Research Report

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Strategic conservation planning for terrestrial animal species in the Central Interior of British Columbia

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Abstract

The Nature Conservancy of Canada used an expert-driven approach to incorporate multiple animal species into an ecoregional assessment for the purpose of conservation planning in the Central Interior of British Columbia. This method has been applied in 14 ecoregions across Canada as part of the organization's mission to "protect areas of biological diversity for their intrinsic value and for future generations" through land purchases and other land protection measures.

A team of biologists identified 100 vertebrate species considered to be of conservation concern in the study area (3 amphibians, 5 reptiles, 28 mammals, and 64 birds) and set targets for spatial representation of their occurrences and habitat. The level of conservation concern associated with each species was assessed based on its formal conservation ranking, conservation priorities set by other organizations, and observed trends and vulnerabilities in a local and provincial context. To identify areas of high conservation priority, targets for the representation of animal species, and those identified separately for plants and ecosystem units, were collectively applied in a series of simulations using Marxan site-selection software. Marxan was directed to meet coarse-filter targets for terrestrial ecosystem units as well as optimally represent fine-filter targets for plants and animals and their habitats.

The final portfolio of conservation areas is based on a "best solution" of planning units (500-ha hexagons) that provide the most effective representation of targets at least cost over 500 Marxan simulations. These areas achieved all of the representation targets for terrestrial animals in terms of the number of element occurrences and percent area of habitat selected. Priority conservation areas are distributed across the study area, building on existing protected areas and providing increased connectivity.

KEYWORDS: *biodiversity; British Columbia; Central Interior Ecoregional Assessment; climate change; conservation planning; Marxan analysis; Nature Conservancy of Canada; terrestrial animal species.*

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Introduction

Ecoregional assessments are undertaken by The Nature Conservancy in the United States and Nature Conservancy of Canada to achieve an overarching conservation goal of "the long term survival of all viable native species and community types through the design and conservation of portfolios of sites within ecoregions."[1] Ecoregional conservation planning involves "selecting and designing networks of conservation sites that will conserve the diversity of species, communities, and ecological systems in each ecoregion" (Groves et al. 2000). Ecoregional portfolios provide an initial building block for more detailed site planning and actions such as the acquisition and placing of conservation easements on ecologically significant lands. To date, the Nature Conservancy of Canada has completed eight assessments within British Columbia, including the Central Interior (Floberg et al. 2001; Round River Conservation Studies et al. 2003; Heinemeyer et al. 2004; Wood et al. 2004; Iachetti et al. 2006; Pryce et al. 2006; Vander Schaaf et al. 2006). The southernmost of these were trans-boundary planning exercises with the northwestern United States.

Ecoregional assessments have two separate components: (1) terrestrial and (2) freshwater. The freshwater analysis for the Central Interior Ecoregional Assessment is described in Howard and Carver (2011:72–87). The terrestrial analysis combines representation of terrestrial ecosystem units (G.M. Kittel et al. 2011a:54–71) and fine-filter analyses for animals (described here) and plants. Planning occurs at two spatial scales: (1) local and (2) landscape. Habitats and species are represented at a local scale within 500 ha planning units (hexagons). Selected hexagons are "clumped" into groupings at the landscape scale to represent larger ecosystem units and habitats for wide-ranging species. Networks link conservation areas to provide connectivity.

Specific objectives of the terrestrial animals component of the Central Interior Ecoregional Assessment were to:

- identify species of conservation concern to be input as "features" in the assessment;
- assess the vulnerability of each species based on its distribution and status in the study area;

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- assign targets for their representation in the final conservation portfolio; and
- evaluate the success of the final set of conservation areas in achieving representation targets and capturing key areas of conservation concern.

The overall process was modified from Groves et al. (2000) to address issues specific to the Central Interior, such as the mountain pine beetle outbreak, and to pilot the consideration of climate change in ecoregional assessments (described in T.G.F. Kittel et al. 2011b:7–35). The assessment process used Marxan conservation planning software to optimize the capture of representation targets at the coarse and fine scales while minimizing costs (Ball et al. 2009; Loos 2011:88–97).

The study area entirely overlaps those areas of British Columbia most heavily affected by mountain pine beetle. The B.C. Ministry of Forests, Lands and Natural Resource Operations has projected that up to 80% of the merchantable pine in central and southern British Columbia could be killed by 2013 as a result of this infestation (see ***http://www.for.gov.bc.ca/hts/rs/beetle_detection.html***). Bunnell et al. (2004) estimated that beetle kill itself has the potential to benefit about two-thirds of resident terrestrial vertebrate fauna in beetle-infested areas of the province but that beetle kill and associated salvage operations may negatively affect at least one-third of species. Impacts to wildlife are primarily associated with changes in the availability of critical habitat attributes, including loss of mature and old forests (Chan-McLeod and Bunnell 2003).

[1] The Nature Conservancy of Canada defines "ecoregions" as "large units of land and water that contain a geographically distinct assemblage of natural communities and species and share similar environmental factors including climate, physiography and soils; and interact ecologically in ways that are critical for their long-term persistence" (Groves et al. 2000). They are not the same as ecoregions defined under British Columbia's ecoregional classification system (Demarchi 1996), although the defining criteria are similar.

Changes projected by climate models show continued increases in winter and summer temperatures in British Columbia, particularly in the north (Spittlehouse 2008). The Central Interior is projected to experience drier summers and wetter winters (Spittlehouse 2008). These changes would result in decreased snow accumulation, accelerated snowmelt, and altered timing and magnitude of streamflow (Pike et al. 2008). Morgan et al.[2] identified four key areas of change affecting wildlife in the province under climate change: (1) phenology; (2) species range and distribution; (3) habitat availability; and (4) population dynamics and community structure.

