FOR GENERATIONS

Report Title: Peace River Wildlife Surveys: 2005 – Habitat Suitability Modeling and Wildlife Inventory Draft Final Report
Project: Peace River Site C Hydro Project
Prepared By: LGL Limited
Prepared for: BC Hydro

NOTE TO READER:

This is a report on a study commissioned toward the development of engineering, environmental and technical work conducted to further define the potential Site C project.

For environmental studies, the focus is on the development of an environmental and socio-economic baseline around the area of the potential Site C Project. Baseline studies are generally a survey of existing conditions within a project study area.

This report and other information may be used for future planning work or an environmental assessment or regulatory applications related to the potential Site C Project.

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Peace River Wildlife Surveys: 2005
Habitat Suitability Modeling and Wildlife Inventory

Draft Final Report

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Executive Summary

Two Peace River facilities provide about one-third of the BC Hydro's total electricity generation with the combined production of the two generating stations providing enough power to service 500,000 homes. The addition of a third major generating station (Site C) on the Peace River has been under consideration for more than 30 years. As part of BC Hydro's ongoing resolve to keep Site C in a state of readiness should conditions warrant such a development, environmental studies conducted 1-3 decades ago must also be kept current. While there has been some recent work, it has largely been conducted out-of-season and of a limited scale. LGL Limited surveyed the Peace River area for priority taxa during spring 2005 to fill existing information gaps for habitats within and adjacent to the Peace River from Hudson's Hope to the Alberta border.

This study had four major objectives, three of which were addressed during 2005 (i, ii, and iii):

i. Conduct spring wildlife inventories of priority taxa;

ii. Conduct vegetation surveys of the target plants on the provincial red and blue lists; and

iii. Develop habitat suitability ratings based on terrestrial ecosystem mapping (TEM) for priority wildlife species where data warrant;

iv. Conduct consultations with the local First Nation groups to determine their interests in the area.

Work to address objective iv has yet to be conducted.

The Peace River study area was stratified into two main survey strata: the core and the periphery. The core stratum was an area of 145 km long X 4 km wide that encapsulated the Peace River corridor from the Peace Canyon Dam to the Alberta border and included an area of approximately 2 km on either bank of the Peace River. The periphery stratum was the area outside of the core stratum that was contained within 7, 1:50,000 mapsheets (5 complete, 2 partial).

During 2005 we sampled for multiple floral and fanual groups following RISC protocols. Sampling occurred between June and August. The groups of interest during these surveys were butterflies, songbirds, raptors, owls, waterfowl, amphibibians and reptiles, and rare plants. We also collected data that would be incorporated into a habitat suitability mapping excercise for the core stratum for select species of songbirds and owls. The focus of our surveys was on species with povincial and federal conservation status, but all species of each focal taxonomic group were recorded when observed. Incidental observations of mammals (terrestrial and semi-aquatic) were recorded but they were not considered for this report.

The following sections identify our major findings regarding the occurrence and distribution of red- and blue-listed species and/or species with COSEWIC designation within the core and periphery strata of the study area.

Butterflies

Butterflies were sampled from 54 unique locations in the Peace River study area; 29 in the core and 25 in the periphery. Sampling occurred in June and July 2005 and butterflies were captured by net, photographed, or identified by site. In all, 245 specimens (of ~305 that were collected or photographed) were given an identification status of "certain" or "probable". Of those, 58% were from the core stratum and 42% were from the periphery stratum. From these sites, 41 butterfly (sub) species were recorded in the entire study area. Of those, 13 species were unique to the core stratum, 7 were unique to the periphery stratum, and 21 were common to both.

Of the 15 Blue-listed species of butterfly considered likely to occur in the study area, eight species were confirmed during the present study, including four of the species closely associated with grassland habitat. Of the eight Blue-listed species found in this study, 4 were recorded only in the core stratum and 4 were recorded in both strata.

According to distribution information presented on the Government of Canada's Canadian Biodiversity Information Facility, none of the 8 (sub) species of Lepidoptera in B.C. that are classified as at-risk by COSEWIC are expected to occur in the project area and as expected, none were recorded during the present study. The CDC's Rare Element Occurrence database lists 6 records of only one species in the project area: Baird's swallowtail. Four of those records correspond to the core stratum and 2 to the periphery stratum. That species was previously identified as the Old World swallowtail by Kondla et al. (1994). One specimen was detected in the core stratum of the present study.

Songbirds

We sampled songbirds from 187 unique songbird pointcount stations distributed throughout the study area with sampling occurring between 4 June and 10 July 2005. Of these, 118 (63%) were in the core stratum (2000 m buffer either side of the Peace River) and 69 (37%) were in the periphery. Each station was visited between 1 and 6 times with 65.8% of all stations visited 4 or more times. Within the core stratum, 51% (n = 60) of all stations were visited 4 or more times and in the periphery stratum, 91% (n = 63) of all sites sampled were visited 4 or more times.

In total, we made 4,580 observations of 114 species (i.e., songbirds and non-songbirds) at all songbird pointcount stations with 2,538 observations of 95 species in the core and 2,042 observations of 88 species in the periphery. Fifteen species were unique to the core, 8 to the periphery, and 69 species occurred in both strata. The difference in total observations in the core versus the periphery was not significant result (t-test; p = 0.6814). Of the total observations, 4,411 (96.3%) were songbirds of 82 species with 2,446 (55.4%) observations in the core and 1,965 (44.5%) observations in the periphery In addition to songbirds, we documented water-associated birds (shorebirds and waterfowl), owls, raptors, and upland game birds (Wilson's Snipe and Ruffed Grouse) at songbird pointcount locations.

We made 155 observations of 6 red- and / or blue-listed songbird species from 99 locations in the Peace River study area. Of the 155 observations, 102 from 66 locations occurred within 75 m of the pointcount center shows the distribution of rare songbirds in the study area, including those that occurred > 75 m from the pointcount center as well as rare bird records from the Rare Element Occurrence (REO) database.

The frequency of occurrence (i.e., the proportion of pointcounts that a species was detected at) was calculated for each of the 81 species detected within 75 m of the pointcount stations for all sites combined (n = 187), only the core (n = 118 sites) and only the periphery (n = 69 sites). Overall, the Red-eyed Vireo was detected at the most sites (58.8%; n = 110). In the core study area, the Red-eyed Vireo again had the highest frequency of occurrence (69.5%; n = 82) and within the periphery, the American Robin had the highest encounter frequency (59.4%; n = 41).

Raptors and Owls

Raptors and owls were sampled using call playback surveys, stand watch surveys, road surveys, and through incidental observations. We also identified the location of active and non-active Bald Eagle nests during an aerial survey of the Peace River. The density of raptors (birds / km) was calculated for observations made during road transects. Densities were highest for the American Kestrel in both strata followed by the Red-tailed Hawk. Other species of raptors documented in the study area included Bald Eagle, Northern Harrier, Sharp-shinned Hawk, Cooper's Hawk, Merlin, Osprey, Golden Eagle, and Broad-winged Hawk.

Owl surveys were attempted, but because the field program occurred late in the year, they were not successful. However, we did document the presence of Barred Owls, Great Horned Owls, Northern Hawk Owls, Northern Saw-whet Owls, and Northern Pygmy-Owls in the study area. More work is required to determine the occurrence and distribution of these species with in the core and periphery strata.

Waterfowl and Water-associated Species

Fourteen species of waterfowl were observed during surveys of the Peace River. A total of 58% of the waterfowl seen were Canada Geese. About one-quarter of the ducks observed were dabbling ducks. About three-fourths of the dabbling ducks were Mallards. Of the diving ducks seen, Common Goldeneyes and Common Mergansers each comprised approximately one-quarter of the total. Of all waterfowl seen during aerial surveys, 63% were observed above the confluence with the Moberly River. Approximately 57% (83 of 146 km) of the Peace River in the study area lies above the confluence of the Moberly River. The main difference in numbers seen above and below the confluence of the Moberly River occurred with diving ducks in which 71% of the sightings were above the Moberly whereas on 46% of the Canada geese and 57% of the dabbling ducks were located above the Moberly.

Eighteen species of water-associated birds were observed during surveys of the Peace River. A total of 1,066 waterbirds were seen during aerial surveys and 3,953 waterbirds were seen during boat surveys. Of the 5,019 waterbirds observed, 60% of the waterbirds seen were Franklin's Gulls. Ring-billed Gulls, California Gulls and Bonaparte's Gulls collectively made up another 16% of the waterbird sightings. Other relatively abundant waterbirds observed were Bank Swallows and Spotted Sandpipers. Of 3,953 waterbirds seen during boat-based surveys of the Peace River, 98% were observed on transects above the confluence with the Moberly River. Only 70 birds were observed on transects below the Moberly River, mostly Bank Swallows and Spotted Sandpipers.

Amphibians and Reptiles

Amphibian searches consisted of time-constrained searches for adults, dipnetting surveys for tadpoles and metamorphs, and time-constrained searches for reptiles. Searches were conducted in both the core and periphery strata throughout the study area. Searches were generally combined with survey efforts for other groups such as butterflies or songbirds. In addition to focused searches for amphibians and reptiles, incidental observations of snakes, frogs, or toads were recorded. Total time-constrained search time for amphibians (adults and tadpoles) totaled 30.75 hours at 83 unique locations (42 core and 41 periphery), dipnetting totaled 5.9 hours at 3 locations (all core), and snake searches totaled 14.96 hours at 18 locations (12 core and 5 periperhy). Dipnet searches were not conducted as frequently as time-constrained searches due to the timing of field surveys and the probability that metamorphs and/or adults would be encountered more often than tadpoles (because tadpoles had already emerged).

Western toads and wood frogs were detected in both the core and periphery strata. Western toads were documented from 21 unique locations (13 core; 8 periphery) and wood frogs were documented from 56 unique locations (22 core; 34 periphery). The only other species of amphibian documented in the study area was the long-toed salamander. Tadpoles of this species were documented from 3 locations, all of which were in the core stratum.

We counted 8 long-toed salamander tadpoles, 16,327 western toads of 5 age classes (+ 1 unclassified category) and 1,340 wood frogs in 4 age classes (+ 1 unclassified category) for a total of 17,675 observations. The large number of western toads can be attributed to the detection of two large egg masses (the total number of eggs in each egg mass was estimated). Juvenile western toads (recently emerged metamorphs) were abundant in both strata. The relative abundance of western toads and wood frogs was not calculated because of the search method employed (time-constrained searches). Similarly, although we did use dipnetting to sample for long-toed salamanders, the timing, duration and extent of sampling did not permit the development of a relative abundance estimate. Breeding populations of the long-toed salamander occur at a minimum of two locations within the core stratum and breeding populations of both wood frogs and western toads occur in both strata and throughout the study area.

