators (e.g., cats, dogs) may become more common in areas where human developments occur (i.e., in areas where acreage development occurs) and those predators may detrimentally affect native grassland specialists in adjacent native habitat types. On the positive side, however, species that can exploit the food and shelter in and around human buildings/structures will increase in abundance as human population grows.

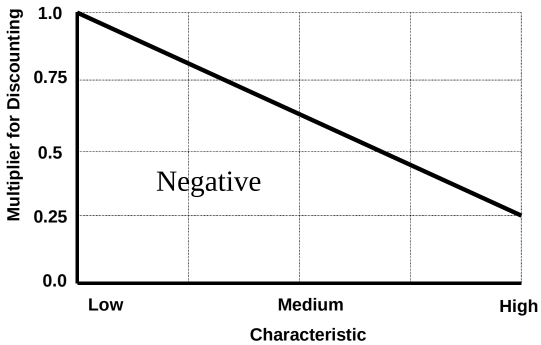
4) *Grazing intensity* – Livestock grazing alters vegetation composition and structure and may affect the amount and suitability of food and habitat for a species. Some native grassland specialists do best with no grazing, other species do best when grazing is light but decrease when grazing is intense, and other species do best in areas that are heavily grazed. For all species, nests, burrows, and young are more likely to be trampled at high livestock densities.

5) *Native Grassland that has been invaded by weeds and agronomic species* – Weedy plants and species introduced for agriculture often become established in areas with disturbed soils. Over time, these weedy/agronomic species then invade the surrounding native grassland, thus reducing the quality of that grassland for Native Grassland Specialists. To compensate for this reduction in habitat quality in native grassland, invasion of weed/agronomic species was modeled in ALCES based on known rates of invasion from human disturbances in the grassland of Alberta. Then, in the habitat model for Native Grassland Specialists, the invaded areas were assigned a habitat rating similar to that for tame pasture.

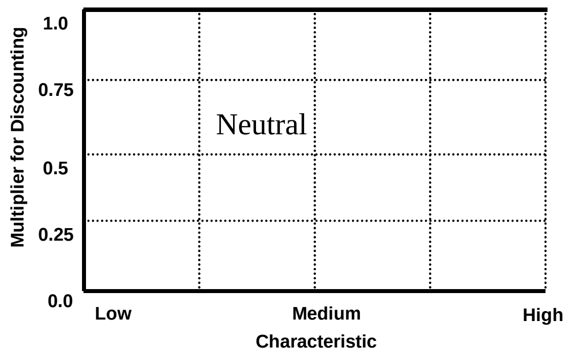
For each species the expected relationship between density and the human disturbance measures were categorized as one of four general types:

Positive = the species density increases as the magnitude of the characteristic increases.

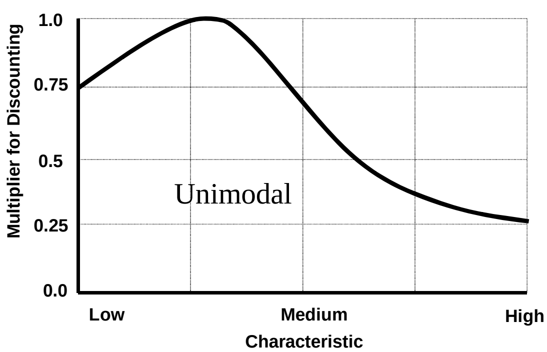




Negative = the species density decreases as the magnitude of the characteristic increases.



Neutral = the species density is not related to the magnitude of the characteristic.



Unimodal = as the magnitude of the characteristic increases the species density initially increases but then decreases.

These relationships were used to discount the habitat ratings within the Grassland Specialists ALCES models.

<u>Algorithms Used for Modeling Grassland Specialists in the SAL Study Area</u>
ALCES models were developed by a very broad group of people between 1995 and 2003. The habitats that were included in the SAL ALCES model are based on the combination of information available for the SAL study area and the habitats that ALCES can incorporate into the SAL models.

Algorithms to combine ratings among habitats, and to incorporate discounting factors into these habitat values were developed by Brad Stelfox and Jim Schieck. In these algorithms, habitat ratings for a species were multiplied by the discounting factor to arrive at an adjusted rating for each habitat. Adjusted ratings were then multiplied by the area of the habitat within the SAL study area, and summed across all habitats for the species. The ratings were then summed across all grassland specialists to obtain an index for the total group. To arrive at an index that relates present and future conditions in the SAL study area to conditions prior to European settlement, the sum of the adjusted ratings was divided by the sum obtained assuming habitats were similar to those present prior to European settlement.

$$\text{IofA} = \frac{\sum^{J}\sum^{m} (HR \times (DMA_{p/f} \times DMB_{p/f} \times DMC_{p/f} \times DMD_{p/f}) \times Area_{p/f})}{\sum^{k}\sum^{m} (HR \times (DMA_{n} \times DMB_{n} \times DMC_{n} \times DMD_{n}) \times Area_{n})}$$

Where: "IofA" is the Index of Abundance for the species in the SAL study area; this index was created as the habitat suitability for the species at any time period divided by the habitat suitability expected under natural conditions

"HR" is the habitat rating developed by experts for the habitat in question

"DMA" is the discounting multiplier based on the amount of cultivation in the landscape

"DMB" is the discounting multiplier based on the density of roads and trails in the habitat

"DMC" is the discounting multiplier based on the human population density in the SAL study area

"DMD" is the discounting multiplier based on the grazing intensity in the habitat in question

"Area" is the area of the habitat available to the species within the study area

"p/f" refers to the conditions when the present (or future) time periods are being modeled

"n" refers to the conditions prior to European settlement

"j" is the number of habitats found at present or in the future

"k" is the number of habitats found prior to European settlement

"m" is the number of species found in the species group

Table 8.1 Habitat Ratings For Native Grassland Specialist Birds

	Sage Grouse	LB Curlew	N Harrier	Prairie Falcon	Burrow Owl	Sprag Pipit	Say's Phoebe	Grass Hop Sp	Brew Sp[1]	Baird Sp	Lark Sp	Lark Bunt	Upland Sandpiper	MC LSpur	CC LSpur
Grassland Habitat Types[3]															
Dry Mixed Grass															
Sandy Soils (sand grass)	L[2]	H	H	H	L	M	L	H	H	M	M	H	H	L	L
Moderate Drainage/Blowout Soils (WG)	H	M	H	H	H	L	L	L	H	L		H	L	L	H
Well Drained Loamy Soils (NTG)	L	H	H	H	H	H	L	L		H		L	L	H	H
Mixedgrass (wheat grass, needle & thread)		H	H	M	M	H		L		H		M	L	L	H
Foothills & Northern Fescue (fescue grass)		L	M	L	L	M				M			M		L
Central/Foothills Parkland (fescue parkland)		L	M	L		M				L			L		
Shrubs (in grassland)			L												
Prairie treed											L				
Breaks & Badlands (valleys & coulees)				H			H				H				
Riparian (floodplain/wetland margins)			H	L	L						L				
Agricultural Habitat Types															
Cereal Crops		L													
Oilseeds		L													
Legume crops		L													
Specialty Crops		L													
Forage Crops		L	M			L				L		L	L		
Tame Pasture		M	L	L	L	L		M		L		L	L	L	L
Forest Habitat Types[5]															
Deciduous (hardwood)															
Mixedwood (Deciduous/Coniferous)															
White Spruce															
Engelmann Spruce															
Douglas Fir															
Pine															
Shrubs (in forestland)															
Wetlands, Bogs, Meadows, Floodplains			L												
Other Habitat Types															
Alpine, Rock, Ice, Bare Inorganic Soil				L											

1 – Ratings were based on the prairie phenotype of the Brewer's Sparrow
2 – Classified as V=Very High, H=High, M=Medium, L=Low, and left blank if of No Value
3 – These habitats occur within the Grassland and Parkland Natural Regions only.
4 – These habitats occur within the Foothills and Rocky Mountain Natural Regions only.