Study area

The Central Interior Ecoregional Assessment study area encompasses the upper two-thirds of the Fraser River Basin (Figure 1). The boundaries of the study area are the same as those of the combined Central Interior and Sub-Boreal Interior ecoprovinces (Demarchi 1996). The area covers approximately 25 million ha. The landforms and ecosystems are diverse and include the flat-to-rolling Chilcotin, Cariboo, Nechako, and McGregor plateaus; the Chilcotin, Bulkley, Tahtsa, and Hart ranges; and the Omineca and Skeena mountains.

In the Central Interior ecoprovince sub-area to the south, dominant forest types are Douglas-fir and lodgepole pine, with some hybrid white spruce in wet sites. Subalpine areas above 1200–1500 m elevation are typically Engelmann spruce and subalpine fir or lodgepole pine forests. Alpine ecosystems occur at highest elevations. In the Sub-Boreal Interior ecoprovince, forests of lodgepole pine, hybrid white spruce, and subalpine fir dominate the landscape.

Methods

The terrestrial animals component of this ecoregional assessment followed the standard methodology used by The Nature Conservancy as described by Groves et al. (2000). Guidance was also provided by other assessments, such as the Okanagan (Pryce et al. 2006), North Cascades and Pacific Ranges (Iachetti et al. 2006), and Southern Rocky Mountains (Neely et al. 2001).

Terrestrial animals were addressed in the assessment through collaborative discussions among 11 scientists having expertise with different animal taxa (amphibians, reptiles, small- and medium-sized animals, birds), interior forest and grassland ecology, and species at risk,[3] as well as regional biologists with extensive local knowledge of the study area. An additional 29 experts were consulted on these and other topic areas, including grizzly bears, ungulates, butterflies, wetland ecology, and habitat mapping (see "Acknowledgements" section). Expertise on invertebrates other than butterflies was not available.

The "Terrestrial Animals Team":

- identified animal species of conservation concern;
- assembled spatial data for each species in the form of element occurrences and habitat maps;
- assigned targets for representation of animal species occurrence and habitat data for the base case and climate change scenarios; and
- reviewed Marxan outputs for errors, gaps, or other considerations (e.g., special elements, added resiliency for climate change, connectivity).

Selecting animal species

The Terrestrial Animals Team selected species based on criteria that included subnational, national, and global conservation rankings (imperiled or endangered and threatened),[4] regional importance, special concern because of ecosystem role or distribution (e.g., keystone, umbrella, endemic, disjunct, peripheral, wide-ranging)[5] or because the species were perceived to have a declining trend. The team also considered species' vulnerability to current and anticipated threats such as mountain pine beetle and climate change. Hunted or trapped species were included

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[2] Morgan, D.G., R. Walton, and D. Fraser. 2009. Assessment of the impact of climate change on terrestrial wildlife in British Columbia. Future Forest Ecosystem Initiative, B.C. Ministry of Forest and Range, and B.C. Ministry of Environment, Victoria, B.C. Unpublished draft.

[3] "Species at risk" is defined under the federal *Species at Risk Act* as an extirpated, endangered, or threatened species or a species of special concern (formerly called "vulnerable").

[4] Subnational rankings are assigned by the British Columbia Conservation Data Centre (***http://www.env.gov.bc.ca/cdc***). National conservation rankings are assigned by the federal Committee on the Status of Endangered Wildlife in Canada (***http://www.cosewic.gc.ca***). Global rankings are assigned by NatureServe (***http://www.natureserve.org***).

[5] Definitions are as follows (from Pryce et al. 2006): *Keystone* = species that has a disproportionate effect on its environment relative to its biomass; *Umbrella* = species that by being protected, may also protect the habitat and populations of other species; *Endemic* = more than 90% of global distribution occurs in the ecoregion; *Disjunct* = more than two ecoregions apart from other more central parts of its range; distribution in ecoregion quite likely reflects significant genetic differentiation from main range due to historic isolation; and *Peripheral* = less than 10% of global distribution occurs in the ecoregion.

FIGURE 1. Study area for the Central Interior Ecoregional Assessment (Map 1 from Nature Conservancy of Canada, 2010b).

for their socio-cultural importance to First Nations but only if they were also of conservation concern.

Over 170 vertebrate species were initially evaluated and, of these, 100 species (3 amphibians, 5 reptiles, 28 mammals, and 64 birds) were selected for inclusion in the assessment. For information on local trends and priorities, the team benefited from conservation priorities previously identified by the BC Conservation Framework, expert panels such as Partners in Flight and the Canadian Intermountain Joint Venture, and organizations such as Ducks Unlimited Canada and the Grasslands Conservation Council.

Invertebrates were not addressed in the assessment. Although the significance of this omission is reduced by the coarse-filter ecosystem representation of the study, it is an acknowledged limitation of the analysis.

Categories of species' data

Each of the 100 selected animal species was assigned to one of five categories for analysis in Marxan. Categories were assigned based on the availability of occurrence data and habitat maps and whether a species' conservation strategy was thought to be best accomplished by occurrence or habitat data. The five Marxan data categories (discussed below) are: (1) element occurrence data; (2) species-specific habitat area; (3) focal ecosystems; (4) alpine species; and (5) data-deficient species and ecosystems.

Element occurrence data

The largest amount of data for animal species was in the form of element occurrences (i.e., site data of habitats such as nest sites, hibernacula, and leks). Occurrence data were available for 28 species: 2 amphibians, 5 reptiles, 16 birds, and 5 mammals (Table 1).

Species-specific habitat area

Wide-ranging animal species were represented by occurrence and distribution habitat polygons as shown on available maps such as habitat suitability and winter habitat maps. Habitat mapping was available for eight mammal species (Table 2).

Focal ecosystems (species represented by specific habitat types)

The team identified special habitat types, called "focal ecosystems," that provide important or critical habitat for multiple animal species. Focal ecosystems have a disproportionately important role in the local landscape but are small enough that they would not necessarily be picked up through coarse-filter representation of terrestrial ecosystem units (as described in Kittel 2011a:54–71).