Two species of garter snake were detected in the Peace River study area: *Thamnophis sirtalis parietalis* (common garter snake, red-sided subspecies) and *T. elegans* (western terrestrial garter snake). Garter snakes were detected at 17 sites. The common garter snake was detected at 7 sites (2 core; 5 periphery), the western terrestrial garter snake was documented from 5 sites, all in the core, and garter snakes not identified to species were documented from an additional 5 sites in the core. There were not enough data to do any statistical testing on the distribution and / or presence of snake species in either stratum or study area.

Rare Plants

Rare plants occurred at 114 sites; 82 in the core and 32 in the periphery. Thirteen species were documented in only one stratum (9 in the core and 3 in the periphery) and most of these species were documented from only 1 site. Rare plants have been documented from the Peace Rive area; however, we documented 6 rare plants that had not been previously documented in the Peace River. An additional 4 species that occur in the CDC database were not documented during these surveys because the timing was wrong or the locality data for the records in the CDC database are from old collections that have not been recently confirmed. We also detected native and non-native vascular plants that had not been reported in the area (n = 24 native; 5 non-native), or in BC (n = 2).

The presence of rare plants in the Peace River study area can be attributed to the presence of 1 of 3 vegetation complexes: 1) valley bottoms, shore of the Peace, and islands in the Peace, 2) breaks above the Peace and Beatton Rivers and their tributaries, and 3) wetland complexes on the plateau above the Peace River.

Recommendations for future work

The 2005 wildlife and vegetation surveys in the Peace River area were fairly comprehensive; however, data gaps still exisit. Furture surveys using similar methods as those in 2005 should be designed to:

1. confirm that suitable habitat attributes are present in predicted ecosystem types, with emphasis on wildlife tree availability and field verification of habitat model attributes.
2. document presence/absence (or relative abundance) of target species in different habitat classes within and outside of the reservoir.

The areas that require further work are presented below. Additional recommendations are provided in the recommendations section.

Butterflies

Butterfly surveys need to be conducted from June through August, with emphasis placed on ecologically-based sampling of habitats, representative sampling of suitable habitats for blue-listed species, and documentation of larval host plants.

Passerines

Surveys within the same strata (i.e, river valley reservoir, river valley non-reservoir, and upland) as 2005 should be repeated to account for potential annual variation and to ensure that previous data adequately describe the habitat relationships. Studies also need to be conducted to verify and validate the TEM-based models developed for rare and endangered species.

Raptor/herons

With the exception of owls, raptor (especially bald eagle) and heron data appear to be adequate based on existing data. More extensive coverage of owl surveys needs to be conducted (this was limited last year due to extensive early-morning passerine surveys resulting in little ability to also work late into the night.). As well, owl surveys should be conducted during the period of March to June and much of this period will have expired by the time field studies will begin in 2006. It may be desirable to conduct some surveys in 2007 if adequate data cannot be collected during 2006. Continued roadside surveys for raptors would be useful to assess distribution, but this would largely be in areas unaffected by hydro development and, therefore, of lower priority.

Waterfowl

While it might be useful to repeat the Harlequin Duck investigations during 2006, negative results last year may be considered adequate. Spring and fall waterfowl, shorebird and crane surveys should be conducted to verify the paucity data that currently exist. Surveys need to be conducted during April and May in the spring, during July-September for fall shorebirds and during September and October for fall waterfowl and cranes. Since most of the spring migration will be missed during 2006, this may need to be surveyed during 2007.

Wetlands and Wetland Species

Wetlands and ponds need to be mapped in the study area. These habitats support populations of pond-breeding amphibians, reptiles, marsh-nesting birds, shorebirds, waterfowl, cranes, small mammals, raptors, furbearers, large mammals, dragonflies, and bats. Wetland and pond habitats should be mapped using aerial photography interpretation, wetland calssication (following wetlands of BC), followed by ground-truthing. Mapping the distribution of these important habitats in proximity to Site C will enable a better assessment of the potential impacts on wildlife.

Surveys for pond-breeding amphibians should occur earlier in the year, and possibly as early as March for some species (e.g., Long-toed salamanders). Studies that occur at the peak of the breeding season will provide valid population estimates for each species. Surveys for marsh-nesting birds could be paired with pond-breeding amphibian surveys.

Rare and Endangered Plant Communities

Although considerable rare and endangered vegetation work was conducted during 2005, it was not linked with the TEM which was not available. Ecosystem mapping can be used to identify areas with potential to support rare species and units with potential need to be investigated. Additional vegetation work can be designed to further support the TEM validation.

Habitat Suitability Index Models

Future field data collection is required to allow for habitat variable testing, model calibration and model verification. Habitat model outputs should be used in conjunction with TEM to stratify sampling efforts for bird and raptor surveys to allow for sampling distribution and intensity sufficient to support model testing and refinement. It is recommended that a full suite of habitat attributes be collected at songbird point count locations and all any owl playback or incidental encounter detection locations. This will facilitate the testing of predictive relationships between habitat model variables and TEM attributes as well as the testing of the predictive accuracy of the models. In addition, data collection during any further TEM field verification activities should be expanded to incorporate systematic structural and vegetative sampling to allow for the testing of predictive relationships between habitat model variables and TEM attributes.

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1. Introduction

Two Peace River facilities provide about one-third of the BC Hydro's total electricity generation with the combined production of the two generating stations providing enough power to service 500,000 homes. The addition of a third major generating station (Site C) on the Peace River has been under consideration for more than 30 years. As part of BC Hydro's ongoing resolve to keep Site C in a state of readiness should conditions warrant such a development, environmental studies conducted 1-3 decades ago must also be kept current. While there has been some recent work, it has largely been conducted out-of-season and of a limited scale. LGL Limited surveyed the Peace River area for priority taxa during spring 2005 to fill existing information gaps for habitats within and adjacent to the Peace River from Hudson's Hope to the Alberta border.

1.1 Objectives

This study has four major objectives:

i. Conduct spring wildlife inventories of priority taxa;
ii. Conduct vegetation surveys of the target plants on the provincial red and blue lists; and
iii. Develop habitat suitability ratings based on terrestrial ecosystem mapping (TEM) for priority wildlife species where data warrant;
iv. Conduct consultations with the local First Nation groups to determine their interests in the area.

Work related to objective iv was not addressed in 2005.

1.2 Study Area

The Peace River system flows out of the Rocky Mountain range in northeastern British Columbia. The W.A.C. Bennett Dam, which impounds Williston Reservoir, and the Peace Canyon Dam, 23 kilometres downstream of the W.A.C. Bennett Dam, which impounds Dinosaur Lake, form the headwaters of this major Canadian river which empties into one of the largest inland deltas in the world – the Peace-Athabasca Delta, before eventually flowing into the Mackenzie River and the Beaufort Sea. In British Columbia, the Peace River flows east from Peace Canyon Dam (located at Hudson's Hope) 145 kilometres to the BC/Alberta border. The Peace River valley between Hudson's Hope and Clayhurst includes large areas of productive farmland along the north bank and extensive woodland along the south bank. The Peace Region is predominantly glaciolacustrine while the banks and substrate of the Peace River corridor are a combination of boulders, cobbles and relatively coarse sand. Associated with the river in many areas are back channels, floodplain wetlands and oxbows. The river, shoreline and islands provide habitat for an abundance of wildlife, some of which occur only in this region of BC. The varieties of aquatic and terrestrial habitat influence the distribution of wildlife within the river valley and in the adjacent upland habitats.

The Peace River study area was stratified into two main survey strata: the core and the periphery (Figure 1). The core stratum was an area of 145 km long X 4 km wide that encapsulated the Peace River corridor from the Peace Canyon Dam to the Alberta border and included an area of approximately 2 km on either bank of the Peace River. The periphery stratum was the area outside of the core stratum that was contained within 7, 1:50,000 mapsheets (5 complete, 2 partial) (Figure 1).

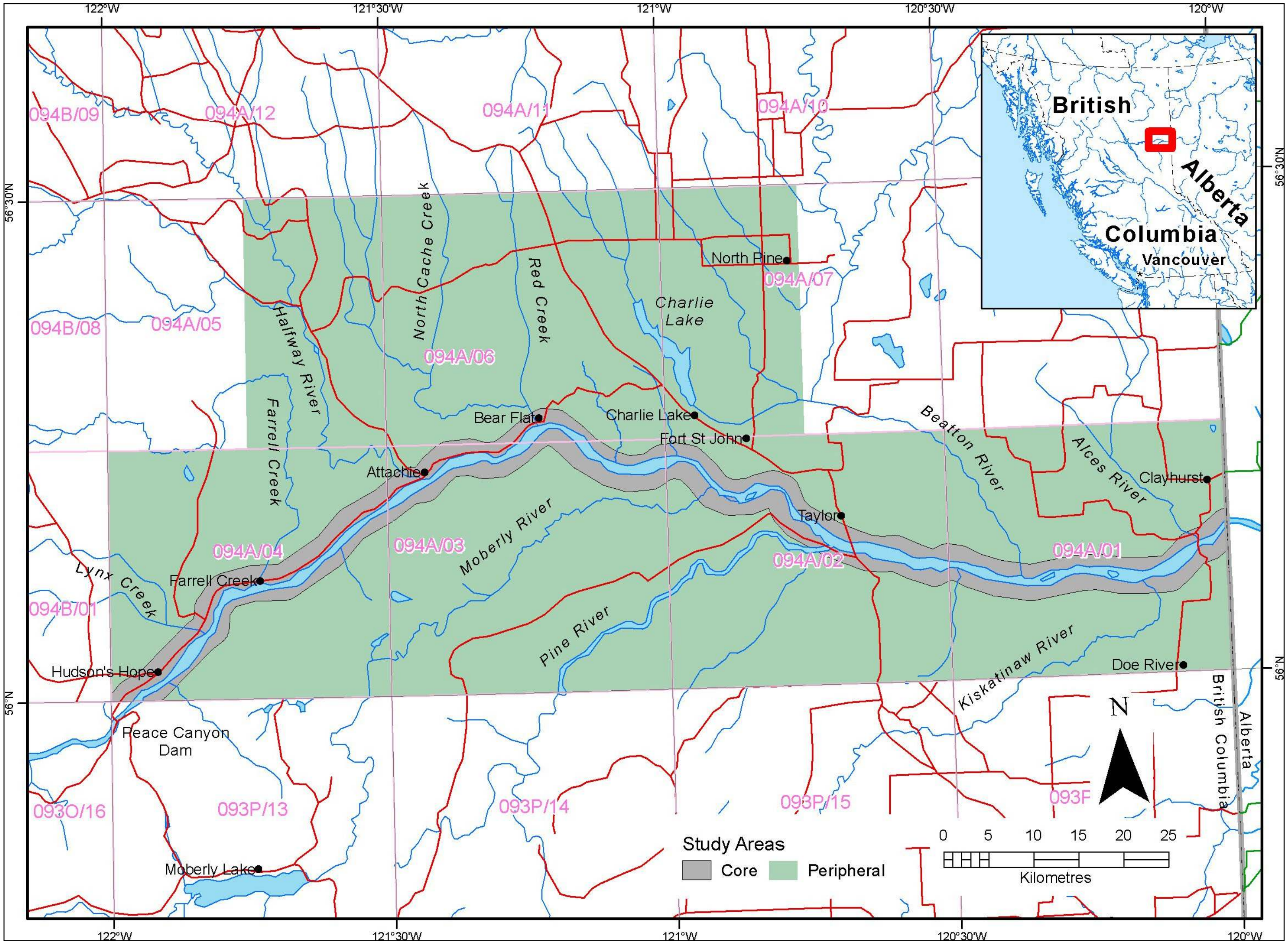

Figure 1. Location of the Peace River study area showing the core (in gray) and periphery (in green) strata.