Table 8.1 cont. Habitat Ratings For Native Grassland Specialist Birds cont.

	Sage Grouse	LB Curlew	N Harrier	Prairie Falcon	Burrow Owl	Sprag Pipit	Say's Phoebe	Grass Hop Sp	Brew Sp[1]	Baird Sp	Lark Sp	Lark Bunt	Upland Sandpiper	MC LSpur	CC LSpur
Water Habitat Types															
Lentic (Lakes, Ponds)															
Small			L												
Large		L	L	L											
Artificial Pond/Lake			L	L											
Lotic (Streams, Rivers)															
Small			L												
Large				L											
Canals			L	L											
Industrial Habitat Types															
Seismic Lines															
Well sites															
Wellsite Roads															
Pipelines/ Transmission Lines				L											
Industrial Plants		L	L	L		L									
Coal Mines															
Gravel Mines															
Feedlots															
Anthropogenic Habitat Types															
Major Roads			L												
Minor Roads			L												
Trails			L												
Rail Network			L												
Towns/Cities															
Rural Residential							M				L				
Acreage Residential															
Recreation (campgrounds, accommodation)											L				
Characteristics Affecting the Value of Habitat Types															
% Cultivation	N[5]	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Road Density	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Human Density	N	N	N	N	N	N	-	N	N	N	N	N	N	N	N
Grazing Intensity	N	U	N	P	P	U	-	U	N	U	U	U	N	P	U

5 – Classified as P=Positive, N=Negative, "-"=Neutral, or U=Unimodal

Table 8.2 Habitat Ratings For Native Grassland Specialist Herptiles

	Tiger Salamander	N Leopard Frog	G Plains Toad	Plains Spadefoot	Wandering G Snake	Plains G Snake	W Hognose Snake	Bullsnake	S-Horned Lizard
Grassland Habitat Types[3]									
Dry Mixed Grass									
Sandy Soils (sand grass)	H		H	M	M	H	H	H	M
Moderate Drainage/Blowout Soils (WG)	M		M	M	M	H	M	M	H
Well Drained Loamy Soils (NTG)	M		M	M	M	H	M	M	H
Mixedgrass (wheat grass, needle & thread)	M		M	M	M	H	M	M	H
Foothills & Northern Fescue (fescue grass)	M				M	M			
Central/Foothills Parkland (fescue parkland)	M				M	M			
Shrubs (in grassland)	M		L	L	M	M		M	
Prairie treed	L		L	L	M<60	M<40		L	
Breaks & Badlands (valleys & coulees)			L		H	M		H	H
Riparian (floodplain/wetland margins)	H	H	H	H	H	H		H	
Agricultural Habitat Types									
Cereal Crops	L		L	L	L	L		L	
Oilseeds	L		L	L	L	L		L	
Legume crops	L		L	L	L	L		L	
Specialty Crops	L		L	L	L	L		L	
Forage Crops	V		L	L	L	M		M	
Tame Pasture	M		L	L	L	M	L	M	
Forest Habitat Types[5]									
Deciduous (hardwood)	L				L<40				
Mixedwood (Deciduous/Coniferous)	L								
White Spruce	L								
Engelmann Spruce	L								
Douglas Fir									
Pine	L								
Shrubs (in forestland)	M				L				
Wetlands, Bogs, Meadows, Floodplains	H	M			M				
Other Habitat Types									
Alpine, Rock, Ice, Bare Inorganic Soil									

1 – Ratings were based on the prairie phenotype of the Brewer's Sparrow
2 – Classified as V=Very High, H=High, M=Medium, L=Low, and left blank if of No Value
3 – These habitats occur within the Grassland and Parkland Natural Regions only.
4 – These habitats occur within the Foothills and Rocky Mountain Natural Regions only.

Table 8.2 cont. Habitat Ratings For Native Grassland Specialist Herptiles cont.

	Tiger Salamander	N Leopard Frog	G Plains Toad	Plains Spadefoot	Wandering G Snake	Plains G Snake	W Hognose Snake	Bullsnake	S-Horned Lizard
Water Habitat Types									
Lentic (Lakes, Ponds)									
Small	H	H	H	H	M	H	L	L	
Large	H	H	M	M	M	H	L	L	
Artificial Pond/Lake	H	M	L	L	M	H	L	L	
Lotic (Streams, Rivers)									
Small	M	H	L	L	M	H	L	L	
Large	M	M	L	L	M	H	L	L	
Canals	L	M	L	L	M	H	L	L	
Industrial Habitat Types									
Seismic Lines	L		L	L	L	L	L	L	L
Well sites	M		L	L	L	L	L	L	L
Wellsite Roads	M		L	L	L	L	L	L	L
Pipelines Transmission Lines	M		L	L	L	L	L	L	L
Industrial Plants	L		L	L	L	L		L	L
Coal Mines			L	L					
Feedlots									
Anthropogenic Habitat Types									
Major Roads	L				L	L	L	L	
Minor Roads	L				L	L	L	L	
Trails	L				L	L	L	L	
Rail Network	L				L	L	L	L	
Towns/Cities	L	L			L	L		L	
Rural Residential	L	L	L	L	L	L		L	
Acreage Residential	L	L	L	L	L	L		L	
Recreation (campgrounds, accommodation)	L	L	L	L	L	L		L	
Characteristics Affecting the Value of Habitat Types									
% Cultivation	N[5]	N	N	N	N	N	N	N	N
Road Density	N	N	N	N	N	N	N	N	N
Human Density	-	N	N	N	N	N	N	N	N
Grazing Intensity	N	N	N	U	-	-	N	-	U

5 – Classified as P=Positive, N=Negative, “-“=Neutral, or U=Unimodal

Table 8.3 Habitat Ratings For Native Grassland Specialist Mammals

	Hayden's Shrew	Nuttall's Cottontail	Richardson G Squirrel	N Grasshopper Mouse	OB Pocket Mouse	O Kangaroo Rat	L-Tailed Weasel	American Badger	Swift Fox	Pronghorn
Grassland Habitat Types[3]										
Dry Mixed Grass										
Sandy Soils (sand grass)	H	M	L	H	H	H	L	M	H	H
Moderate Drainage/Blowout Soils (WG)	M	M	M	H	M	L	M	M	H	H
Well Drained Loamy Soils (NTG)	M	M	H	M	M	L	H	H	H	H
Mixedgrass (wheat grass, needle & thread)	M	M	H	M	L		M	H	H	M
Foothills & Northern Fescue (fescue grass)	L	L	M	L			L	L		L
Central/Foothills Parkland (fescue parkland)	L		M				L	L		
Shrubs (in grassland)	L	H	L	L	L	L	L	L	M	M
Prairie treed	L						L	L	L	L
Breaks & Badlands (valleys & coulees)	L	H		L	L	L	L	L	M	H
Riparian (floodplain/wetland margins)		L	L				H	L		M
Agricultural Habitat Types										
Cereal Crops			L	L	L	L	L	L		M
Oilseeds			L	L			L	L		L
Legume crops			L	L			L	L		L
Specialty Crops			L	L			L	L		L
Forage Crops	L	L	M	L	L	L	M	M	L	M
Tame Pasture	L	L	M	L	L	L	H	M	L	M
Forest Habitat Types[5]										
Deciduous (hardwood)										
Mixedwood (Deciduous/Coniferous)										
White Spruce										
Engelmann Spruce										
Douglas Fir										
Pine										
Shrubs (in forestland)										
Wetlands, Bogs, Meadows, Floodplains										
Other Habitat Types										
Alpine, Rock, Ice, Bare Inorganic Soil										

1 – Ratings were based on the prairie phenotype of the Brewer's Sparrow
2 – Classified as V=Very High, H=High, M=Medium, L=Low, and left blank if of No Value
3 – These habitats occur within the Grassland and Parkland Natural Regions only.
4 – These habitats occur within the Foothills and Rocky Mountain Natural Regions only.