Focal ecosystems were assumed to provide important habitat representation for 52 species including 39 birds and 13 mammals (including 9 bat species) that are otherwise unrepresented by occurrence data or species-specific habitat maps. Focal ecosystems include mature and old forest types, wetlands, grasslands, riparian areas, cliff complexes, cave complexes, ice-free lakes, hot springs, and karst. Areas of known species aggregations and hotspots for biodiversity were also mapped and included as well as designated Important Bird Areas and Wildlife Habitat Areas. Focal ecosystems are described in more detail in the Central Interior Ecoregional Assessment Appendix (Nature Conservancy of Canada 2010a).

Alpine species

The team assumed that the coarse-filter representation of ecosystem units (Kittel 2011a:54–71) would address alpine species, which have typically been poorly inventoried and their habitats not mapped in detail. Four alpine species were addressed through coarse filter ecosystem unit representation: Golden-crowned Sparrow, White-tailed Ptarmigan, American pika, and hoary marmot.

Data-deficient species and ecosystems

Species for which the team was unable to find existing data or to generate useful habitat maps were noted as "data deficient." These species have been documented for completeness and to guide future data-gathering efforts. One amphibian species, eight bird species, and three focal ecosystems are data-deficient, as listed in the Central Interior Ecoregional Assessment Appendix (Nature Conservancy of Canada 2010a).

Data assembly

Data for species and focal ecosystems were assembled from throughout the Central Interior study area. Primary sources are listed in the Central Interior Ecoregional Assessment Appendix (Nature Conservancy of Canada 2010a). All data gathered met the Conservancy's data standard (Ecoregional Data Standards Technical Team 2004). Occurrence data were screened to eliminate data that were more than 20 years old, spatially imprecise, or that potentially represented the same individual more than once (e.g., multi-year sightings along a transect).

TABLE 1. Terrestrial animal species represented by element occurrence data in the Central Interior Ecoregional Assessment

Common name	**Scientific name**	**Primary rationale for selection**[a]	**Secondary rationale for selection**[a]
Amphibians			
Great Basin spadefoot toad	*Spea intermontana*	COSEWIC Threatened: CDC Blue-listed	Vulnerable to climate change
Western toad	*Bufo boreas*	COSEWIC Special Concern	Range-wide declines; vulnerable to climate change
Reptiles			
Garter snake (common or western)	*Thamnophis sirtalis* or *elegans*	Aggregations (hybernacula) are important habitat elements	
"Great Basin" gopher snake (*deserticola* subspecies)	*Pituophis catenifer deserticola*	COSEWIC Threatened status	CDC Blue-listed
Racer	*Coluber constrictor*	COSEWIC Special Concern; CDC Blue-listed	Peripheral
Rubber boa	*Charina bottae*	COSEWIC Special Concern	
Western painted turtle population 2	*Chrysemys picta* population 2	COSEWIC Special Concern, CDC Blue-listed	Range-wide declines
Birds			
American Avocet	*Recurvirostra americana*	CDC Red-listed; CIJV priority	Wetland obligate; vulnerable to grazing
American Kestrel	*Falco sparverius*	PIF priority	Heavily declining; vulnerable to loss of old Douglas-fir and pine
American White Pelican	*Pelecanus erythrorhynchos*	Global Rank G3; CDC Red-listed	Disjunct species: single known breeding colony in province
Barrow's Goldeneye	*Bucephala islandica*	COSEWIC Special Concern; CDC Red-listed; regionally important	Most of the global population occurs in the study area
Bobolink	*Dolichonyx oryzivorus*	PIF/CIJV focal priority; is a Ducks Unlimited flagship species	Declining trend; native habitats (meadows) disappearing
Broad-winged Hawk	*Buteo platypterus*	CDC Blue-listed	
Eared Grebe	*Podiceps nigricollis*	CIJV priority; CIJV and PIF focal priority	Vulnerable: small number of colonies on shallow fishless lakes
Great Blue Heron	*Ardea herodias herodias*	CDC Blue-listed; CIJV priority	Birds are abandoning nests; larger colonies are gone; are breeding in smaller colonies
Lesser Scaup	*Aythya affinis*	CIJV priority	Heavily declining trend; Duck's Unlimited species of concern
Lewis' Woodpecker	*Melanerpes lewis*	COSEWIC Special Concern; CDC Red-listed; CIJV and PIF priority	Umbrella species for cavity nesters; narrow habitat requirement

TABLE 1. Continued

Common name	Scientific name	Primary rationale for selection[a]	Secondary rationale for selection[a]
Long-billed Curlew	*Numenius americanus*	COSEWIC Special Concern; CDC Blue-listed	CIJV and PIF priority: grasslands species
Northern Pintail	*Anas acuta*	Declining trend	Vulnerable: nests destroyed by field cultivation
Prairie Falcon	*Falco mexicanus*	CDC Red-listed; CIJV and PIF priority	Vulnerable to nest disturbance; CITES-listed
Sandhill Crane	*Grus canadensis*	CDC Blue-listed; CIJV priority	Vulnerable to loss of forested wetlands and shallow marsh complexes
Sharp-tailed Grouse (*columbianus* subspecies)	*Tympanuchus phasianellus columbianus*	CDC Blue-listed; CIJV and PIF priority	Grassland ecotype vulnerable to loss of native grasslands
Yellow-breasted Chat, (*auricollis* subspecies)	*Icteria virens auricollis*	COSEWIC Endangered status; CDC Red-listed	CIJV and PIF priority
Mammals			
American badger (*jeffersonii* subspecies)	*Taxidea taxus jeffersonii*	COSEWIC Endangered; CDC Red-listed	Central Interior study area supports a large percentage of the provincial population
Fringed myotis	*Myotis thysanodes*	CDC Blue-listed	
Townsend's big-eared bat	*Corynorhinus townsendii*	IUCN Vulnerable status	CDC Blue-listed
Western small-footed myotis	*Myotis ciliolabrum*	CDC Blue-listed	Vulnerable due to limited distribution
Western spotted bat	*Euderma maculatum*	COSEWIC Special Concern; CDC Blue-listed	Vulnerable: discontinuous distribution and specialized diet/roosting

[a] Acronyms used in the column: CDC = British Columbia Conservation Data Centre; CIJV = Canadian Intermountain Joint Venture; CITES = Convention on International Trade in Endangered Species; COSEWIC = (federal) Committee on the Status of Endangered Wildlife in Canada; PIF = Partners in Flight; IUCN = International Union for Conservation of Nature.