Both study strata occur within the Peace River Basin (PRB) ecoregion in the Peace Lowland ecosection (PEL) that lies adjacent to the Peace River. The PRB ecoregion is a wide plain that lies between rolling uplands to the north and south and is dissected by the Peace River and its tributaries. This ecosection has the mildest climate and the lowest snowfall in the PRB ecoregion. The project sie is located within the Peace, moist, warm variant of the Boreal White and Black Spruce (BWBSmw1) subzone. The BWBSwm1 experiences frequent outbreaks of arctic air masses and features long, very cold winters and short growing seasons. The mean annual temperature ranges from –2.9°C to 2°C; monthly averages remain below 0°C for 5 to 7 months of the year and above 19°C for only 2 to 4 months of the year. Annual precipitation averages between 330 and 570 mm, with 35% to 55% occurring as snow (Delong et al. 1991).

2. Methods

2.1 Habitat Capability/Suitability Ratings

Terrestrial ecosystem mapping (TEM) is a system of ecosystem classification and mapping that provides information about bioterrain data and ecological attributes suitable for interpretation by a variety of disciplines, including impact assessment. We developed models to interpret the capability and suitability of wildlife habitat for select species using TEM as a base. The base TEM was available for the core stratum only. The models are applicable to habitat on the Peace River floodplain, as well as upland habitat within 2000m from the bank of the river. Our models were based on provincial standards for wildlife habitat capability and suitability ratings (RISC 1999). The recommended approach is to develop a life requisite habitat model for the focal species, collect bioterrain data and ecological attributes through field or GIS/remote sensing methods to delineate various habitat units, then apply the model to the various habitat units represented on TEM or other mapping bases. The provincial standards are based on a habitat assessment methodology developed more than 20 years ago by the U.S. Fish and Wildlife Service (USFWS) called Habitat Evaluation Procedures (HEP). Habitat Evaluation Procedures is a species-habitat approach in which habitat suitability for focal species is documented with an index, the Habitat Suitability Index (HSI). This value is derived from an evaluation of the ability of key habitat components to supply the life requisites of selected wildlife species. HSI values are obtained for individual species through use of documented habitat suitability models employing measurable key habitat variables (*e.g.*, percent canopy closure).

HEP consists of six steps:

1. Select focal species.
2. Delineate and quantify relatively homogeneous habitat types.
3. Develop habitat suitability models for each focal species. The models consist of relationships between measurable habitat components (relating to life requisites) and habitat suitability, and a unifying algorithm.
4. Measure the habitat components identified in the habitat suitability models.
5. Calculate HSI’s and Habitat Units (HU’s) for each species based on the suitability and areal extent of each habitat type (model implementation).
6. Assess habitat use data for checking and “fine-tuning” the model (model evaluation).

The methods used to implement each of these steps are described below.

2.1.1 Selection of Focal Species

The objective for habitat modelling is to provide information on the potential distribution within the Peace River core study area of habitats for species of conservation concern. The intent is to inform managers about potential impacts to species populations should these habitats become unavailable. Conservation concern is related to both provincial and federal status, as well as the relationship of species to habitats available primarily in the Peace River core. The species selection process was limited to only those species included in the Peace River Spring 2005 Wildlife Surveys. We used the following criteria to select the focal species:

1. designated conservation status
2. relationship to key habitats associated with the Peace River core study area
    - a) white spruce dominated mixedwood
    - b) aspen dominated riparian mixedwood
    - c) native grasslands and shrub meadows / cultivated fields
    - d) wetlands
3. frequency of occurrence in 2005 spring wildlife inventories
4. historical records of occurrence
5. level of available knowledge of species habitat relationships

Rare songbirds for the area met all the criteria above, including associations with all major key habitats, and were considered suitable for modeling (Table 1). Exceptions were Bay-breasted Warbler (BBWA) and Nelson's Sharp-tailed Sparrow (NSTS). Neither were detected during 2005. Both species are highly secretive and difficult to detect with point count methodology. However, the Bay-Breasted Warbler is considered to be associated with old growth white spruce forests. Modelling for other spruce associated species, such as the Cape May Warbler, is expected to account for BBWA habitat to some degree. NSTS are associated with freshwater wetlands, and are more appropriately dealt with through suitable wetland identification and mapping rather than habitat modelling. LeConte's Sparrows were detected; however their tight association with sedge meadows (Mark Phinney, pers. comm.) makes them more suitably addressed through mapping of that unique resource rather than habitat modelling. Habitat relationship summaries for rare songbirds appear in Table 3. Other songbirds or songbird communities may be suitable for future habitat modelling efforts, depending on future planning objectives.

Boreal Owls were selected for modelling because, although not the most frequently detected owl species, they tend to be tightly associated with conifer dominated forests (Table 1). It is anticipated that the White Spruce dominated mixedwood communities found in the Peace core would provide unique habitats. Northern Saw-whet Owls and Barred Owls were detected most frequently in the 2005 surveys; however, both are aspen-mixedwood forest habitat generalists and are likely as abundant in both the core study area as in the surrounding region. Northern Saw-whet Owls are similar to Boreal Owls in habitat structural requirements, though deciduous rather than conifer associated. Barred Owls, on the other hand, have been found in other studies to select mixedwood stands of White Spruce, Balsam Poplar and Trembling Aspen (Takats 1998) and to be found at lower elevations associated with large riparian systems where Balsam Poplar are present. This makes it likely to be tightly associated with habitats in the Peace River core, and a good candidate for this modelling exercise (Table 1).

Other species such as the Great Gray Owl, Great Horned Owl and the Northern Hawk Owl are not anticipated to be dependent on key habitats found primarily in the core area. Even though the blue-listed, Short-eared Owl occurs at the northernmost extent of their range in the Peace River corridor, this species was not detected during this survey. They are known for their irruptive nesting habits (Clayton 2000), especially in northern parts of their range (Johnsgard 1988; Holt and Leasure 1993), and it is possible that they nest in the Peace River corridor in some years. Natural and cultivated open field habitats are well-distributed throughout the region and are not restricted to the core study area. If occurrences are located, specific sites should be given conservation priority.

Table 1. Wildlife species selected for habitat suitability index (HSI) model development.

Common Name	Code	Scientific Name	Model Life Requisite
Black-throated Green Warbler	BTNW	*Dendroica virens*	Reproductive Habitat
Canada Warbler	CAWA	*Wilsonia canadensis*	Reproductive Habitat
Connecticut Warbler	COWA	*Oporornis agilis*	Reproductive Habitat
Cape May Warbler	CAMA	*Dendroica tigrina*	Reproductive Habitat
Philadelphia Vireo	PHVI	*Vireo philadelphicus*	Reproductive Habitat
Boreal Owl	BOOW	*Aegolius funereus*	Reproductive Habitat
Barred Owl	BAOW	*Strix varia*	Reproductive Habitat

Several taxonomic groups surveyed in 2005 were not considered suitable for modelling (Table 2).

Table 2. 2005 taxonomic survey groups for which HSI models were not developed.

Taxonomic Group	Rationale
Butterflies	Insufficient information on individual species requirements.
Raptors	Primarily generalist open habitat raptors were detected throughout the broader study area.
Amphibians and Reptiles	Wetland / open water amphibians were detected. Wetland / suitable wet habitat classification and mapping are more appropriate than modelling.
Waterfowl	Species detected are primarily associated with the Peace River and its shoreline; shoreline mapping is more informative than modelling.
Owls (except Boreal Owl and Barred Owl)	Species such as Great Gray Owls and Great Horned Owls are not anticipated to be dependent on key habitats found primarily in the core stratum.

Great Blue Herons and Harlequin Ducks were not detected during the 2005 survey period. Paucity of records does not support any meaningful use of habitat modelling. If occurrences are located, specific sites should be given conservation priority.

In general, waterfowl species identified during June and July were not anticipated to be dependent on key habitats found primarily in the core area. Cavity-nesting duck species (Bufflehead, Common Goldeneye, Barrow's Goldeneye) were considered, as they occurred relatively frequently in the 2005 survey period, and are associated with riparian aspen mixedwood forest of sufficient size and age, generally associated with the Peace River core, to support cavities excavated primarily by Northern Flickers and Pileated Woodpeckers. However, there is limited information on brood movements in the area, and their tight association with the Peace River shoreline in combination with a lack of many other suitable aquatic habitats (open water, lakes and rivers) in the core stratum led to the conclusion that modeling would not enhance the understanding of their distribution in the study area.

2.1.2 Delineation of Habitat Types

The habitat evaluation analysis requires discrete habitat types to be recognized within the study area. It is assumed these habitat types are homogeneous units with relatively uniform biophysical conditions. This critical assumption is required to extrapolate the evaluation of habitat suitability from areas actually sampled on the ground to unsampled areas.

We used TEM for the core stratum of the Peace River study area as the map base for our habitat suitability models. The TEM field verification data provided some additional attribute data which was included to assess the habitat types.