Table 8.3 cont. Habitat Ratings For Native Grassland Specialist Mammals cont.

	Hayden's Shrew	Nuttall's Cottontail	Richardson G Squirrel	N Grasshopper Mouse	OB Pocket Mouse	O Kangaroo Rat	L-Tailed Weasel	American Badger	Swift Fox	Pronghorn
Water Habitat Types										
Lentic (Lakes, Ponds)										
Small										
Large										
Artificial Pond/Lake										
Lotic (Streams, Rivers)										
Small										
Large										
Canals										
Industrial Habitat Types										
Seismic Lines			L	L	L	L	L	L	L	L
Well sites	L	L	M	L	L	L	L	M	L	L
Wellsite Roads	L	L	M	L	L	L	L	M	L	L
Pipelines, Transmission Lines	L	L	M	L	L	L	L	M	L	L
Industrial Plants			L				L	L	L	
Coal Mines			L				L	L		L
Gravel Mines			L				L	L		L
Feedlots			L				L	L		
Anthropogenic Habitat Types										
Major Roads			M				L	M	L	L
Minor Roads	L	L	M	L	L	L	L	H	L	M
Rail Network			L				L	L	L	M
Towns/Cities			L				L	L		L
Rural Residential	L	L	M	L	L	L	M	L	L	L
Acreage Residential			L				M	L	L	
Recreation (campgrounds, accommodation)	L	L	M	L	L	L	L	M		L
Characteristics Affecting the Value of Habitat Types										
% Cultivation	N[5]	N	-	N	N	N	N	-	N	N
Road Density	N	N	U	N	N	N	N	U	N	N
Human Density	-	N	-	N	N	N	-	-	N	N
Grazing Intensity	N	-	U	U	U	U	U	U	U	N

5 – Classified as P=Positive, N=Negative, "-"=Neutral, or U=Unimodal

Changes In Grassland Specialists Over Time

ALCES was used to model changes in the amount and quality of each cover type in the SAL study area, and how these changes affected Grassland Specialists between pre-European settlement (approximately 1700) and the present. During this period agriculture, forestry, energy, transportation, and tourism reduced the amount of habitat available for Grassland Specialists by converting native cover types into "anthropogenic" cover types. In addition, human activities associated with population growth and resource use/extraction affected the quality of the remaining native habitat.

Two types of information were determined for Grassland Specialists:

i) *Predicted Historic Index of Abundance for Grassland Specialists* – This was the index of expected abundance for Grassland Specialists prior to European settlement. Abundance was converted to an index so that the average abundance in 1700 had a value of 1.0 (note that this index would have had a value of 0.0 if no Grassland Specialists were present, and would be greater that 1.0 if Grassland Specialists abundance was greater than that present in 1700). Natural variation in moisture and fire were used to estimate the "range of natural variation" in Grassland Specialists abundance. This range of variation may be an underestimate because other factors (eg. inter- and intra-specific interactions) may affect Grassland Specialists abundance.

iii) *Predicted Present Index of Abundance for Grassland Specialists* – This was the predicted index of abundance for Grassland Specialists in 2000 after accounting for conversion of natural habitats to anthropogenic habitats and the human uses/activities that degrade the value of the remaining habitat for Grassland Specialists. This index of abundance was standardized as a proportion of the historical index.

Index of Abundance Prior to European Settlement	Historic Range of Variation (Natural Variation)	Index of Abundance in 2000 After Accounting for Habitat Degradation (% of Historic Index)
1.0	10% of Historic Abundance	55% of Historic Abundance

9.0 Anthropogenic Vertebrate Species Group

Background

Based on discussions during August 2002, two groups of vertebrates (Native Grassland Specialists, Anthropogenic Generalists) were modeled for SAL. Anthropogenic generalists included species that are positively associated with human activities. Virtually all of these species are habitat generalists, and many were introduced by humans. Changes to this species group should be very obvious within the ALCES modeling of the SAL study area.

Participants

Modeling anthropogenic birds occurred in Calgary AB, on October 16, 2002. Jim Schieck facilitated the discussions in which avian experts Brenda Dale, Cleve Wershler, Doug Collister, Dave Scobie, Dave Prescott, and Richard Quinlan participated. Subsequent to the workshop, discussion among participants occurred via email. The ratings and relationships developed by experts (see Table 9.1) are based these discussions. Modeling the anthropogenic mammals occurred in Calgary AB, on October 15, 2002. Jim Schieck facilitated the discussions in which mammal experts Ed Hofman, David Gummer, Hal Reynolds, Ursula Bannash and Doug Collister participated. Subsequent to the workshop, discussion among participants and with Andy Didiuk, and Dave Scobie occurred via email. The ratings and relationships developed by experts (see Table 9.2) are based on these discussions. Due to incomplete knowledge the opinions of both bird and mammal experts may change as new information is gathered. To remain current, this expert driven process will need to be repeated every 1-2 years.

Habitat Value Based on Expert Opinion

For each of the bird/mammal species evaluated, the wildlife biologists rated each of the ALCES habitats as:

No Value = the species does not forage or breed in the habitat,
Low Value = the species may be found in the habitat but forages or breeds at very low density there,
Medium Value = the species is often found in the habitat but rarely reaches as high a density as found in their most preferred natural habitat,
High Value = the species is expected to have densities as high as that found in their most preferred natural habitat, or
Very High Value = the species is expected to have densities higher than those found in their most preferred natural habitat.

The categorical ratings that workshop participants assigned to each bird/mammal species are presented in the Tables 9.1–9.2 below. For modeling within ALCES, these categorical ratings were converted to numerical ratings (No Value = 0.0, Low Value = 0.1, Medium Value = 0.5, High Value = 1.0, and Very High Value = 1.0).

Discounting Habitat Value Based on Human Disturbance

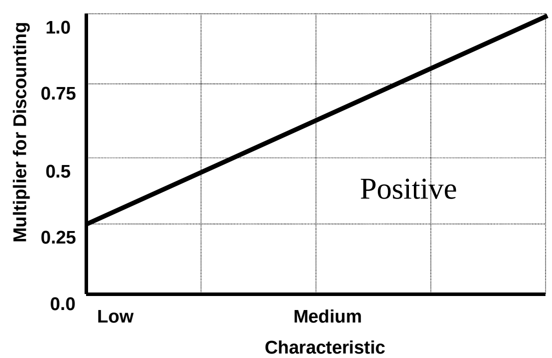
For each anthropogenic generalist bird/mammal species, the workshop participants identified relationship used to discount/increase the values of the habitats in the ALCES based on the human activities in the habitats. The human uses that were used for discounting/increasing values were:

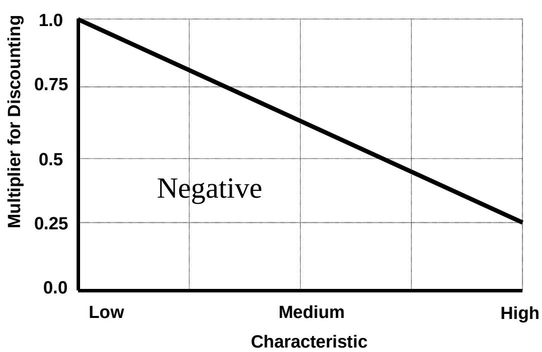
1) *Amount of cultivation in the landscape* **-** Cultivation creates habitats that are used preferentially by many anthropogenic species. Waste grain from cultivation provides food for many species, and may increase the suitability of adjacent habitats. In addition, cultivation intermixed with natural habitats may be beneficial to species that live mainly in human created habitats, because these species may nest/den and forage in cultivated areas and forage in the adjacent natural habitats. However, pesticides in cultivated landscapes may contaminate the food for some species.
2) *Density of roads and trails* – Roads, pipelines, transmission lines, and other trails create habitats that are used preferentially by many anthropogenic species. In addition, these roads/trails may facilitate movement and the use adjacent native habitats by generalist species.