Most of the element occurrence data points were located in the south (Central Interior ecoprovince), with large concentrations along major travel corridors.

Setting representation targets

Representation targets are explicit, numerical objectives for representing each species or habitat in the conservation strategy solution. Targets were identified using the method described in Comer (2003) and from the Okanagan Ecoregional Assessment (Pryce et al. 2006).

Targets for species represented by element occurrence data (known nesting, breeding, or feeding locations) were the number of data points to be captured in the final solution. Targets for species represented by habitat map units were the percent area of the total area of habitat to be included in the solution.

Table 3 shows the template used to set representation targets for occurrences or habitat area of each species. Table 4 provides definitions for the distribution categories shown in Column 1 of Table 3. Separate targets were assigned to the Sub-Boreal Interior and Central Interior ecoprovinces through team discussion, based on expert knowledge of the species and study area.

Targets for the number of element occurrences were based on two factors: (1) the conservation status of the species and (2) its distribution (endemic, limited, widespread, or peripheral) relative to the ecoregion (Table 4). The number of target occurrences was set according to the degree of conservation concern associated with the species.

TABLE 2. Terrestrial mammal species represented by habitat area data in the Central Interior Ecoregional Assessment

Common name	Scientific name	Primary rationale for selection[a]	Secondary rationale for selection
Bighorn sheep	*Ovis canadensis canadensis*	CDC Blue-listed; regionally important species	Disjunct species
Caribou (northern and mountain ecotypes)	*Rangifer tarandus*	Regionally important; CDC Blue-listed (northern mountain population)	Declining trend: priority species for conservation planning
Fisher	*Martes pennanti*	CDC Blue-listed; regionally important	Vulnerable to mountain pine beetle salvage and loss of old forest structure
Grizzly bear	*Ursus arctos*	COSEWIC Special Concern; CDC Blue-listed	Southern populations are particularly at risk
Mountain goat	*Oreamnos americanus*	Declining trend	Regionally important; Ministry of Environment priority
Mule deer	*Odocoileus hemionus*	Vulnerable to loss of critical winter habitats	Regionally important; hunted species
Thinhorn sheep	*Ovis dalli*	Declining trend	Ministry of Environment priority
Wolverine	*Gulo gulo luscus*	Global Status: IUCN Vulnerable; COSEWIC Special Concern; CDC Blue-listed	Umbrella species of predator–prey systems

[a] Acronyms used in the column: CDC = British Columbia Conservation Data Centre; COSEWIC = (federal) Committee on the Status of Endangered Wildlife in Canada; IUCN = International Union for Conservation of Nature.

TABLE 3. Template for representation targets for terrestrial animal species (from Pryce et al. 2006)

Distribution within the study area	Representation targets					
	Polygon data (% area)			Occurrence data (no. of data points)		
	"High Risk" Scenario	"Moderate Risk" Scenario	"Low Risk" Scenario	"High Risk" Scenario	"Moderate Risk" Scenario	"Low Risk" Scenario
Endemic	18	30	48	63	125	188
Limited				34	67	101
Widespread				19	38	57
Peripheral				12	23	35

The team assumed that species of very high conservation concern, such as those with imperiled status, warrant the conservation of all potentially viable occurrences. For example, a target of 100% was applied to lek sites for the *columbianus* subspecies of the Sharp-tailed Grouse, since the subspecies has a limited distribution in the province and populations using native grasslands are in significant decline (Leupin 2003). A target of 100% was also applied if very few records were known to exist. On the other hand, a moderate risk target of 38 nesting colonies was applied to Great Blue Heron (spp. *herodias*), since this widespread

TABLE 4. Definition of distribution categories (Column 1, Table 3 as they apply to terrestrial animals (from Neely et al. 2001)

Category	Distribution occurring within the ecoregion (%)
Endemic	> 90
Limited	50–90, typically global distribution is limited to two to three ecoregions
Widespread	10–50 and more than three ecoregions
Peripheral	< 10%

subspecies is not considered at risk nationally, but colonies are known to be vulnerable to habitat disturbance and destruction (Gebauer and Moul 2001).

Targets for percent area of mapped habitat area were set to meet one of three possible conservation scenarios: (1) "high risk," (2) "moderate risk," and (3) "low risk." The Nature Conservancy methodology assumes 30% to be a moderate risk "ecoregional objective" (Neely et al. 2001; Comer 2003). The Central Interior followed the method of the Okanagan assessment (Pryce et al. 2006), which also assumed a 30% moderate risk target but identified more conservative low and high risk targets compared to Comer (2003).

Habitat area targets reflected the degree of conservation concern associated with each habitat area, with lower risk targets set for habitats of higher conservation concern. Core habitat areas, such as designated wildlife habitat areas and ungulate winter ranges, were assigned a target of 100%, as were targets for particularly vulnerable focal ecosystems.

The full set of targets (with rationales) for the terrestrial animals component of this assessment is provided in the Central Interior Ecoregional Assessment Appendix (Nature Conservancy of Canada 2010a).

Setting targets for a climate change scenario

The Central Interior Ecoregional Assessment piloted a method for considering climate change as part of planning for terrestrial and freshwater conservation strategies. Recognizing the high level of uncertainty associated with climate change predictions, the assessment used a vulnerability-based approach to enhance the resiliency and adaptive potential of the conservation portfolio in the face of uncertain future threats (Kittel et al. 2011b:7–35). For the terrestrial animals component, experts adjusted the occurrence and habitat area targets up or down for each species and focal ecosystem according to their perceived vulnerability to climate change effects. Table 5 summarizes the assessment strategies for each of five climate change effects that are affecting animal species and ecosystems.