2.1.3 Model Development

A fundamental step in the HEP approach is the development of a systematic means of assigning suitability ratings to a given area (*i.e.* habitat polygon) for an evaluation species. This is done by developing a model that links Suitability Indices (SI's) to the various components of a species' habitat. SI values are developed for each habitat variable considered to influence habitat suitability for a particular species. SI's are generally calculated from relationships developed between specific variable measurements and carrying capacity. These relationships permit suitability indices to be directly calculated from the ratio of habitat conditions (based on in-field variable measurements, literature or expert opinion) to optimal habitat conditions.

Table 3. A summary of rare songbird habitat relationships (after Enns and Siddle 1996).

			Habitat Description				
Species	**Status**[1]	**Primary Habitat**	**Overstorey**	**Understorey**	**Age**	**Foraging Habits**	**Nesting Habits**
BTNW	Blue	Old growth riparian mixedwood	Mesic White spruce and Balsam Poplar; tall stands	Herbaceous; Open	Mature - old	Upper ½ canopy	Conifers 2-8m high
CAWA	Blue	Mature / old growth aspen	Riparian mixedwood with Birch component, as well as Trembling Aspen, Balsam Poplar and White Spruce; Steep Slopes	Shrubby	Mature - old	3 – 4 m up from forest floor	ground
BBWA	Red	Old growth spruce	Mixedwood with large, tall White Spruce, Trembling Aspen and Birch	Shrubby 1 to 2 m	Mature – old	Mid-canopy	Secretive
CMWA	Red	Old growth spruce	Dense White Spruce; tall stands	Herbaceous / Mossy; Open	Mature – old	High in canopy	10-20m high in conifers
COWA	Red	Old growth aspen	Trembling Aspen; large, tall trees; flat to gently sloping sites	Shrubby < 3 m	Mature – old	Ground	Ground
PHVI	Blue	Habitat generalist	Dense Trembling Aspen stands with closed canopies (80-100% CC)	Herbaceous	Young (< 20 years)	Mid-canopy	Mid-canopy
LCSP	Blue	Sedge meadow / grassland	Shrub carrs, sedge meadows, adjacent White Spruce stands common	n/a	n/a	Ground (on sedges)	Ground (in sedges)
NSTS	Red	Freshwater wetlands	Wet sedge meadows, emergent cattails, fens, open water wetlands	n/a	n/a	On or slightly above ground	On or slightly above ground

[1] BC Conservation Data Centre: http://srmwww.gov.bc.ca/cdc/

In practice, the model is generally developed from the top down by determining the following components:

- season;
- life requisites;
- important habitat factors; and
- measurable habitat variables.

If habitats are used differently on a seasonal basis, habitat suitability models must be developed for each season. Thus each evaluation species may require more than one model and HSI values for habitat polygons may vary by season. The songbirds we modelled were non-resident species, and a single model for the breeding season (late spring through early fall) was developed for each of the six species. Boreal Owls are resident and Barred Owls likely so. However, reproductive habitat was assumed to be limit population density and distribution and models were developed exclusively for the breeding season.

Life requisites are those biological elements that directly affect a species' presence and abundance. Food and cover are universal life requisites, although they may be interrelated and thus only one or the other need be considered in the model. Other factors such as reproductive considerations when unique from food/cover factors may also need to be incorporated into the models. We identified life requisites for our evaluation species from scientific literature (peer reviewed scientific journals), species status reports from British Columbia and Alberta and species compendiums, and existing models where available. We supplemented information for the songbirds with expert opinion, as there were little data for these species' life requisites in the Peace Lowland area.

The habitat models developed during this study were based on the assumption that important habitat factors could be identified that directly influenced an area's ability to provide life requisites to an evaluation species. Once those important habitat factors were identified, habitat variables that adequately measured those factors were selected based on their ability to be evaluated in a cost effective manner from maps, remotely sensed data or field measurements.

Suitability Indices (SI) for habitat variables and/or for life requisite combinations of variables (e.g. nesting, cover) were combined in relationships intended to represent their influence on overall habitat suitability. These relationships may be additive or compensatory. Where two or more variables influenced habitat suitability in an additive fashion, a significance-weighting factor was associated with each life requisite and/or habitat variable associated with life requisites. SI values and relationships were subjectively determined according to available empirical evidence. In many cases habitat variables were modifiers included in the model because they detracted from food or cover values. Once the SI values were determined, the mechanics of the model were described through a series of algorithms that linked the habitat components (variables) to the life requisites, and an overall Habitat Suitability Index (HSI).

2.1.4 Habitat Variables

TEM Attributes. The HEP approach requires that model variables be adequately measured in each habitat type to be assessed. This was partly accomplished during the TEM field validation sampling completed by Keystone Wildlife Research. We did not re-sample the habitat units, but instead used the available TEM attribute data to the greatest possible extent in combination with information available from the ecosystem site guide for the BWBS (DeLong et al. 1990) and the wetland identification guide (Mackenzie and Moran 2004) . Model construction has attempted to consider the attribute composition and resolution of the TEM inventory. However, where the model requires attribute data which is not included in the available TEM produced for the study area, predictive relationships were be established between model attributes and corresponding TEM attributes anticipated to "approximate" those attribute values from the model.

GIS Analysis. Several measurable habitat variables identified in the models developed for this study were determined from GIS analysis rather than directly from the TEM. These included stand area, and testing for adjacency of aspen stands to floodplains in the Canada warbler model.

2.1.5 Model Implementation

We calculated a Habitat Suitability Index (HSI) value for each season modelled for each evaluation species. TEM and GIS data were used to determine the SI values for each habitat variable in a model. HSIs for individual life requisites and the overall habitat suitability for each evaluation species was then calculated using the algorithm developed for each model. This procedure was repeated for each habitat polygon, for each species and for each season for which a model was developed. The output of each HSI model was a value between 0 and 1, inclusive. These values were then reclassified to the 4 point provincial scale recommended for birds (RISC 1999). Model outputs were visually examined to evaluate if the model adequately valued habitats as intended. Models were fine-tuned and modified as required so that outputs (resulting suitability maps) fairly represented the level of current knowledge.

2.1.6 Model Evaluation

We used 2005 survey data and BC Conservation Data Centre records to help assess the habitat capability/suitability ratings determined by our models. There were insufficient data to quantitatively assess the models' predictions. Instead, we visually compared model predictions of highly suitable habitat for each evaluation species to any reported occurrences for that species.

2.2 Wildlife Inventory

2.2.1 Selection of Study Sites

Initially aerial photographs, topographic maps and expert knowledge were used to determine the location of survey sites. Representative habitat types within each stratum were sampled, with some habitat types sampled more intensively (to enhance the probability of detecting a species with provincial or federal conservation status). We sampled many sites opportunistically while in the field, which provided flexibility to sample in areas that were not identified thorough initial aerial photograph or map interpretation. We also sampled sites with known suspected occupancy by rare or endangered species.

In general, more sites were sampled in the core stratum because of the potential impact on this stratum from the construction of site C. Attempts were made to sample similar habitats in the periphery stratum where they existed but site selection was not paired between the core and periphery.

Habitats within the core stratum were sampled from approximately the Peace Canyon Dam down river to the Alberta border. The periphery stratum was sampled in all 7 mapsheets (Figure 1); however the portion of the periphery stratum delineated by the eastern half of mapsheet 94A07 and the north end of mapsheet 94A01 were sampled less than other areas in the periphery because of access or lack of habitat. Most of the land in these two areas is privately owned agricultural land and access would have required illegal trespass. Road access was not available to all areas (e.g., southwest facing slopes of the Beatton River) and where road access was available, there were few large habitat patches to sample in.

2.2.2 Methods

The methods used for each component of the wildlife inventory followed Resources Inventory Standards Committee (RISC) protocols or were based, at least in part, on these RISC protocols. Specifically, the following protocols were either used or referred to when designing the study, collecting field data, and during data analysis:

Amphibians:	RISC 1998a: Inventory methods for pond-breeding amphibians and painted turtle (Version 2.0)
Butterflies:	RISC 1998b: Inventory methods for terrestrial arthropods, (Version 2.0)
Owls:	RISC 2001: Inventory methods for raptors, (Version 2.0)
Raptors:	RISC 2001: Inventory methods for raptors, (Version 2.0)
Snakes:	RISC 1998c: Inventory methods for snakes (Version 2.0)
Songbirds:	RISC 1999a: Inventory methods for forest and grassland songbirds, (Version 2.0)
Waterfowl:	RISC 1999b: Inventory methods for waterfowl and allied species (Version 2.0)

Datasheets used for each component of the field work can be found in Appendix II.

2.3 Butterflies

The Peace River valley and surrounding area contains a very rich butterfly fauna, with Kondla *et al.* (1994) recording 76 species from the area. More recent estimates indicate that more than 80 species of butterflies are known to occur in the Peace River region (C. Guppy pers. comm.). Eighteen species on the BC CDC Blue-list are found within the Peace Forest District, of which 15 Blue-listed species were expected to occur in the Peace study area (Table 4). The remaining three species are associated with alpine, sub-alpine and tundra habitats not represented in the study area. For many of the 15 Blue-listed species and subspecies the lower elevations of the Peace River valley, as typified by the core stratum of the study area, are the only known locations in BC where strong populations occur (Guppy and Shepherd 2001). Of particular interest were eight Blue-listed species (highlighted in Table 4) that are closely associated with native grassland habitat on South-facing slopes. Within the study area this habitat is generally restricted to the north side of the Peace River (ie, within the Core stratum of the study area), as well as adjoining tributaries, such as the Beatton and Pine River valleys, and a few upland fragments (i.e., within the Periphery stratum) (Hervieux 2002). The primary objective of sampling was to document the occurrence and distribution of Blue-listed butterfly species in the Peace River study area (Core and Periphery strata). Secondarily, we wanted to develop a list of all butterfly species detected in the study area.

Sampling was conducted between the 1st June and 24th July 2005, coinciding with the flight periods of all 15 Blue-listed species likely to occur in the study area (Table 4). A combination of satellite photography and ground-reconnaissance was used to select sampling sites based on the broad characteristics of habitat associated with the Blue-listed species (Table 4), and with the aim of sampling as widely as possible within the study area. Habitats for the eight grassland-associated Blue-listed species (e.g., south-facing grassy slopes) were assigned the highest priority for sampling. Other general habitat types sampled included disturbed roadsides, and sloughs. Opportunistic samples were also taken throughout the study area.

Table 4. Blue-listed butterflies of the Peace Forest District expected to occur in the study area. Eight species closely associated with native grassland habitat on south-facing slopes are highlighted. Source: CDC website http://srmapps.gov.bc.ca/apps/eswp/ accessed May 2005.