3) *Total number of humans in the SAL study area* – Many generalist species (e.g., magpies, house sparrows, cats, dogs, etc.) depend on human crested habitats. These anthropogenic species exploit the food and shelter in and around human buildings and other human structures, and will increase in abundance as the human population grows.
4) *Grazing intensity* – Livestock grazing alters vegetation composition and structure, and may increase the amount and suitability of food and habitat for a anthropogenic generalists. However, for all species, nests/dens and young are more likely to be trampled at high livestock densities.
5) *Native Grassland that has been invaded by weeds and agronomic species* – Weedy plants and species introduced for agriculture often become established in areas with disturbed soils. Over time, these weedy/agronomic species then invade the surrounding native grassland, and alter the quality of that habitat for many species. This invasion of weedy species is often beneficial to Anthropogenic Generalists. To compensate for the change in habitat quality in native grassland, invasion of weed/agronomic species was modeled in ALCES based on known rates of invasion from human disturbances into the grassland of Alberta. Then, in the habitat model for Anthropogenic Generalists, the invaded areas were assigned a habitat rating similar to that for tame pasture.

For each anthropogenic generalist species, the expected relationships between density and the human disturbance measures were categorized as one of four general types:

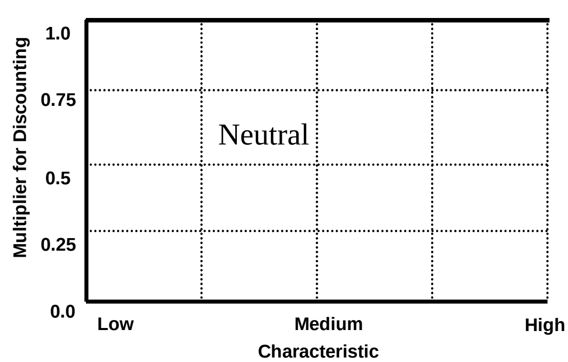
Positive = the species density increases as the magnitude of the characteristic increases.

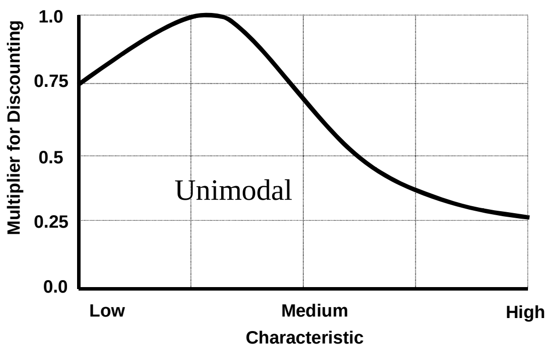




Negative = the species density decreases as the magnitude of the characteristic increases.

Neutral = the species density is not related to the magnitude of the characteristic.





Unimodal = as the magnitude of the characteristic increases the species density initially increases but then decreases.

These relationships were used to discount/increase the habitat ratings within the ALCES models.

Algorithms Used for Modeling Anthropogenic Generalists in the SAL Study Area

ALCES models were developed by a very broad group of people between 1995 and 2003. The habitats that were included in the SAL ALCES model are based on the combination of information available for the SAL study area and the habitats that ALCES can incorporate into models.

Algorithms to combine ratings among habitats, and to incorporate discounting factors into these habitat values were developed by Brad Stelfox and Jim Schieck. In these algorithms, habitat ratings for a species were multiplied by the discounting factor to arrive at an adjusted rating for each habitat. Adjusted ratings were then multiplied by the area of the habitat within the SAL study area, and summed across all habitats for the species. The ratings were then summed across all Anthropogenic Generalists to obtain an index for the total group. To arrive at an index that relates present and future conditions in the SAL study area to conditions prior to European settlement, the sum of the adjusted ratings was divided by the sum obtained assuming habitats were similar to those present prior to European settlement.

$$\text{IofA} = \frac{\sum^{J} \sum^{m} (\text{HR x } (\text{DMA}_{p/f} \text{ x DMB}_{p/f} \text{ x DMC}_{p/f} \text{ x DMD}_{p/f}) \text{ x Area}_{p/f})}{\sum^{k} \sum^{m} (\text{HR x } (\text{DMA}_{n} \text{ x DMB}_{n} \text{ x DMC}_{n} \text{ x DMD}_{n}) \text{ x Area}_{n})}$$

Where: "IofA" is the Index of Abundance for the species in the SAL study area; this index was created as the habitat suitability for the species at any time period divided by the habitat suitability expected under natural conditions

"HR" is the habitat rating developed by experts for the habitat in question

"DMA" is the discounting multiplier based on the amount of cultivation in the landscape

"DMB" is the discounting multiplier based on the density of roads and trails in the habitat

"DMC" is the discounting multiplier based on the human population density in the SAL study area

"DMD" is the discounting multiplier based on the grazing intensity in the habitat

"Area" is the area of the habitat available to the species within the study area

"p/f" refers to the conditions when the present (or future) time periods are being modeled

"n" refers to the conditions prior to European settlement

"j" is the number of habitats found at present or in the future

"k" is the number of habitats found prior to European settlement

"m" is the number of species found in the species group

Table 9.1 Habitat Ratings For Anthropogenic Birds

	RB Gull	Rock Dove	BB Magpie	Robin	BH Cowbird	Starling	House Sparrow
Grassland Habitat Types[2]							
Dry Mixed Grass			L[1]		L		
Sandy Soils (sand grass)			L		L		
Moderate Drainage/Blowout Soils (WG)			L		L		
Well Drained Loamy Soils (NTG)			L		L		
Mixedgrass (wheat grass, needle & thread)			L		L		
Foothills & Northern Fescue (fescue grass)			L		L	L	
Central/Foothills Parkland (fescue parkland)			L		L	M	
Shrubs (in grassland)			H		H		
Prairie treed			H	H	H	M	M
Breaks & Badlands (valleys & coulees)			M		M	L	
Riparian (floodplain/wetland margins)	L	H	M	H	H	M	
Agricultural Habitat Types							
Cereal Crops	L	L	L	L	L	L	
Oilseeds	L	L	L	L	L	L	
Legume crops	L	L	L	L	L	L	
Specialty Crops	L	L	L	L	L	L	
Forage Crops	L		L	L	L	M	
Tame Pasture	L	L	L	L	M	M	
Forest Habitat Types[5]							
Deciduous (hardwood)			L<20	M	L	L	
Mixedwood (Deciduous/Coniferous)				M	L	L	
White Spruce				M	L	L	
Engelmann Spruce				M	L	L	
Douglas Fir				M	L	L	
Pine				M	L	L	
Shrubs (in forestland)			L	M	M	L	
Wetlands, Bogs, Meadows, Floodplains			L	M	L	L	
Other Habitat Types							
Alpine, Rock, Ice, Bare Inorganic Soil				M			

1 – Classified as V=Very High, H=High, M=Medium, L=Low, and left blank if of No Value
2 – These habitats occur within the Grassland and Parkland Natural Regions only.
3 – These habitats occur within the Foothills and Rocky Mountain Natural Regions only.

Table 9.1 cont. Habitat Ratings For Anthropogenic Birds cont.