Data analysis

The Central Interior Ecoregional Assessment used Marxan conservation planning software, which applies a simulated annealing algorithm with iterative improvement to select priority areas for conservation (Ball et al. 2009). The program begins by selecting a random set of planning units and then finds improvements to this initial set by randomly adding or removing planning units. At each iteration, the new set of units is compared with the previous one and the better of the two is accepted. Over many iterations (a million per simulation for this project), the analysis converges on the most efficient set of planning units—a set that maximizes the achievement of representation targets and minimizes the cost of reserve design. In the Central Interior terrestrial analysis, costs were represented by a scaled suitability index (low–high) based on a single cost of distance to, and density of, roads (Loos 2011:88–97).

A uniform grid of 500-ha hexagons represented the planning units for the terrestrial analysis. Hexagons were used because of their consistent size and low edge-to-area ratio. The size of the units was selected to balance representation of local-scale features with an efficient aggregation of ecological systems into landscape-scale conservation areas over the 24.6 million ha of the study area (Loos 2011:88–97). Analyses were completed separately for the Central Interior and Sub-Boreal Interior portions of the study area.

Marxan analysis includes the following two basic outputs (Ball et al. 2009).

1. The "summed solution" identifies consistently selected planning units, and therefore "hotspots" of high conservation value based on the number of times each planning unit is included in the analysis. See Map 18 in the Central Interior Ecoregional Assessment Map Volume (Nature Conservancy of Canada 2010b).
2. The "best solution" is the selection of polygons that best meets the representation targets at the lowest overall cost (Figure 2).

The final portfolio of conservation areas is taken from the "best solution."

Previous ecoregional assessments have sought to integrate the targets for freshwater and terrestrial targets, but this was not successful, primarily because the planning units for the two realms are quite different and integration resulted in a less than optimal solution for both (Iachetti et al. 2006; Pryce et al. 2006). In the Central Interior assessment, separate Marxan analyses were run and the "best solutions" were later combined.

All Marxan runs were based on current condition; no scenarios were projected into the future. The climate change scenario was based on current

TABLE 5. Strategies to address vulnerabilities of terrestrial animals to climate change effects

Climate change effect	Example effects	Vulnerable species examples	Ecoregional assessment climate strategy
1. Loss of habitat structure at stand and landscape scales	Old forest structure altered by beetle kill and associated salvage logging (Chan-McLeod and Bunnell 2003)	Species dependent on old/mature forests (e.g., mule deer, pine marten, fisher, bats)	Targets were increased for vulnerable species and focal ecosystems
2. Change in composition of ecological communities	Reduced forage, particularly for specialist species (e.g., Koteen 2002)	Clark's Nutcrackers and grizzly bears vulnerable to loss of whitebark pine stands	Targets were increased for vulnerable ecosystems to buffer against change
		Red squirrels and Red Crossbills vulnerable to reduced cone supply due to loss of mature/old pine forests	Targets were increased for focal ecosystems that provide alternative food sources
	Increases in species that thrive under climate change may be detrimental to other species (Seip 2008)	Caribou vulnerable to increased number and proximity of deer and moose and associated increases in wolves	Targets were decreased for species likely to be "winners" under climate change or these species were not included as features
3. Change in hydrology because of alterations in precipitation, evapo-transpiration, and snow accumulation and melt times	Variability in peak and low flows; impacts on water levels of wetlands, lakes, streams (Pike et al. 2008)	Wetland-dependent species such as amphibians, Eared Grebe, Sandhill Crane, Black Tern, Long-billed Curlew	Targets were increased for species strongly associated with wetlands and riparian areas and for focal ecosystems such as small forested wetlands
4. Change in timing of life stage events and habitat use	Early emergence from winter habitats; change in timing of winter range use	Sandhill Cranes and Common Loons are arriving earlier and departing later from summer nesting areas (Bunnell and Squires 2005)	Targets were increased for vulnerable species
5. Shifts in climatic envelopes (altitudinal and latitudinal)	Ecosystems shift in response to warming temperatures (Hamann and Wang 2006)	Alpine species (hoary marmot, American pika, White-tailed Ptarmigan)	Ensure connectivity at different spatial scales during conservation area design
	Warming of high-elevation habitats (Moritz et al. 2008)	Species aggregations (e.g., important bird areas)	Buffer biodiversity hotspots (through increased targets and conservation area design) to provide additional conservation value
	Loss of important habitat "hotspots"		

land base conditions, but targets were adjusted to create a conservation scenario that was intended to provide added resilience to future climate threats.

Review and prioritization of Marxan outputs

The Terrestrial Animals Team reviewed the "best solution" of conservation areas generated by Marxan to identify and manually fill in any obvious gaps. All targets were met in the Marxan analysis and this *post hoc* review served to add connectivity and local knowledge to the Marxan results.

The combination of the "best solution" and supplementary planning units added by the Team made up the final terrestrial portfolio. The portfolio was then stratified, using a computer-generated assessment of conservation value and vulnerability, to rank priority areas for future conservation action by the Conservancy (results summarized in Loos 2011:88–97).