Scientific Name	Common Name	Habitat Notes	Flight Period
Agriades glandon lacustris	Arctic Blue, *lacustris* subspecies	South-facing grass/shrub slopes. Usually in association with *Saxifraga* sp.	Late May to late June.
Carterocephalus palaemon mandan	Arctic Skipper	Openings in mature aspen/poplar and aspen forests. Grass/shrub slopes. Clearcuts.	June and July.
Cercyonis pegala ino	Common Woodnymph, *ino* subspecies	Open and semi-open habitats, especially grassy meadows. Larval foodplants are grasses and sedges.	Late July to late August.
Coenonympha california benjamini	Common Ringlet, *benjamini* subspecies	Adults prefer various types of meadows and grasslands. Larval foodplants are mainly grasses.	Late May to early August.
Erebia discoidalis	Red-disked Alpine	Mainly wet grassy areas. One larval host plant is *Poa canbyi.*	May and June.
Hesperia comma assiniboia	Common Branded Skipper, *assiniboia* subspecies	South-facing grass/shrub slopes of the Peace River.	Late July to late August.
Oeneis alberta alberta	Alberta Arctic	South-facing grass/shrub slopes of the Peace River. Larval host is genus *Festuca*.	May and June
Oeneis uhleri varuna	Uhler's Arctic	Dry bunchgrass hillsides.	June and July. Possibly flies only every second year in BC.
Papilio machaon pikei	Baird's Swallowtail, *pikei* subspecies	South-facing open dry grass/shrub slopes along the Peace River. Larval foodplant is tarragon.	Late May to early July.
Phyciodes batesii lakota	Tawny Crescent	South-facing open dry grass/shrub slopes. Mature open aspen woodland and adjacent mesic meadows.	Late June to late July.
Pyrgus communis	Checkered Skipper	Peace River Valley grasslands. Strays can turn up in almost any open situation.	June to September.
Satyrium liparops	Striped Hairstreak	South facing slopes of the Peace River and some of its tributaries. Associated with chokecherry.	Late June to late July.
Satyrium titus titus	Coral Hairstreak, *titus* subspecies	South-facing grass/shrub slopes of the Peace River. The larval foodplant is chokecherry.	July.
Speyeria aphrodite manitoba	Aphrodite Fritillary, *manitoba* subspecies	South-facing grass/shrub slopes. Roadside ditches.	Mid July to mid August.
Speyeria cybele pseudocarpenteri	Great Spangled Fritillary, *pseudocarpenteri* subspecies	At edge of and in open mature aspen woodland. Moist grassy spots in dry grass/shrub slopes.	July.

2.3.1 Field Methods

The Resources Information Standards Committee (RISC) has not developed inventory standards specifically for butterflies. The RISC inventory fundamentals and the standards developed for terrestrial arthropods were adapted for butterflies for this project by omitting inapplicable components. Data were recorded in the field on data forms designed specifically for the project (Appendix II). The forms were (in part) based on existing RISC data forms, information from recent literature and dataforms developed by C. Guppy (2001).

The primary method used for sampling butterflies was net capture and, where possible, sight observation. Non-random transects were established within presumably suitable habitats for target butterflies. All sampling locations were documented using a Garmin GPS 12 handheld GPS receiver. General and specific habitat variables were recorded at all sample locations. Time was tracked at all sites sampled, and for most sites, the distance traversed was also recorded. The amount of effort in a particular habitat was measured using the amount of time spent searching by all searchers. Opportunistic surveys were also conducted using digital photography. In most of these cases only a general locality was recorded, but this was sufficient to assign photographed specimens to a stratum.

Collectors/observers walked transects noting or capturing all butterflies encountered. Captured specimens were collected as voucher specimens or were photographed using a digital camera. Those species able to be identified in the field were released at the site of capture and no more specimens of the species were collected at that site. Collected butterflies were euthanized by pinching the thorax between the thumb and forefinger then placed in a glassine envelope with the date, location (zone and UTM coordinates), stratum, and collector recorded on each envelope. Butterflies rarely fly during cloudy times and so sampling occurred primarily under sunny conditions, although opportunistic sampling occurred in all weather except hard rain.

Collected specimens and digital photographs were submitted to Dr. Jens Roland at the University of Alberta for identification. Butterfly taxonomy followed names used in the National Collection and the Strickland Museum at the University of Alberta and the Butterflies of BC (Guppy and Shepard 2001). Sub-species-level identifications were not undertaken in all instances in this study as they were deemed unnecessary for species where only one sub-species is known from this area.

2.4 Birds

2.4.1 Songbirds and Allied Species

Approximately 200 species of forest, grassland and parkland breeding “songbirds” and allies inhabit the Peace River region (Campbell et al. 1990b, 1997). This group consists primarily of passerines (perching birds) and close relatives such as woodpeckers and kingfishers. Many of these species depend on specific forest and parkland habitats. Our surveys focused on detecting red- or blue-listed species (Table 5).

Table 5. Red-listed and blue-listed passerines that occur in the Peace River area.

Species	CDC Status[1]	Habitat Notes	Seasonality
Philadelphia Vireo *(Vireo philadelphicus)*	Blue	Open deciduous or mixed woodland, forest edge, alder and willow thickets, especially near streams.	June to mid August.
Bay-breasted Warbler *(Dendroica castanea)*	Red	Boreal coniferous forest, occasionally adjoining second growth or deciduous scrub.	June to late August.

Species	CDC Status[1]	Habitat Notes	Seasonality
Cape May Warbler *(Dendroica tigrina)*	Red	Primarily in older forests of spruce and/or fir	June to late August.
Black-throated Green Warbler *(Dendroica virens)*	Blue	Breeds in a variety of forest types with a coniferous component.	Late May to September.
Connecticut Warbler *(Oporornis agilis)*	Red	Mature aspen forest.	June to late August.
Canada Warbler *(Wilsonia canadensis)*	Blue	Woodland undergrowth, especially aspen-poplar, tall shrubbery near water, deciduous second growth.	June to late August.
Le Conte's Sparrow *(Ammodramus leconteii)*	Blue	Wetlands, sedge meadows, and grasslands within aspen parkland.	June to September.
Nelson's Sharp-tailed Sparrow *(Ammodramus nelsoni)*	Red	Freshwater marshes and wet meadows.	June to September.

[1] BC Conservation Data Centre: http://srmwww.gov.bc.ca/cdc/

Relative abundance of all detected songbirds and allies was determined mainly through systematic replicated point counts. These standard techniques for determining relative abundance are described in detail by the Resources Inventory Committee (1997a, e), and by other authorities (e.g., Manuwal and Carey 1991, Darling 1992, Bibby et al. 1992, Milliken 1992).

2.4.1.1 Variable Radius Point Counts

Variable Radius Point Counts (RISC 1999) were used as the primary method of assessing passerine distribution and abundance in the study area. Point counts in general are considered preferable to other methods in forested habitats and “difficult” terrain (Ralph et al. 1993). We established a total of 187 sites, 118 in the core and 67 in the periphery. Counts were conducted between 4 June and 12 July, dates that fall mostly within the 1 May to 10 July period recommended for breeding bird counts in northern portions of BC (RISC 1999). Although designed primarily for passerine birds, all species detected during each count were recorded, as recommended in BC’s songbird inventory guidelines (RISC 1999). As birds often move in response to a disturbance or a distraction, an individual can be missed during any five-minute count period even during peak territorial or chick-rearing times. For this reason, each count was scheduled to be replicated up to six times. However, interference from unsuitable weather and/or other logistical factors prevented a full set of replications at each site and the actual number of samples per site ranged from one to six.

No method detects all species with equal accuracy as frequency and duration of singing varies with species, population density, season, weather, and disturbance (Robbins 1981a, 1981b; Ralph et al. 1993; RISC 1999). Detectability even varies among habitats (Richards 1981). However, territorial singing of most passerine species is highest and most reliable around dawn (official sunrise), with song tapering off during the next four hours (Skirvin 1981; Ralph et al. 1993). For this reason, counts designed to determine overall composition of the breeding avifauna within a given area are conducted during those hours and we followed that protocol, conducting all counts within four hours of sunrise, as recommended in RISC (1999).

At each point count location observers waited approximately one minute after arriving before starting the 5 – minute count. All birds detected within the initial three-minute listening period were plotted by estimated distance from the centre point of a 75 m diameter plot on a standard form, using a standard set of symbols indicative of their behaviour on first detection (Ralph et al. 1993; RISC 1999). All birds detected during the next two subsequent minutes (3 – 5) [but not during the first three] were plotted on a second circle in the same manner (RISC 1999), rather than using differently coloured pencils in one circle (as recommended by Ralph et al. 1993). If a detected bird moved during the 5 – minute count, the direction of movement was indicated by an arrow on the count form.

Each count was conducted by one of five observers (Michael D. Bentley, Sandra Kinsey, Laird Law, Martin K. McNicholl or Thomas Plath) familiar with the songs and call notes of birds of the North American aspen parklands. Whenever feasible, at least some replications were conducted by an observer different from the one who conducted the original count to reduce potential biases caused by differences in hearing ability, degree of familiarity with local dialects in songs and call notes, familiarity with infrequent or localized call notes and other observer differences (Cyr 1981; Ramsey and Scott 1981; Robbins and Stallcup 1981; Ralph et al. 1993; RISC 1999).

Pointcounts were assigned to 1 of 10 habitat types based on the dominant vegetation occurring within 75 m of the pointcount center (Table 6). These general habitat types were used to assign habitat-associations for certain species so that comparisons of general habitat association could be made between the strata.

Table 6. General habitat types assigned to the songbird pointcount stations.

Code	Habitat values	Definition
1	Coniferous	Primarily coniferous forest
2	Deciduous	Primarily deciduous forest
3	Shrub	Shrub (Willow) habitats
4	Mixed: Coniferous-Deciduous	Mixed forest where coniferous trees are more abundant than deciduous
5	Mixed: Deciduous-Coniferous	Mixed forest where deciduous trees are more abundant than coniferous
6	grassland-cultivated fields	Grassland
7	marsh	Marsh / wetland / bog
8	Cliff	Cliff
9	Edge	Grassland/ woodland transition
10	Unclassified	Habitat type not indicated

2.4.2 Raptors (birds of prey)

Only 3 species of local raptors are listed by the BC Conservation Data Centre: one falcon, one buteo hawk and one owl. These species are listed Table 7.

Table 7. Blue-listed and red-listed raptors in the Peace River region (BC CDC 2005).