	RB Gull	Rock Dove	BB Magpie	Robin	BH Cowbird	Starling	House Sparrow
Water Habitat Types							
Lentic (Lakes, Ponds)							
Small							
Large	H						
Artificial Pond/Lake	V						
Lotic (Streams, Rivers)							
Small							
Large	M						
Canals	M						
Industrial Habitat Types							
Seismic Lines					L		
Well sites					L	L	
Wellsite Roads					L		
Pipelines, Transmission Lines					M	L	
Industrial Plants	H	M	L		M	L	L
Coal Mines			L				
Gravel Mines			L				
Feedlots	H	H	H		V	V	V
Anthropogenic Habitat Types							
Major Roads	L	L	L		M	L	
Minor Roads	L	L	L		M	L	
Trails	L	L	L		M	L	
Rail Network		L	L		M	L	
Towns/Cities	H	H	M	V	M	V	V
Rural Residential		V	M	H	V	V	V
Acreage Residential		H	L	M	V	M	V
Recreation (campgrounds, accommodation)			L	M	M	L	M
Characteristics Affecting the Value of Habitat Types							
% Cultivation	P[4]	P	-	-	P	P	-
Road Density	P	-	P	-	P	-	-
Human Density	P	P	P	P	P	P	P
Grazing Intensity	-	-	P	-	P	P	P

4 – Classified as P=Positive, N=Negative, “-“=Neutral, or U=Unimodal

Table 9.2 Habitat Ratings For Anthropogenic Mammals

	Pocket Gopher	House Mouse	Dog	Coyote	Cat	Common Raccoon	Striped Skunk
Grassland Habitat Types[2]							
Dry Mixed Grass							
Sandy Soils (sand grass)	H[1]			H		M	M
Moderate Drainage/Blowout Soils (WG)	M			H		L	L
Well Drained Loamy Soils (NTG)	M			H		M	M
Mixedgrass (wheat grass, needle & thread)	L			H		M	M
Foothills & Northern Fescue (fescue grass)	M			H		L	L
Central/Foothills Parkland (fescue parkland)	M			H		L	L
Shrubs (in grassland)	L			H		M	L
Prairie treed	L			H		M	M
Breaks & Badlands (valleys & coulees)				H		H	M
Riparian (floodplain/wetland margins)				H		H	M
Agricultural Habitat Types							
Cereal Crops	L	L	L	M		M	L
Oilseeds	L	L	L	M		M	L
Legume crops	L	L	L	M		M	L
Specialty Crops	L	L	L	M		M	L
Forage Crops	V	L	L	M		M	L
Tame Pasture	H	M	L	H	L	M	L
Forest Habitat Types[5]							
Deciduous (hardwood)	L			L		M	L
Mixedwood (Deciduous/Coniferous)	L			L		M	L
White Spruce				L		M	
Engelmann Spruce				L		M	
Douglas Fir				L		M	
Pine				L		M	
Shrubs (in forestland)	L			L		M	
Wetlands, Bogs, Meadows, Floodplains				L		M	L
Other Habitat Types							
Alpine, Rock, Ice, Bare Inorganic Soil							

1 – Classified as V=Very High, H=High, M=Medium, L=Low, and left blank if of No Value
2 – These habitat types occur within the Grassland and Parkland Natural Regions only.
3 – These habitat types occur within the Foothills and Rocky Mountain Natural Regions only.

Table 9.2 Habitat Ratings For Anthropogenic Mammals cont.

	Pocket Gopher	House Mouse	Dog	Coyote	Cat	Common Raccoon	Striped Skunk
Water Habitat Types							
Lentic (Lakes, Ponds)							
Small							
Large							
Artificial Pond/Lake							
Lotic (Streams, Rivers)							
Small							
Large							
Canals							
Industrial Habitat Types							
Seismic Lines	M			M			L
Well sites	M	L		M		L	L
Wellsite Roads	M			M			L
Pipelines, Transmission Lines	H			M			L
Industrial Plants	L	H	L	M		L	L
Coal Mines	L	M		M		L	L
Gravel Mines	L	M		M		L	L
Feedlots	L	H	L	V	L	M	L
Anthropogenic Habitat Types							
Major Roads	L			L		L	
Minor Roads	M			M	L	L	
Trails	M			M	L	L	
Rail Network	L	M		L		L	L
Towns/Cities	L	V	V	M	V	M	H
Rural Residential	V	V	V	H	V	H	V
Acreage Residential	H	H	V	H	V	H	V
Recreation (campgrounds, accommodation)	M	M	H	L	L	L	L
Characteristics Affecting the Value of Habitat Types							
% Cultivation	U[5]	P	-	P	P	P	P
Road Density	-	-	-	-	-	-	-
Human Density	P	P	P	P	P	P	P
Grazing Intensity	-	-	-	-	-	-	-

4 – Classified as P=Positive, N=Negative, "-"=Neutral, or U=Unimodal

Changes In Anthropogenic Generalists Over Time

ALCES was used to model changes in the amount and quality of each cover type in the SAL study area, and how these changes affected Anthropogenic Generalists between pre-European settlement (approximately 1700) and the present. During this period agriculture, forestry, energy, transportation, and tourism reduced the amount of habitat available for Anthropogenic Generalists by converting native cover types into "anthropogenic" cover types. In addition, human activities associated with population growth and resource use/extraction affected the quality of the habitats.

Two types of information were determined for Anthropogenic Generalists:

i) *Predicted Historic Index of Abundance for Anthropogenic Generalists* – This was the index of expected abundance for Anthropogenic Generalists prior to European settlement. Abundance was converted to an index so that the average abundance in 1700 had a value of 1.0 (note that this index would have had a value of 0.0 if no Anthropogenic Generalists were present, and would be greater that 1.0 if Anthropogenic Generalists abundance was greater than that present in 1700). Natural variation in moisture and fire were used to estimate the "range of natural variation" in Anthropogenic Generalists abundance. This range of variation may be an underestimate because other factors (eg. inter- and intra-specific interactions) may affect Anthropogenic Generalists abundance.

ii) *Predicted Present Index of Abundance for Anthropogenic Generalists* – This was the predicted index of abundance for Anthropogenic Generalists in 2000 after accounting for conversion of natural habitats to anthropogenic habitats and the human uses/activities that affect the quality of the habitats for Anthropogenic Generalists. This index of abundance was standardized as a proportion of the historical index.

Index of Abundance Prior to European Settlement	**Historic Range of Variation (Natural Variation)**	**Index of Abundance in 2000 After Accounting for Habitat Degradation (% of Historic Index)**
1.0	15% of Historic Abundance	620% of Historic Abundance

10.0 Results For The Coarse Filter Analyses

Coarse filter analyses evaluated changes in habitat as surrogates for changes in wildlife. A wide variety of coarse filter metrics was possible, but only a few of these were identified as most important for SAL (see Section 2). ALCES was used to model how the amount and/or quality of these key coarse filter metrics changed between pre-European settlement (approximately 1700) and the present (2000). During this period agriculture, forestry, energy, transportation, and tourism converted some of the native cover types into "anthropogenic" cover types. In addition, human activities associated with population growth and resource use affected the quality of the remaining native habitats.

Three types of information were determined for each coarse filter metric:

i) *Historic Area or Amount* – This was the area/amount of each metric present prior to European settlement (ie. approximately 1700).
ii) *Range Of Variation In Historic Area or Amount* – Natural variation in moisture conditions and fire were used to estimate the "range of natural variation" that would have occurred in the historic areas/amounts.
iii) *Present Area or Amount* – This was the area/amount of each metric in 2000.