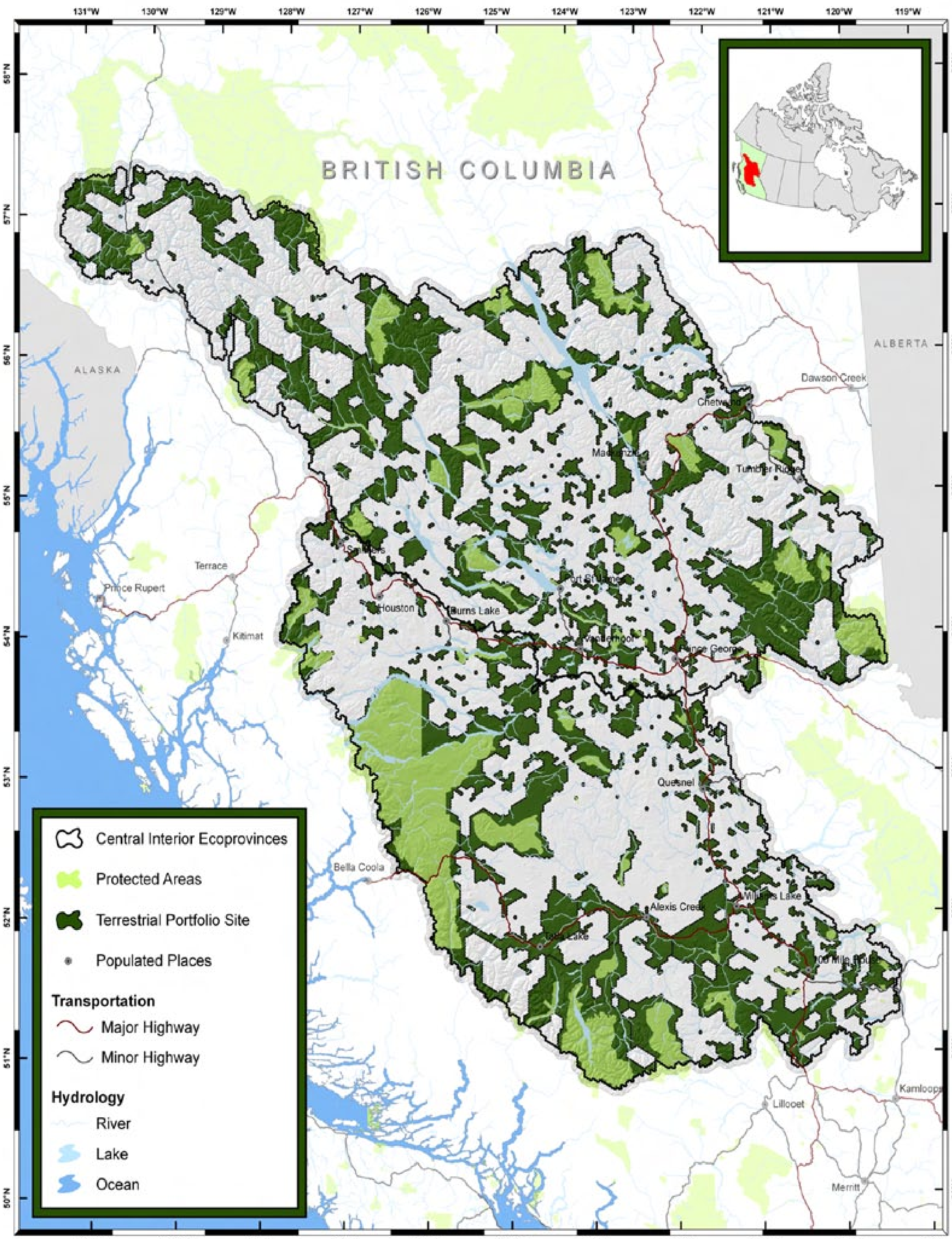

FIGURE 2. Final terrestrial portfolio for the Central Interior Ecoregional Assessment based on the standard NCC scenario (without climate change adjustments) (Map 23 from Nature Conservancy of Canada, 2010b).

Results

The terrestrial portfolio

The total area of the terrestrial portfolio (Figure 2), including newly identified areas and existing protected areas is 10.2 million ha, or 39.4% of the study area. One quarter (24%) of the solution is in existing protected areas.

The dark polygons shown in Figure 2 are sites outside existing protected areas that are a priority for conservation management to meet targets for terrestrial plants, animals, and ecosystem units. This solution builds on existing protected areas to create large contiguous regions that have some degree of connectivity across the larger land base. Additionally, some small polygons are included in the final solution to capture sites of high conservation value.

The largest conservation priority areas are relatively remote from human settlements and transportation corridors, but there are smaller areas close to relatively populated locales such as Williams Lake, B.C. These small areas may be particularly important for conservation action given their vulnerability to human disturbance.

Figure 3 shows the results of the *post hoc* prioritization of the portfolio based on conservation value (i.e., rarity, diversity, and irreplaceability of animal and plant species within each planning unit) and vulnerability (Loos 2011:88–97). The highest priority areas are small fragmented polygons along major transportation corridors, in particular Highway 97 between the town of 100 Mile House and the city of Prince George.

Overlap with the freshwater portfolio

Combining the terrestrial and freshwater portfolios provides additional connectivity and expands the size of individual conservation areas. As might be expected, much of the incremental connectivity provided by the freshwater solution is along major river corridors. The terrestrial and freshwater solutions show large areas of overlap (i.e., over 4 million ha in total, representing 38% of priority areas in the terrestrial solution) (see also Howard and Carver 2011:72–87). See Map 26 in the Central Interior Ecoregional Assessment Map Volume (Nature Conservancy of Canada 2010b).

Results of the climate change scenario

The climate scenario was built on the standard Nature Conservancy of Canada (NCC) scenario by increasing the size of polygons rather than completely shifting the solution to new areas. The Marxan analysis selected units in proximity to the priority aggregations identified in the standard NCC scenario while continuing to avoid areas of low conservation value. The end result was a doubling of the number of frequently selected units in the "summed solution" for the climate scenario compared to that of the standard NCC scenario (Figure 4, Table 6).

A larger proportion of planning units added to the standard NCC solution occur in the more northern parts of the study area (in the Sub-Boreal Interior sub-area). The overall outcome of the climate adjustments is an increase in the size and connectivity of priority conservation areas (Kittel et al. 2011b:7–35).

Discussion

Conservation planning for multiple species poses many challenges, not the least of which is our lack of knowledge about population dynamics and interactions (Neely et al. 2001; Wilhere 2008) and the multiple scales at which these various species exist (Fischer et al. 2004; Tear et al. 2005). Although all Nature Conservancy projects fall under the goal of "the long term survival of all viable native species and community types," a pragmatic aspect to their implementation is shared by many organizations—that is, how to out carry out effective conservation design given limited data, time, and resources.