Species	Conservation Status[1]	Habitat Notes	Seasonality
Broad-winged Hawk *(Buteo platypterus)*	Blue	Broadleaf and mixed forest, prefers dense woods, less frequently in open woodland. Nests in trees often modifying old nests of other species.	May to September.
Peregrine Falcon *anatum* subspecies *(Falco peregrinus anatum)*	Red	Usually nests on a ledge of a cliff or other steep location.	May to October.
Short-eared Owl *(Asio flammeus)*	Blue	Open habitats especially grasslands, marshes and agricultural areas.	April to October.

[1] BC Conservation Data Centre: http://srmwww.gov.bc.ca/cdc/

Raptors are separated into two main groups. One group includes all of the owls and the other group includes all hawks, eagles, falcons, kites and the Osprey. About 18 species occur regularly during spring and summer in the Peace River region.

We surveyed for all diurnal and nocturnal raptors, with an emphasis on the three listed species using a combination of standard methods:

- Systematic boat, foot and roadside surveys were conducted within representative habitats
- Systematic replicated call playback surveys for selected owl species during day and night from specific locations in representative habitats

These standard techniques for determining relative abundance are described in detail by the Resources Inventory Committee (2001).

2.4.3 Owls

Many species of owls are surprisingly common although the paucity of records of some species tends to indicate otherwise. This is mainly due to the nocturnal habits of most owls. Owl surveys were limited to call-playback surveys and incidental observation. Because the timing of our field work did not coincide with the onset of breeding, call play-back surveys were used only to try and determine presence of owl species in the study area.

2.4.3.1 Call Playback Surveys

The use of call playback surveys takes advantage of the knowledge that most owls use songs and/or calls to establish and defend territories and to attract mates (Smith 1987). This is the primary quantifiable method that LGL uses to investigate the distribution and habitat use of owls. Owls respond to call playback by either vocalizing or approaching the call station, which allows detection by the observer who can then record the bird relative to the habitat type. However, our surveys did not occur at the time of year considered optimal for call-playback surveys (winter).

The precise time of year when the playback call surveys are conducted is quite critical (RISC 1997a). Different species begin nesting earlier than other species and the length of the various stages of the breeding cycle also differs between species. It is recommended that call playback surveys not be conducted when raptors are laying or in the early stages of incubation. Therefore we were not able to use call playback for some species early in the survey period when owls were likely to be laying or incubating. We made a determination based on literature review, local expert opinion, and our own observations as to which species we could broadcast calls for during a particular period. We adopted recommended procedures for conducting call playback surveys for raptors as reviewed and outlined by RISC (2001).

The calling station method is the recommended approach for conducting call playback surveys. This method consists of establishing and sampling from a series of playback stations in representative habitats. At each station, the call of each potential species is played and then the observers look and listen for a visual and/or audio response.

2.4.3.2 Other Survey Methods

In addition to these surveys, passive listening for birds (including owls) was used in a variety of habitats. Nocturnal listening station surveys often provide data that is unobtainable or less obtainable during the day. For example, the begging calls of young owls are distinctive, frequent and loud. Observations of owl families located in this way can provide important information about habitat use and other topics. Several other species are primarily vocal at night including the red-listed Nelson's Sharp-tailed Sparrow and the Red-listed Yellow Rail. Owl observations also occurred during songbird pointcount surveys.

2.4.4 Short-eared Owl

The Short-eared Owl presents a unique case among the owls in the Peace River study area. It is the only listed species (Blue-listed), migratory, mainly diurnal, and prefers open habitats. Call playback is not effective, as this species does not typically respond to broadcast calls. Incidental observations were used instead to assess breeding presence of the Short-eared Owl in the study area.

2.4.5 Eagles, Hawks and Falcons

Surveys for raptors included boat, vehicle (roadside), foot surveys, incidental observations, and an aerial survey. Table 8 lists the recommended survey techniques for raptor species that occur in the Peace River study area.

Of the 2 listed species in this group, Peregrine Falcon nest sites are expected to be fairly evident due to the specialized microsite (cliffs) and the loud vocalizations of the adults. The Broad-winged Hawk is very quiet and secretive during nesting but does have a distinctive call and often soars on hot days.

2.4.5.1 Aerial Survey

An aerial survey was flown on 4 July 2005 under favourable conditions: the sky was clear, the wind was less than 5 knots, and the temperature rose to approximately 22°C in the afternoon. The survey design followed the discussion of suitable approaches recommended by the Resources Inventory Committee for waterfowl and allied species (RISC 1999). Surveys were conducted using helicopter (Bell 206 Jet Ranger), which has superior accuracy compared to fixed-wing, and several other important advantages: slower speed, greater maneuverability, superior visibility, and variable flight heights (RISC 1999). A maneuverable aircraft was a necessity to survey the shoreline along both the north and south bank, as well as around islands, and to determine the location of large raptor or heron nests. A helicopter also allowed us to circle concentrations of birds once or twice to better determine species composition and estimate numbers. The aerial survey's main objective was to determine species composition, distribution, habitat, and relative abundance of birds, and to document the location of large raptor or heron nests.

The survey began at approximately 0845 hours and continued through approximately 1545 hours. During this time both the north and south banks of the Peace River were surveyed as well as mid-channel islands and portions of the Pine, Moberly, Beatton, Halfway, and Kiskatinaw Rivers (MAP). The Peace River was surveyed from the Alberta / BC border to the Peace Canyon Dam. The survey track followed the mainstem approximately 50 m from shore, periodically breaking off to cover adjacent back channels, and other floodplain wetlands.

We flew at an altitude of approximately 50 m and a survey speed of about 120 km/hour. Observers (2) seated in the front left and rear right of the helicopter observed wildlife with the naked eye, occasionally assisted by binoculars. The aircraft intercom allowed communication among the survey crew and pilot. In addition to observing wildlife, the forward observer (MB.) acted as navigator, and the rear observer (TP.) recorded observations on tape, linking each record with a registration number from the helicopter's GPS system. We also used a Garmin GPS 12 handheld GPS receiver to track the route of the helicopter.

Table 8. Status and recommended inventory technique for raptors that may occur in the Peace River area during the study.

Common Name	Scientific Name	Conservation Status[1]	Recommended Inventory Technique for Relative Abundance (RISC)	Timing of Survey(s)
Osprey	*Pandion haliaetus*	Yellow List	Aerial, boat and ground transects	Early June
Bald Eagle	*Haliaeetus leucocephalus*	Blue List	Aerial, boat and ground transects	Early June
Northern Harrier	*Circus cyaneus*	Not Listed	Aerial and ground transects	Early May
Sharp-shinned Hawk	*Accipiter striatus*	Not Listed	Call playback	Late May-Early June
Northern Goshawk	*Accipiter gentilis atricapillus*	Yellow List	Call playback	Late May-Early June
Broad-winged Hawk	*Buteo platypterus*	Blue List	Stand watch	
Red-tailed Hawk	*Buteo jamaicensis*	Not Listed	Aerial, boat and ground transects	Early June
Golden Eagle	*Aquila chrysaetos*	Not Listed	Aerial, boat and ground transects	Late May-Early June
American Kestrel	*Falco sparverius*	Not Listed	Aerial, boat and ground transects	Early June
Merlin	*Falco columbarius*	Not Listed	Aerial, boat and ground transects	Early June
Peregrine Falcon *anatum* subspecies	*Falco peregrinus anatum*	Red List	Aerial, boat and ground transects	Late May-Early June
Great Horned Owl	*Bubo virginianus*	Not Listed	Call playback	April
Northern Hawk Owl	*Surnia ulula*	Not Listed	Call playback	April
Northern Pygmy-Owl	*Glaucidium gnoma californicum*	Not Listed	Call playback	May
Barred Owl	*Strix varia*	Not Listed	Call playback	April
Great Gray Owl	*Strix nebulosa*	Not Listed	Call playback	April
Short-eared Owl	*Asio flammeus*	Blue List	Aerial and ground transects	May
Boreal Owl	*Aegolius funereus*	Not Listed	Call playback	May
Northern Saw-whet Owl	*Aegolius acadicus*	Not Listed	Call playback	May

[1] BC Conservation Data Centre: http://srmwww.gov.bc.ca/cdc/

2.4.5.2 Roadside Surveys

Road transects were surveyed following RISC (2001). Vehicle speed ranged from 15-40 km/hr along roads in the core and periphery strata of the Peace River study area. Typically two people occupied the vehicle with one driver and one observer. In some cases, however, one person drove the vehicle and stopped at raptor sightings to record data. A Garmin GPS handheld GPS receiver was used to document the route traversed during surveys and to georeference raptor sightings. Efforts were made to replicate road surveys so that a minimum of three surveys occurred per section of road; however, in most cases, roads were surveyed only one or two times.

2.4.5.3 Boat Surveys

Raptor surveys of the Peace River and larger tributaries occurred in conjunction with boat surveys for waterfowl. A Garmin hand-held GPS unit was used to georeference all raptor observations, including nests.

2.4.5.4 Other Methods for Obtaining Data about Hawks, Eagles, and Falcons

Raptor observations were also made through incidental observations and through observations made while scanning the skyline at selected locations along the Peace River. For example, there were several look-outs along Highway 29 that provided an excellent view of the Peace River, the floodplain of the Peace River, agricultural fields adjacent to the Peace River, and cliff and forest habitats.

2.4.6 Waterfowl and Other Waterbirds

Waterfowl (swans, geese, and ducks) and other waterbirds such as loons (*Gavia* spp.), grebes (*Podiceps* spp.), Sandhill Crane, American Bittern, and shorebirds (Scolopacidae, Charadriidae) make up an important component of the avifauna of British Columbia. More than 50 species in this group occurs in the Peace River region of British Columbia.

Four species, American Bittern, Trumpeter Swan, Surf Scoter, and Sandhill Crane are blue-listed (vulnerable/sensitive). Various other species are yellow-listed indicating more emphasis on management. The Harlequin Duck is of special interest in the Peace River area.

Relative abundance and distribution of waterfowl and other waterbirds was determined mainly through boat surveys and an aerial survey of the Peace River as well as lower sections of its main tributaries and wetlands in the area. Table 9 lists most of the regular waterfowl and waterbirds, their conservation status and recommended survey techniques and timing.

Table 9. Status and recommended inventory techniques for waterfowl and other similar waterbirds that occur in the Peace River area.