Coarse Filter (Habitat) Indicators for Grassland

Area of Native Grasslands – This index was calculated as the sum of all polygons for a native grassland cover types in the SAL study area. These indicators were calculated for each cover type individually, and then summed to produce a general value that displayed the combined change for all cover types in the grassland / parkland portion of the SAL study area:

Cover type	Area Prior to European Settlement	Historic Range of Natural Variation	Area in 2000	% of Historic Area in 2000
Sand grass (dry mixed grass)	390,000 ha	Zero	220,000 ha	55%
Northern wheat grass (dry mixed grass)	1,670,000 ha	Zero	780,000 ha	45%
Needle and thread grass (dry mixed grass)	2,560,000 ha	Zero	940,000 ha	35%
Mixed grass	1,810,000 ha	Zero	390,000 ha	20%
Foothills and northern fescue grassland	3,060,000 ha	Zero	610,000 ha	20%
Central and foothills parkland	1,250,000 ha	Zero	580,000 ha	45%
Shrubby area	200,000 ha	Zero	130,000 ha	65%
Riparian and treed area	720,000 ha	Zero	220,000 ha	30%
Badlands and breaks	170,000 ha	Zero	110,000 ha	65%
TOTAL	**11,850,000 ha**	**Zero**	**3,990,000 ha**	**35%**

Percent Of Native Grassland and Parkland Invaded by Weeds and Agronomic Species – This index was calculated as the proportion of native grassland cover types that were invaded by weedy and agronomic plants. This index was calculated as a weighted average across all native grassland cover types to create a general value for the grassland / parkland portion of the SAL study area. Note that this calculation does not include weedy and agronomic plants on anthropogenic cover types – these anthropogenic cover types cover approximately 66% of the total Grassland and Parkland area.

Area Invaded Prior to European Settlement	Historic Range of Natural Variation	Area in 2000	% of Historic Native Grassland Invaded in 2000	% of Remaining Native Grassland Invaded in 2000
0 ha	Zero	920,000 ha	10%	25%

Vegetation Structure –This index was developed by Alberta Public Lands (Barry Adams and Mike Alexander) in conjunction with Brad Stelfox as a composite index of vegetation vertical complexity, horizontal complexity, and species diversity for each type of native grassland. Vegetation complexity was affected by natural and human disturbances but increases over time as vegetation recovers. Vegetation complexity was converted to an index with a maximum of 1.0 in each cover type. A weighted average across all native grassland cover types was used as an integrated value for the grassland / parkland portion of the SAL study area.

Vegetation Structure Prior to European Settlement	Historic Range of Natural Variation	Vegetation Structure in 2000	% of Historic Vegetation Structure in 2000
0.88	25%	0.96	110%

<u>Coarse Filter (Habitat) Indicators for Forests</u>

Area of Forest – Indices were calculated as the sum of all forest polygons in the SAL study area. The indicators were calculated for each cover type individually, and then summed to produce a general value that displayed the combined change for all cover types in the forest portion of the SAL study area.

Cover type	Area Prior to European Settlement	Historic Range of Natural Variation	Area in 2000	% of Historic Area in 2000
Deciduous	397,000 ha	Zero	375,000 ha	95%
Mixedwood	88,000 ha	Zero	83,000 ha	95%
Spruce	383,000 ha	Zero	362,000 ha	95%
Pine	574,000 ha	Zero	533,000 ha	95%
Fir	313,000 ha	Zero	290,000 ha	95%
Shrubby Forest	160,000 ha	Unknown	159,000 ha	99%
TOTAL	**1,915,000 ha**	**Zero**	**1,801,000 ha**	**95%**

Area of Forest In Old Seral Stages – These indices were calculated as the sum of all forest polygons in the SAL study area older than 140 years because these ages were assumed have "old-growth" characteristics. The indicators were calculated for each cover type individually, and then summed to produce a general value that displayed the combined change for all cover types in the forest portion of the SAL study area.

Cover type	Area Prior to European Settlement	Historic Range of Natural Variation	Area in 2000	% of Historic Area in 2000
Deciduous	159,000 ha	20%	27,000 ha	15%
Mixedwood	44,000 ha	15%	19,000 ha	45%
Spruce	253,000 ha	15%	112,000 ha	50%
Pine	103,000 ha	20%	24,000 ha	25%
Fir	204,000 ha	10%	112,000 ha	55%
TOTAL	**762,000 ha**	**20%**	**304,000 ha**	**40%**

Density of Anthropogenic Edge –This index was calculated as the total amount of edge in forested habitats created by human features, divided by the total area of forest. The human features (roads, trails, railways, pipelines, transmission lines, seismic lines, well sites, industrial plants, coal mines, gravel mines, feedlots, rural and acreage residential areas, towns and cities, and recreational areas) were all assumed to create edges. Linear features were assumed to create edges on both sides of the feature, polygon features were assumed to be square and create edge around the square. Edge density was calculated as a weighted average across all forest types to create an integrated value for the forested portion of the SAL study area. From a wildlife perspective, it is the amount of core area (i.e., the inverse of edge) that is important. However, amount of core area was not tracked in ALCES and thus edge density was used as a surrogate index.

Anthropogenic Edge Prior to European Settlement	Historic Range of Natural Variation	Anthropogenic Edge in 2000	% of Historic Anthropogenic Edge in 2000
0 km per km^2	0%	1.3 km per km^2	All anthropogenic edge has been created by humans

Coarse Filter (Habitat) Indicators for Aquatic Habitat

Area Flowing Water – This index was calculated as the sum of all polygons classified as streams, rivers, or canals in the SAL study area. Areas of streams and rivers were used because lengths were not available within the ALCES data for SAL.

Flowing Water Prior to European Settlement	Historic Range of Natural Variation	Flowing Water in 2000	% of Historic Flowing Water in 2000
111,000 ha	Zero	82,000 ha	75%

Proportion of the Flowing Water that is Natural – This index was calculated as the area of streams/rivers divided by the total area of streams/rivers/canals in the SAL study area. Area of streams and rivers was used because length was not available within the ALCES data for SAL.

% Flowing Water that was Natural Prior to European Settlement	Historic Range of Natural Variation	% Flowing Water that is Natural in 2000
100%	Zero	85%

Area Of Standing Water – This was calculated as the sum of all polygons classified as wetlands, lakes, or reservoirs in the SAL study area.

Standing Water Prior to European Settlement	Historic Range of Natural Variation	Standing Water in 2000	% of Historic Standing Water in 2000
150,000 ha	Zero	174,000 ha	115%

Proportion of the Standing Water that is Natural – This index was calculated as the area of wetlands, ponds, and lakes divided by the total area of wetlands, ponds, lakes, and reservoirs in the SAL study area.

% Standing Water that was Natural Prior to European Settlement	Historic Range of Natural Variation	% Standing Water that is Natural in 2000
100%	Zero	70%

Sediment Loading in Water – This was calculated as the total tons of sediment that enters the water from uplands within the SAL study area divided by the total volume of water that enters the SAL study area from precipitation and melt. The number is converted to an index (that varies between 1.0 and 0.0).

Index of Sediment Loading Prior to European Settlement	Historic Range of Natural Variation	Index of Sediment Loading in 2000
1.0	10%	0.10

Appendix 1: SAL Model of Classic Prairie Fish Guild

Michael Sullivan[1] and Brad Stelfox[2]
[1]Alberta Fish and Wildlife Division
[2]Forem Technologies

Background

To model the potential responses of fish to land use changes in the Southern Alberta study area, a series of meetings and interviews were conducted with local and international fisheries biologists and ecologists. An initial meeting with Alberta biologists was held in Calgary on 10 December 2003 to select appropriate species or guilds and their distributional preferences. This was followed by a series of interviews (both by telephone and personal meetings) with a larger group of fisheries experts to determine the most importance aspects of anthropogenic changes to populations and habitat quality, both in Alberta and other North American prairie river systems. A final meeting with Alberta fisheries biologists was held in Calgary on 15 June 2004 to discuss and modify the modeled parameters.