The approach used for terrestrial animal species in the Central Interior Ecoregional Assessment has been refined over many projects (e.g., Wood et al. 2004; Pryce et al. 2006; Vander Schaaf et al. 2006) to provide a useful and reliable outcome within available resources. Previous assessments have acknowledged the challenges of setting rigorous representation targets that will maintain the viability of each species (Neely et al. 2001; Pryce et al. 2006). Issues include a lack of information on population dynamics and the effect of one population's viability on another (Tear et al. 2005; Wilhere 2008). For this reason, ecoregional assessments set preliminary targets that can be adjusted as future information becomes available. Target setting is based on the assumption that, "as a general rule, the conservation of multiple examples [of data for] each species, stratified across its geographic range, will represent the variability/integrity of the feature [species] and its environment" (Neely et al. 2001). This approach also provides redundancy to enhance resilience to environmental stochasticity. The outputs of the climate change scenario provide additional adaptive capacity and resilience by increasing the representation of vulnerable habitats and species occurrences (Kittel et al. 2011b).

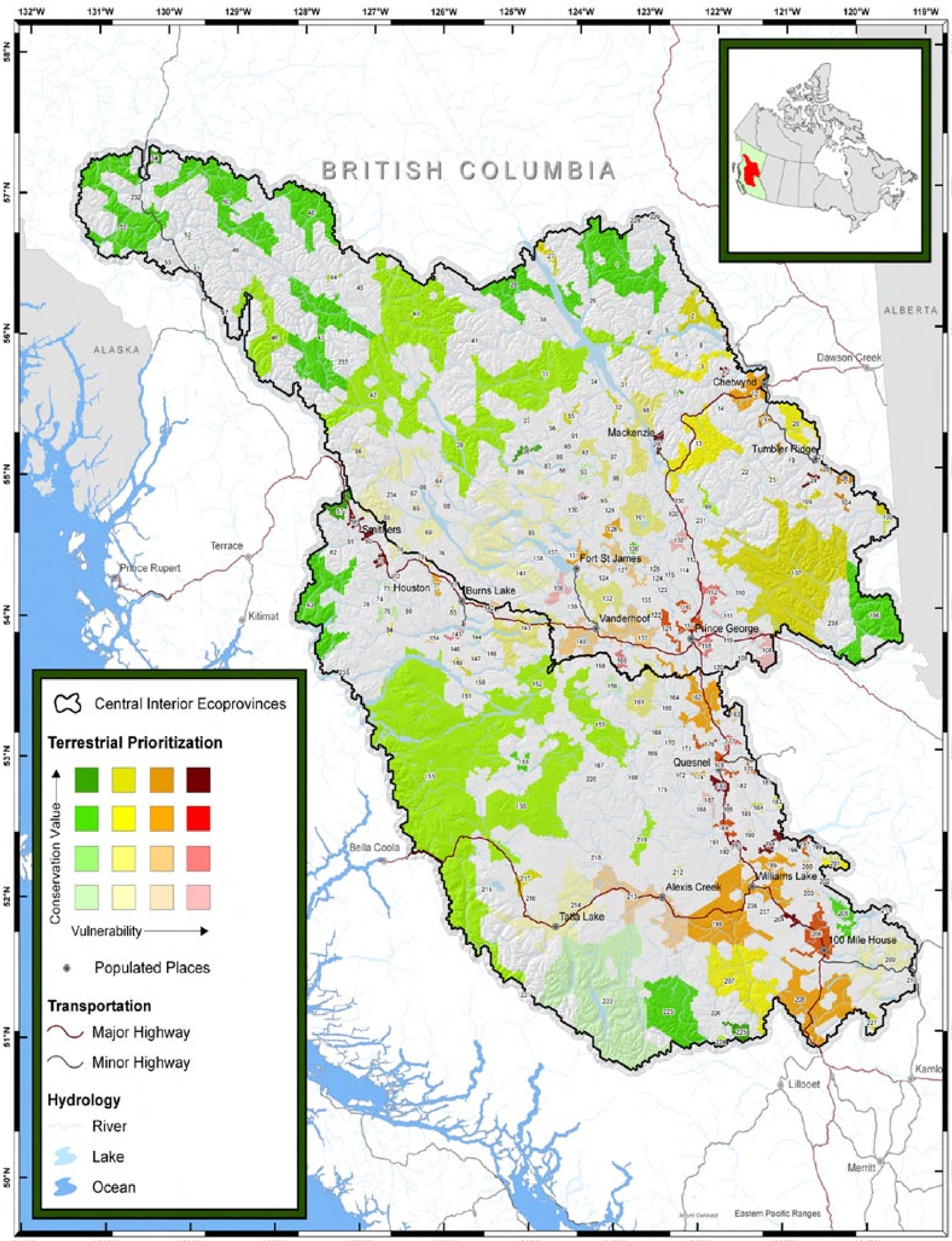

FIGURE 3. Prioritization of polygons in the terrestrial portfolio of conservation areas based on conservation value and vulnerability (methods described in Loos 2011:88–97). Areas of highest conservation value and vulnerability (orange to red) are highest priority for future conservation actions (Map 22 from Nature Conservancy of Canada, 2010b).