Common Name	Scientific Name	Status[1]	Recommended Inventory Method	Survey Timing
Common Loon	*Gavia immer*	Not Listed	Aerial and boat surveys	Mid June
Horned Grebe	*Podiceps grisegena*	Not Listed	Aerial and boat surveys	Mid June
American Bittern	*Botaurus lentiginosus*	Blue Listed	Aerial and boat surveys	Mid June
Trumpeter Swan	*Cygnus buccinator*	Blue Listed	Aerial and boat surveys	Mid June
Canada Goose	*Branta canadensis*	Yellow Listed	Aerial and boat surveys	Mid June
Green-winged Teal	*Anas crecca*	Yellow Listed	Aerial and boat surveys	Mid June
Mallard	*Anas platyrhynchos*	Yellow Listed	Aerial and boat surveys	Mid June
Northern Pintail	*Anas acuta*	Yellow Listed	Aerial and boat surveys	Mid June
Blue-winged Teal	*Anas discors*	Yellow Listed	Aerial and boat surveys	Mid June
American Wigeon	*Anas americana*	Yellow Listed	Aerial and boat surveys	Mid June
Ring-necked Duck	*Aythya collaris*	Yellow Listed	Aerial and boat surveys	Mid June
Lesser Scaup	*Aythya affinis*	Yellow Listed	Aerial and boat surveys	Mid June
Harlequin Duck	*Histrionicus histrionicus*	Yellow Listed	Aerial and boat surveys	Mid June
Surf Scoter	*Melanitta perspicillata*	Blue Listed	Aerial and boat surveys	Mid June
White-winged Scoter	*Melanitta fusca*	Yellow Listed	Aerial and boat surveys	Mid June
Common Goldeneye	*Buchephala clangula*	Yellow Listed	Aerial and boat surveys	Mid June
Barrow's Goldeneye	*Buchephala islandica*	Yellow Listed	Aerial and boat surveys	Mid June
Bufflehead	*Buchephala albeola*	Yellow Listed	Aerial and boat surveys	Mid June
Common Merganser	*Mergus merganser*	Yellow Listed	Aerial and boat surveys	Mid June
American Coot	*Fulica americana*	Not Listed	Aerial and boat surveys	Mid June
Sandhill Crane	*Grus canadensis*	Blue Listed	Aerial and boat surveys	Mid June

[1] BC Conservation Data Centre: http://srmwww.gov.bc.ca/cdc/

2.4.6.1 Aerial Surveys for Waterfowl

Refer to section 2.4.5.1 for details on the aerial survey.

2.4.6.2 Boat Surveys

Boat surveys were used to inventory waterfowl use of the Peace River and coincided with song-bird point count surveys and traveling the river to and from camping locations. One person operated the boat during surveys while a second person counted birds and georeferenced the location of each bird sighting using a Garmin handheld GPS receiver. The GPS unit was also used to map the area sampled during each boat survey. The entire length of the Peace River from approximately Hudson's Hope to the Alberta border was surveyed at least once, with several sections surveyed more than one time.

2.5 Amphibians and Reptiles

Five species of amphibians may occur in the project area (Table 10) (Green and Campbell 1984; Corkran and Thoms 1996; CARCN 1999; Wiacek 1998; Matsuda et al. in press). The Western Toad (*Bufo boreas*) and the Wood Frog (*Rana sylvatica)* were documented in the floodplain of the Peace River during 1999 surveys (Hawkes and Fraker 2000). Data from 1975 surveys suggest that the Boreal Chorus Frog (*Psuedacris triseriata*), the Columbia Spotted Frog (*Rana luteiventris*), and the Long-toed Salamander (*Ambystoma macrodactylum*) also occur in the study area, at least on the south bank of the Peace near the Pine River. During reconnaissance-level surveys of the Williston Reservoir watershed, Hengeveld (1999) documented eggs, tadpoles, juveniles, or adults of Long-toed Salamanders, Western Toads, Columbia Spotted Frogs, and Wood Frogs; Boreal Chorus Frogs were not detected and Long-toed Salamanders were not detected in the Peace system (Hengeveld 1999). Two species of garter snakes have the potential of occurring in the floodplain of the Peace River. One species, the Common Garter Snake (*Thamnophis sirtalis*) occurs in the floodplain of the Peace River (Hawkes and Fraker 2000) and another (the Western Terrestrial Garter Snake, *T. elegans*) may occur based on distribution data (Gregory and Campbell 1984). Of the reptiles and amphibians that could be found in the study area, only the Western Toad has any conservation status (COSEWIC: Species of Special Concern).

Table 10. Provincial and National status of amphibians and reptiles that occur in the Peace River area.

Scientific Name	Common Name	BC Status[1]	COSEWIC Status
Ambystoma macrodactylum	Long-toed Salamander	Yellow	Report Under Review
Bufo boreas	Western Toad	Yellow	Special Concern
Pseudacris maculata	Boreal Chorus Frog	Yellow	Not assessed
Rana luteiventris	Columbia Spotted Frog	Yellow	Not at Risk
Rana sylvatica	Wood Frog	Yellow	Not assessed
Thamnophis elegans	Western Terrestrial Garter Snake	Yellow	Not assessed
Thamnophis sirtalis parietalis	Common Garter Snake	Yellow	Not assessed

[1] BC Conservation Data Centre: http://srmwww.gov.bc.ca/cdc/

2.5.1 Field Methods

Surveys for amphibians and reptiles occurred in the core and periphery strata and followed Resources Inventory Standards Committee (RISC) protocols. For amphibians, we used *Inventory Methods for Pond-breeding Amphibians and Painted Turtle* (RISC 1998a) and for snakes we used *Inventory Methods for Snakes* (RISC 1998b). Heyer et al. (1994) provides additional suitable and applicable survey methodology for conducting terrestrial time-constrained surveys, primarily for amphibians; these methods are applicable to snakes as well.

Field surveys for metamorphosed juveniles and adult amphibians consisted mainly of time-constrained searches at suitable habitats, which for pond-breeding amphibians were marshes, ponds, and roadside ditches with emergent vegetation. The long-toed salamander is bi-phasic, spending most of its life on land and returning to ponds to breed in the spring. Therefore, we also searched for this species in forested areas with high volumes of coarse woody debris (CWD). Time-constrained searches for snakes occurred in similar habitats, as well as at the interface between grassy habitats and shrub or forest habitats. Other areas like roadsides, gravel pits, and gravel bars, and power line right-of-ways were also searched. Searches for amphibian tadpoles consisted primarily of dipnetting at breeding habitats in both the core and periphery strata. Habitats were visually assessed as suitable for breeding prior to searching.

Survey efforts were concentrated at potential breeding habitats such as off channel and back water habitats, ponds / pools within the floodplain of the Peace River, and wetland / pond habitats that occur within the 2000 m core survey area on either side of the Peace River. Moreover, habitats that were previously surveyed in 1999 (see Hawkes and Fraker 2000) were revisited to evaluate species presence and persistence. Aquatic habitats were the prominent habitat type surveyed but we also surveyed upland dispersal habitat and forested riparian habitats along the banks of the Peace River and forested islands within the Peace River were also included.

The terms of reference for this project indicated that it would be ideal to determine the relative abundance of amphibians in the floodplain of the Peace River. For pond-breeding amphibians, this would require the use of systematic surveys, larval surveys, and pitfall trapping. We did not use pitfall trapping for several reasons. The best time to use pitfall traps for anurans (and the Long-toed Salamander), is early in the breeding season so that adults migrating to breeding ponds can be captured. However, the onset of breeding had occurred prior to our field work, thereby reducing the efficacy of pitfall trapping for pond-breeding amphibians. Additionally, because small mammals were not part of the Terms of Reference, we did not use pitfall trapping so that we could avoid trapping (and killing) small mammals unnecessarily. Furthermore, pitfall traps produce varying degrees of success for different species of amphibians. For example, Hawkes (unpublished data) found that common species of amphibians were not always detected using pitfall traps (in this case western redbacked salamanders, *Plethodon vehiculum*) and that time-constrained searches of suitable habitat types always resulted in their detection.

Determination of relative abundance (e.g., number of animals per unit area or number of animals caught per unit time) was determined for amphibian populations in both the core and periphery strata. Data collected in 2005 was compared to Hawkes and Fraker (2000) to evaluate any temporal shifts in relative abundance that may have occurred since 1999, although any results obtained will be spurious given the large annual variation inherent in amphibian count data.

2.5.1.1 Time-constrained Searches

A time–constrained search is an efficient means to determine the presence of amphibians and reptiles in an area containing suitable habitat (RISC 1998a; Scott 1994). By focusing the survey effort on areas of suitable habitat, the overall time required to survey an area decreases. Furthermore, the likelihood of encountering the target species increases because all survey effort will be spent in habitat types that have been known to harbor the target species in other areas.

Long-toed Salamanders are a species of mole salamander that spend much of their time inside logs or under ground their making the detection difficult. However, searches for this species in suitable habitats (riparian forests with abundant leaf litter and woody material) should result in detection (RISC 1998a; Corkran and Thoms 1996; Olsen 1999). Suitable habitat was located by examining aerial photos and by searching the habitat plots while on the ground. Additionally, 1:5,000 orthophotos produced for BC Hydro by Chillborne Environmental Ltd. (1999) were assessed for the distribution of suitable habitats (as per Hawkes and Fraker 2000) Areas identified by Hawkes and Fraker (2000) were revisited. Time-constrained searches were conducted by lifting suitable cover objects (rocks and woody debris) and searching the area beneath them. All displaced habitat features were returned to their original position to minimize habitat disturbance.

2.5.1.2 Data Collection

All data were recorded on either the *Animal Observation Form - frog Auditory Survey, Animal Observation Form - Pond-Breeding Amphibians Road Survey* or the *Animal Observation Form - Pond-Breeding Amphibians/Painted Turtle Search* – Adult (RISC 1998c). When amphibians or reptiles were captured they were weighed using Pesola® scales to the nearest 0.25 gram, measured (snout-vent length and total length), categorized by age class and sex (if possible), photographed, and released at the site of capture. The location of each capture was documented on maps of the project area with UTM coordinates for each capture location obtained using a Garmin GSP 12 handheld GPS receiver. Habitat information was collected including air temperature, relative humidity, water temperature (if relevant), habitat type, canopy cover, forest age, dominant tree species, microsite feature and species, and any other relevant site-specific information. Photographs of most sites sampled were taken.

2.6 Rare and Endangered Plant Communities

The objective of this component of the study was to: "confirm the occurrence, distribution and abundance of rare and sensitive species". Because the Terms of Reference emphasized inventory of rare plants, our study design and methods focused on the detection of those species. A more general survey approach is usually inadequate for rare plants (RISC 1999). In addition to documenting rare plants we also documented all species of vascular plants observed in both the core and peripheral strata of the study area.