The initial group of fish experts chose to model in SAL a guild of fish defined as the "classic prairie river fish". This list was not meant to include all species found in the study area, but to describe a guild whose historical presence defined the taxal character of natural river systems in the prairie portion of the SAL landscape. The species included:

Common Name	Scientific Name
Sturgeon	*Acipenser fulvescens*
Sauger	*Sander canadensis*
Mooneye	*Hiodon tergisus*
Goldeye	*Hiodon alosoides*
Silver Redhorse	*Moxostoma anisurum*
Quillback	*Carpiodes cyprinus*
Brassy Minnow	*Hybognathus hankinsoni*
Western Silvery Minnow	*Hybognathus argyritis*
Emerald Shiner	*Notropis atherinoides*
River Shiner	*Notropis blennius*
St. Mary's Sculpin	*Cottus bairdi*
Stonecat	*Noturus flavus*
Bull Trout	*Salvelinus confluentus*

Participants

Initial Meeting (Calgary, 10 Dec 2004)
Terry Clayton (Alberta Fish and Wildlife, by telephone)
Roger Korth (University of Alberta)
Trevor Rhodes (Alberta Fish and Wildlife)
Michael Sullivan (Alberta Fish and Wildlife)
Facilitated and assisted by Jim Schiek, Brad Stelfox and Lana Robinson

Expert Interviews
Tim Banek (Missouri Dept of Conservation)
Bruce Barton (University of South Dakota)
Daryl Bauer (Nebraska Game and Parks)
Charles Berry (South Dakota State University)
Ron Brooks (Southern Illinois University - Carbondale)
Don Pereira (Minnesota DNR)

Pat Short (Wisconsin DNR)
Jim Stephen (Kansas Wildlife and Parks)

Final Meeting (Calgary, 15 June 2004)
Terry Clayton (Alberta Fish and Wildlife)
Alan Locke (Alberta Fish and Wildlife)
Trevor Rhodes (Alberta Fish and Wildlife)
Michael Sullivan (Alberta Fish and Wildlife)
Facilitated and assisted by Lana Robinson and Jan Simonson

The ratings and relationships developed by these experts (Table 1) are based on their opinions and due to incomplete knowledge these opinions may change as new information is gathered. To remain current, this expert driven process will need to be repeated every 1-2 years.

Defining Distributional Preferences:

For each species, distributional preference for the four aquatic landscape types modeled in ALCES (river, lake, reservoir, and canal) were defined as High, Moderate, Low, None (Table 1). None of these species inhabited any of the terrestrial cover types.

Discounting of Habitat Quality

A discounting approach was then applied to habitat quality by identifying which landuse metrics affect the use of established habitat types. Each metric was given equal weighting because each has the potential to individually result in the loss of the fish guild. Each metric was then scaled from two extremes, the historical condition, and the condition causing the loss of the guild. By using this scale, each metric has equivalent weighting.

The three landuse metrics chosen were:

1. *Proportion of the mainstem river volume used for the full suite of human landuse practices (Figure 1).*

This single metric was chosen to best represent, in a simple mechanistic relationship, the spectrum of changes that occur with anthropogenic flow regulation. Numerous case histories in western Canada and the United States show that fishes are affected by the following aspects of river flow; seasonal pattern of flow, magnitude and duration of floods and droughts, changes in silt cycles, changes in temperature, and changes in river morphology. For strategic modeling purposes, mainstem river volume is a single metric that adequately encompasses major aspects of these detailed changes.

2. *Nutrient loading index representing current/historic loading of phosphorus and nitrogen (Figure 2).*

This metric represents a scaled change in nutrient loading of river water. Local and international fisheries biologists described several case histories (both in Alberta and other jurisdictions) of excessive nutrient loading resulting in algae blooms and subsequent oxygen-depletion and fish kills.

3. *Density of roads that could be used by the public to gain access to aquatic features (Figure 3).*

Access and subsequent angling pressure has been clearly demonstrated to result in declines in populations of low-productivity fish species, such as the large-bodied and predatory fishes found in the Southern Alberta study area. This metric was considered by the Alberta experts to be adequately correlated to changes in fishing pressure. Major changes to fishing regulations and restrictions on access would affect the correlation of this metric with fishing pressure.

The experts agreed that computation of combined habitat quality in ALCES for this guild should follow a multiplicative rather than an additive approach. This means that if one of the weighted discounting variables attains a value of 0, then the combined habitat quality would be 0.

The response of individual species to the discount variables was defined as neutral, positive, negative, or unimodal and minimum and maximum ranges for the axes of these variables were defined.

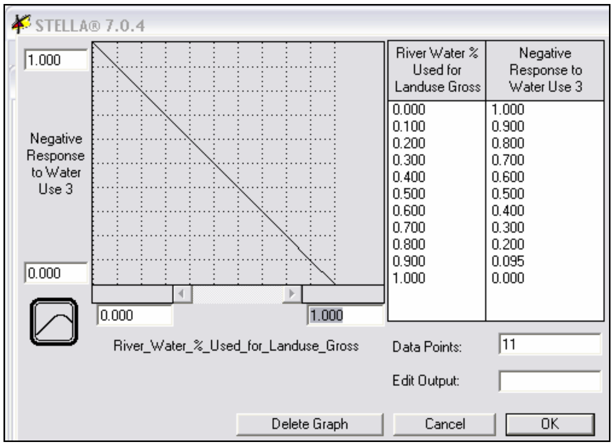


Figure 1. Response of prairie fish guild to proportion of mainstem river water volume removed for human landuse. All of these fish species were defined to respond in a negative fashion.

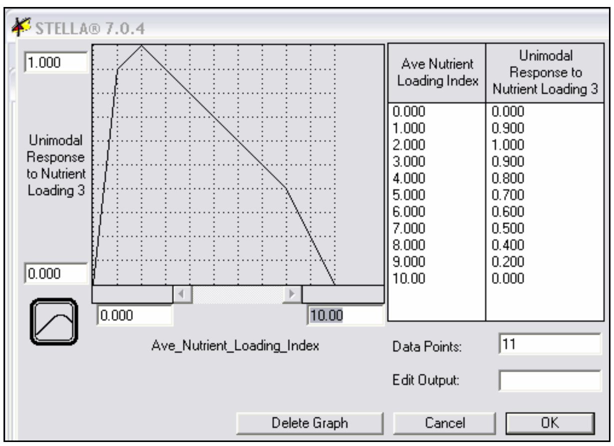


Figure 2. Response of prairie fish guild to nutrient loading index. All of these fish species were defined to respond in a unimodal fashion, characterized by an initial increase in productivity with nutrient addition, followed by a decline in populations because of stresses from summer and winter kill.