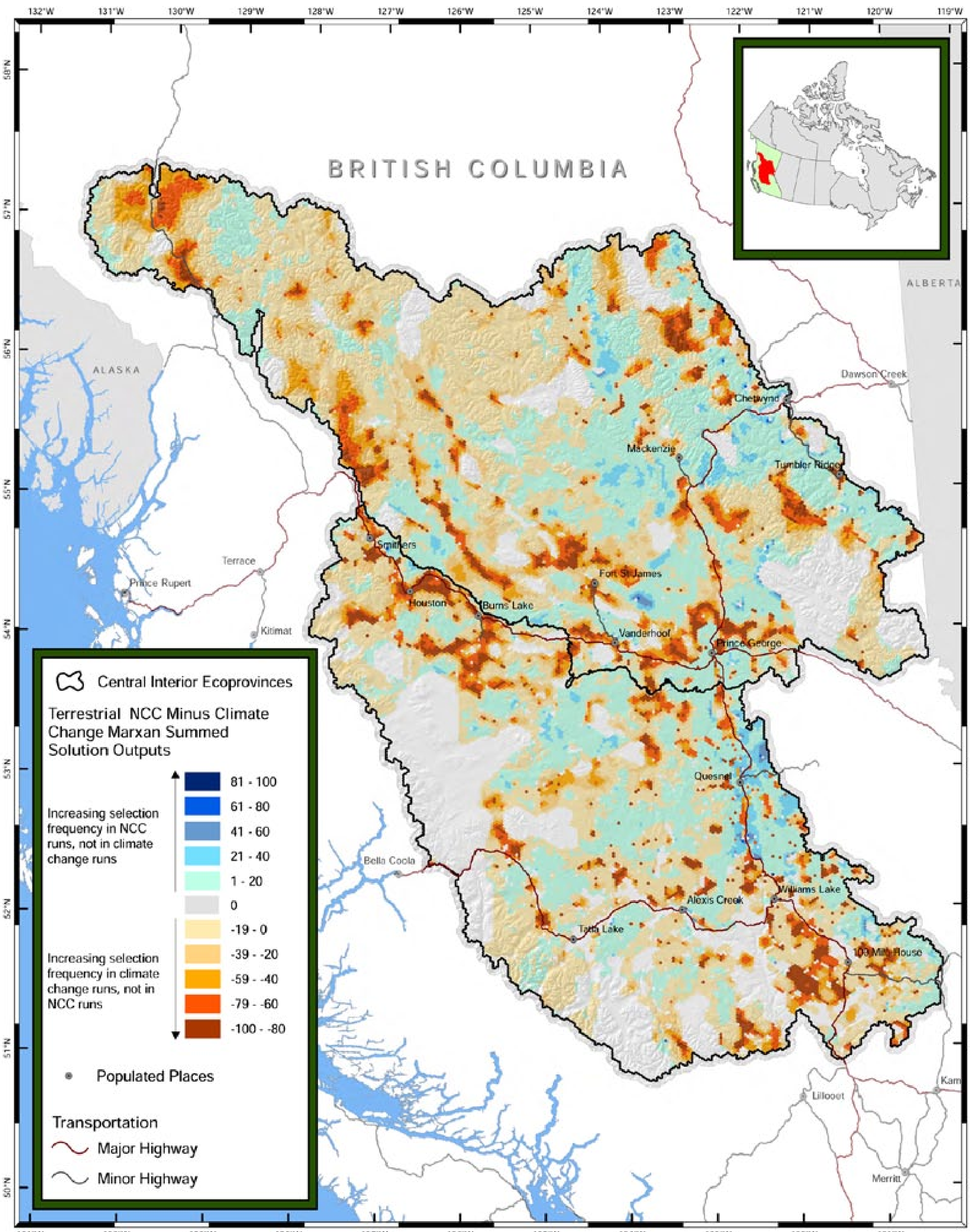

FIGURE 4. Comparison of the "summed solutions" of the standard Nature Conservancy of Canada scenario and the climate change scenario. Blue polygons are those selected more frequently in the standard scenario and orange/brown polygons are those selected more frequently in the climate change scenario (Map 28 from Nature Conservancy of Canada, 2010b).

TABLE 6. Comparison of number of highest priority planning units (selected > 60% of the time) outside of protected areas in the summed solutions for the standard NCC and climate change scenarios

Scenario	Total units (%)
Standard NCC only	2
Climate change only	51
Combined standard and climate change scenarios	47
Total	**100**

The Central Interior assessment expanded its criteria for species from a focus on species at risk to include species of socio-economic value and vulnerability to future decline. Although not as many endemic, rare, and at-risk species exist in this study area compared to other ecoregions such as the Okanagan, high-value habitats and habitat elements for a large diversity of the province's animal species were included in this assessment.

As ever, one of the biggest limitations to the analysis process was a paucity of data, particularly for relatively remote areas, although this unequal distribution is offset to some extent by targets for coarse-filter representation of ecosystem units. The concentration of high-priority areas to the south is, in part, an artifact of the large amounts of occurrence data available along the main roads in the southern portion of the study area. The significance of this limitation in the short term is reduced since the greatest current threats to species are in areas of highest human density, as reflected by settlements and roads. Over the longer term, however, the "best solution" may not optimally identify areas of vulnerability to future developments, as human activities spread into previously undeveloped areas.

The outputs of the climate change scenario show that steps can be taken during ecoregional assessment planning to enhance the resilience of conservation solutions to possible climate change effects. The vulnerability assessment approach used to develop the climate change scenario aims to address the high level of uncertainty associated with future climate predictions (Kittel et al. 2011b:7–35). Under this "no regrets" approach, the focus is on what is known about species and ecosystems and designing a conservation portfolio to optimize opportunities for adaptation (Kittel et al. 2011b).

The combined terrestrial and freshwater solutions for the Central Interior assessment will assist the Nature Conservancy of Canada to strategically direct its priorities for future conservation actions, such as finer-scale planning and land acquisitions, in partnership with the various levels of government (federal, provincial, municipal, and First Nations), other organizations, and industry. It is expected that the products of this assessment will also help to inform conservation efforts by other parties.

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Test Your Knowledge . . .

Strategic conservation planning for terrestrial animal species in the Central Interior of British Columbia

How well can you recall some of the main messages in the preceding Research Report? Test your knowledge by answering the following questions. Answers are at the bottom of the page.

1. What were the key criteria used to select animals species for representation in the Central Interior Ecoregional Assessment?
   A) Subnational, national, and global conservation ranking
   B) Ecosystem role
   C) Socio-economic importance
   D) Local population trends
   E) All of the above

2. What proportion of habitats for each species were represented in a "high risk" conservation scenario?
   A) Small
   B) Large

3. What is an element occurrence?
   A) An area of known mineral value
   B) An area undergoing primary succession following a disturbance
   C) A known nesting, breeding, or feeding location

ANSWERS

1. E 2. B 3. C