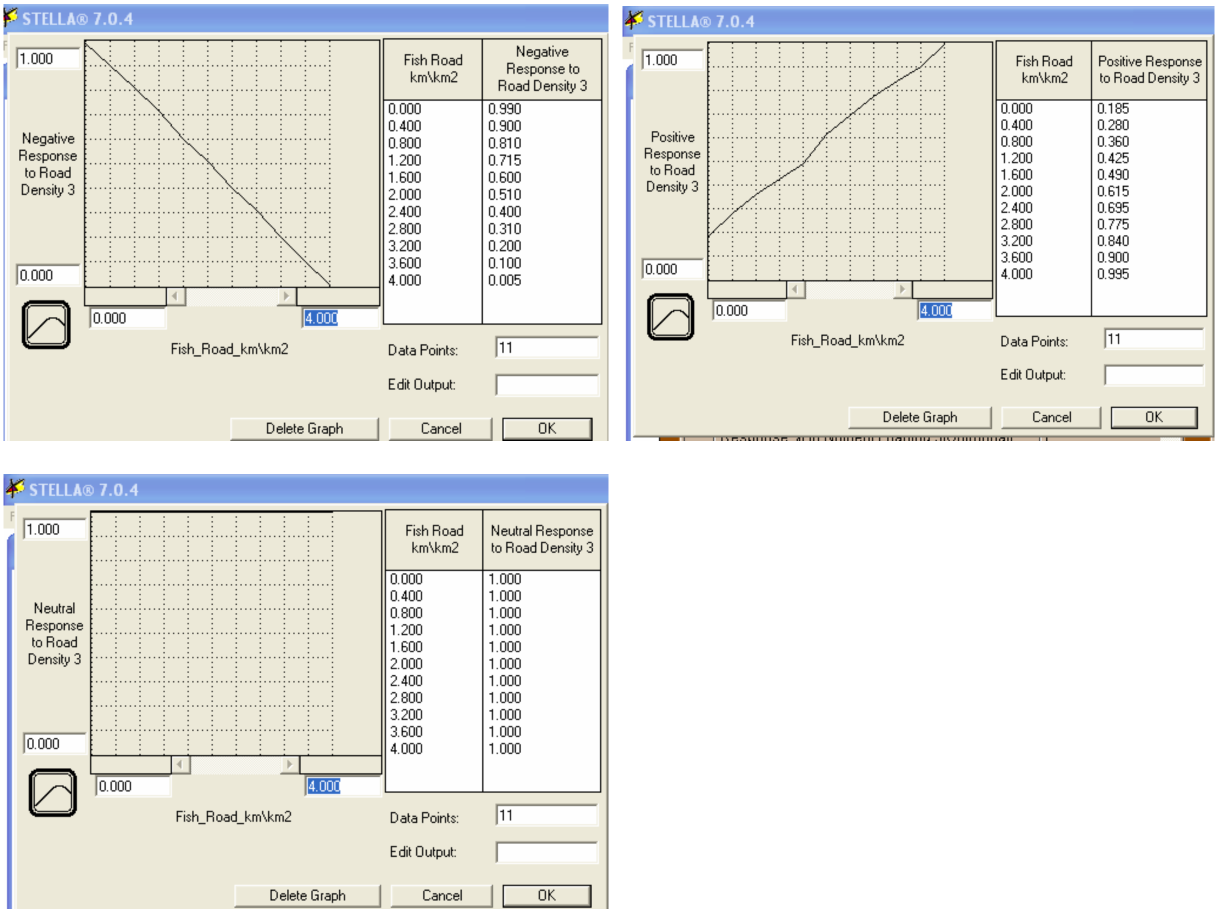


Figure 3. Response of prairie fish guild to density of linear features that represent access to aquatic features. Of the species in the guild, 50% (large-bodied predatory fishes) were defined with a negative response, 30% (small-bodied prey fishes) with a positive response, and 20% (non-prey and non-angled fishes) with a neutral response.

Algorithms Used for Modeling the "Classic Prairie Fish Guild" in the SAL Study Area

Algorithms to combine ratings among habitats, and to incorporate discounting factors into these habitat values were developed by Brad Stelfox and Jim Schieck. In these algorithms, habitat ratings for a species were multiplied by the discounting factor to arrive at an adjusted rating for each habitat. Adjusted ratings were then multiplied by the area of the habitat within the SAL study area, and summed across all habitats for the species. The ratings were then summed across all species in the group to obtain an index for the total group. To arrive at an index that relates present and future conditions in the SAL study area to conditions prior to European settlement, the sum of the adjusted ratings was divided by the sum obtained assuming habitats were similar to those present prior to European settlement.

$$SI = \frac{\sum^{J} \sum^{m} (HR \times (DMA_{p/f} \times DMB_{p/f} \times DMC_{p/f}) \times Area_{p/f})}{\sum^{k} \sum^{m} (HR \times (DMA_{n} \times DMB_{n} \times DMC_{n} \times DMD_{n}) \times Area_{n})}$$

Where: "SI" is the suitability index of the species group within the study area in relation to suitability expected prior to European settlement

"HR" is the habitat rating developed by experts for the habitat in question

"DMA" is the discounting multiplier based on the amount of river water used for landuse

"DMB" is the discounting multiplier based on the relative nutrient loading indices

"DMC" is the discounting multiplier based on the linear feature density

"Area" is the area of the habitat available to the species within the study area

"p/f" refers to the conditions when the present (or future) time periods are being modeled

"n" refers to the conditions prior to European settlement

"j" is the number of habitats found at present or in the future

"k" is the number of habitats found prior to European settlement

"m" is the number of species found in the species group

External Validation of Fish Guild Assumptions in ALCES

As part of the ALCES / SAL modeling process, experts from other North American jurisdictions were consulted with regards to landscape-level ecosystem changes and effects on prairie river fish communities. In particular, these experts were asked about case histories within their jurisdictions where prairie landscapes were developed and fishes were affected. The goal was to determine what major landscape changes were the most important, as they were likely to affect Alberta's prairie fishes.

The fisheries scientists interviewed were:

- Daryl Bauer (Nebraska Game and Parks)
- Ron Brooks (Southern Illinois University - Carbondale)
- Don Pereira (Minnesota DNR)
- Pat Short (Wisconsin DNR)
- Tim Banek (Missouri Dept of Conservation)
- Charles Berry (South Dakota State University)
- Bruce Barton (University of South Dakota)
- Jim Stephen (Kansas Wildlife and Parks)

The two common and overriding problems each jurisdiction faced were flow changes (primarily through dams and irrigation) and water quality changes (primarily through agricultural and industrial run-off). Specific relationships included increases in water clarity (because of silt capture by dams) reducing habitat area for light-sensitive species such as walleye and sauger, reductions in water temperature (because of bottom-draw dams) affecting spawning success, flow regime changes affecting nursery habitat, and increased nutrients causing algae blooms, water quality changes and summer-kill of fish. Case histories described included:

- Platte River (Wyoming - Nebraska) – summer-kill caused by increased nutrient input
- Niobrara River (Nebraska) – sauger spawning reduced because of increased clarity of mainstem Missouri River
- James River (Dakotas) – loss of nursery habitat for variety of fishes because of flow changes
- Missouri River (Montana, Dakotas) – pallid sturgeon endangered because of habitat loss from flow changes

Access (and increased fishing pressure) was not a major issue with these jurisdictions, except for Minnesota and Wisconsin. Fisheries in these two more northern ecosystems have lower natural productivity and will therefore be more affected by increased fishing pressure. Alberta is further north, has much lower fisheries productivity than any of these jurisdictions, and increased access will therefore have a larger detrimental effect on Alberta's fisheries.

In summary, for the ALCES / SAL model, the primary landscape-level changes affecting prairie river fish communities in Alberta will be water use, nutrient input, and access. These conclusions are supported by consultations with North American fisheries experts.

	Sturgeon	Sauger	Mooneye	Goldeye	Silver Redhorse	Quill Back	Brassy Minnow	W. Silvery Minnow	Emerald Shiner	River Shiner	St. Mary's Sculpin	Stonecat	Bull Trout
Water Habitat Types[1]													
Lentic (Lakes, Ponds)	N	N	N	N	N	N	N	N	M	N	N	N	L
Reservoir	N	N	N	N	N	N	N	N	M	N	N	N	N
Lotic (Streams, Rivers)	H	H	H	H	H	H	H	H	H	H	H	H	H
Canal	N	N	N	N	N	N	N	N	L	N	N	N	N
Characteristics Affecting the Value of Habitat Types [2]													
% of Mainstem River Water Used by landuse	N	N	N	N	N	N	N	N	N	N	N	N	N
Nutrient Loading	U	U	U	U	U	U	U	U	U	U	U	U	U
Access Density	N	N	N	N	N	N	P	P	P	P	--	--	N

Table 1. Distributional preferences of members of the prairie fish guild and ALCES parameters affecting habitat types.

[1] H=High, M=Moderate, L=Low, N=None

[2] N=Negative, P=Positive, U=Unimodal, -- = Neutral