2.6.1 Surveys for Rare Plants

Surveys for rare plants occurred between 20 July and 5 August 2005. Prior to commencing field work, the BC CDC was queried for the known distribution of rare plants in the Peace River study area. In total, a list containing 27 red and blue-listed plant taxa was developed for riparian habitats and associated lower grass/shrub slopes for the Peace River district; these taxa became the main taxa of interest for this study. In addition to documenting the presence and distribution of rare plant taxa in the core and periphery strata we also developed extensive plant lists for the study area. Based on our previous collecting experience in this area we paid special attention to the habitats that were most probable sites of the rare and unusual species.

Sample locations were selected first by looking at satellite and aerial imagery of the study area. Additional sample sites were selected opportunistically and as access allowed. Many areas in the core stratum were accessed by boat. We also visited sites that we had visited in other years to determine if rare plants continued to persist in these areas. All sample locations were documented using GPS and mapped. Voucher specimens of rare species and species that were impossible to identify in the field were collected, pressed and processed in the herbarium specimens. Voucher specimens will be deposited in the UBC Herbarium.

We visited areas throughout the core and periphery strata; however, we were not able to access the area to the south of the Peace River (Boudreau Lakes) because of inclement weather and treacherous road conditions.

2.7 Statistical Analyses

SAS v. 9.1 (© 2002-2003 by SAS Institute Inc., Cary, NC, USA.) was used for most statistical analyses. Other analyses were done using Microsoft Excel 2002. Paired t-tests, one-way ANOVA, and two-way ANOVA were used to test for differences in bird species occurrence (presence), relative abundance, and habitat use between the core and periphery strata. Morisita's index (Morisita 1959; Horn 1966; Brower et al. 1990) was used to measure community similarity and is based on Simpson's index of dominance (Simpson 1949). Morisita's index calculates the probability that specimens randomly drawn from two sites will be of the same species, relative to the probability that specimens randomly drawn from the same site will be of the same species. This index is desirable because sample size and diversities of the samples have little influence on its calculation (Morisita 1959; Wolda 1981). We used it to compare songbird species similarity between habitat strata (core and periphery) and within habitat types sampled. Morisita's index gives a value from 0.0 (no similarity) to 1.0 (identical) and was chosen because it is affected little by sample size. Only songbirds detected within 75 m of the pointcount center were used in the analyses.

3. Results

3.1 Habitat Capability / Suitability Modeling

3.1.1 Model Development

Habitat Suitability Index models were developed for the following seven species:

Common Name	Code	Scientific Name	Model Life Requisite
Black-throated Green Warbler	BTNW	*Dendroica virens*	Reproductive Habitat
Canada Warbler	CAWA	*Wilsonia canadensis*	Reproductive Habitat
Connecticut Warbler	COWA	*Oporornis agilis*	Reproductive Habitat
Cape May Warbler	CAMA	*Dendroica tigrina*	Reproductive Habitat
Philadelphia Vireo	PHVI	*Vireo philadelphicus*	Reproductive Habitat
Boreal Owl	BOOW	*Aegolius funereus*	Reproductive Habitat
Barred Owl	BAOW	*Strix varia*	Reproductive Habitat

Complete model documentation for each species can be found in Appendix I.

3.1.2 Habitat Variables

For the seven HSI models, a total of 17 habitat variables were identified for which Suitability Index (SI) relationships were developed for each model (Table 11). Variables were divided into five functional groups dictated by the type of variable and source of information required or available to parameterize each variable: species composition, structural, age, topographic, and spatial.

Habitat types in the TEM are defined as ecosystem units, modified by a combination of up to two site modifiers, which represent a combination of characteristic vegetative and biophysical features of the TEM polygons (RISC 1998d). Each unique ecosystem unit polygon is also ascribed a structural stage. Because the TEM coverage does not contain structural or compositional attribute information required to parameterize the HSI models, predictive relationships needed to be established between TEM attributes and HSI model variables (Table 12). Details on the development of TEM attribute – habitat variable relationships and associated data transformations can be found in Appendix X.

Species Composition

The TEM coverage developed for the Peace River core stratum does not contain attribute information for the composition of any vegetative strata (i.e. tree, shrub, herb, bryophyte) within ecosystem units (Keystone Wildlife Research 2006). Therefore, to parameterize HSI model species composition variables, it was necessary to establish predictive relationships between ecosystem units and percent species composition. This was accomplished by combining an analysis of field plot attribute data (VPro) collected during TEM field verification activities in 2005 and provided by Keystone Wildlife Research in an output summary table (Lauren Simpson, personal communication), with information obtained from the ecosystem site guide for the

BWBS (LMH22, DeLong et al. 1990), as well as descriptions from the provincial wetland identification guide (LMH 52, Mackenzie and Moran 2004).

The VPro output contained a summary of 296 full ecosystem and Ground Information Form (GIF) plots. It was assumed that VPro plot data was collected in climax sites (mature and old structural stages 6 and 7 respectively), although this may not necessarily be the case. For each plant species within each ecosystem unit in the VPro output data, a percent presence is provided, followed by mean percent cover. Percent presence is the proportion of sample plots containing a particular plant. Percent cover is the proportion of a plot covered by the foliage of each species.

Plot data was limited for some ecosystems (< 5 plots) and ranged up to 53, with the average around 20 for all other ecosystem units (Lauren Simpson, personal communication). Results for those ecosystsem units with limited plot data were interpreted cautiously, and supplemented with information from the site and wetland guides to facilitate model variable parameterization.

Structural and Age Variables

Tree height and tree size (diameter at breast height) were not measured during TEM field validation and crown closure varied significantly within ecosystem unit and structural stage (Lauren Simpson, personal communication). Therefore the range of canopy closure and the presence of large trees anticipated to be found in habitat types was predicted by the structural stage of the ecosystem unit. Predicted relationships between structural stage and structural variables were developed based on site guide information, stand composition (e.g. tree species) and best available expert opinion. Structural stage was also presumed to be representative of stand age. This association was established on corresponding age / structural stage relationships in the TEM guidelines (RISC 1998d) in combination with presumed age / structural stage relationships specific to the composition of stands in the study area.

Topographic and Spatial Variables

The topographic variables of slope and floodplain were generated through the identification of suitable site modifiers in the TEM. Spatial variables were determined through GIS analysis of area and distance.

Table 11: Peace River wildlife Habitat Suitability Index (HSI) models: list of habitat variables.

Habitat Variable (S)	CAWA	PHVI	COWA	CAMA	BTNW	BOOW	BAOW
Species Composition:							
% Tall Shrub Understorey Cover	x						
% Herbaceous Understorey Cover			x				
% Deciduous in Tree Canopy	x	x	x				
% Trembling Aspen (At) in Tree Canopy						x	x
% White Spruce (Sw) in Tree Canopy				x	x	x	x
% Black Spruce (Sb) in Tree Canopy						x	x
% Balsam Fir (Bl) in Tree Canopy						x	x
% Lodgepole Pine (Pl) in Tree Canopy						x	
Structural:							
Stems/Hectare Large Live and Dead Trees						x[1]	x[1]
% Canopy Closure		x[1]				x[1]	x[1]
Age:							
Structural Stage[2]	x	x	x	x	x	x	x
Topographic:							
Slope	x						
Floodplain	x						
Spatial:							
Stand Area	x		x		x		
Distance from Human Disturbance							x
Distance from Opening							x

[1] canopy closure and presence of large trees are predicted by structural stage of the stand.

[2] structural stage is assumed to be representative of stand age.

Table 12. Habitat variables for which predictive associations with TEM attributes[1] were established.

Model Variable	Description and Associated TEM Attributes	Data Source
Species Composition		
% Tall shrub understorey cover	1.5-4.0m tall, continuous, association with EU[1], site modifiers[1] and StrcStg[1]	Site Guides (BWBSmw1, Wetland) VPro plot data, TEM[1]
% Herbaceous understorey cover	All species, continuous, association with EU, site modifiers and StrcStg	Site Guides (BWBSmw1, Wetland) VPro plot data, TEM
% Deciduous in tree canopy	Continuous, association with EU and site modifiers	Site Guides, VPro plot data, TEM
% At in tree canopy	Continuous, association with EU and site modifiers	Site Guides, VPro plot data, TEM
% Sw in tree canopy	Continuous, association with EU and site modifiers	Site Guides, VPro plot data, TEM
% Sb in tree canopy	Continuous, association with EU and site modifiers	Site Guides, VPro plot data, TEM
% Bl in tree canopy	Continuous, association with EU and site modifiers	Site Guides, VPro plot data, TEM
% Pl in tree canopy	Continuous, association with EU and site modifiers	Site Guides, VPro plot data, TEM
Structural		
Stems/ha large live and dead trees	≥30cm dbh, continuous, predicted association with EU and StrcStg	Site Guides (BWBSmw1, Wetland)
% canopy closure	Continuous, predicted association with EU and StrcStg	Site Guides (BWBSmw1, Wetland)
Age		
Structural Stage	Discrete	Site Guides (BWBSmw1, Wetland)

[1]TEM coverage attributes include ecosystem unit (EU, two letter code), seral association, site modifiers (a to z), structural stage (StrcStg), and structural stage modifier (a,b,c).

3.1.3 Model Implementation

HSI models were applied in Arc GIS 9.0. Scripts were developed in Fox to link model variable lookups to the TEM dataset to produce HSI values for each TEM polygon. These values were then reclassified to the 4 point provincial scale recommended for birds (RISC 1999) based on the rule of thirds (Nil=0, Low= (>0-33.3), Moderate=> (33.3-66.6), High= (>66.6-100).

Complex TEM polygons, where there were 2 or 3 ecosystem types within one polygon, were rated through the application of ratings for individual habitat variables for each ecosystem type combined through a weighted sum into a final suitability score for the entire polygon. The final habitat suitability output tables are .dbf tables allocating habitat suitability values for all TEM polygons in the core study area.

The models were applied to a draft version of the TEM (February 14, 2006) and data quality control issues created a number of attribute field errors such as incorrect characters in fields, blank cells, mis-coded ecosystem units, and incorrect polygon complexes (i.e. deciles adding up to > 10). Polygons with character errors in fields were ascribed a default value of Nil. Complex polygons where deciles added up to > 10 were not given a rating. Models were run on the full TEM dataset of 5,062 polygons.

3.1.4 Model Evaluation

Model outputs were visually evaluated relative to knowledge of ecosystem types and distributions in the core study area, 2005 survey data, and available location / occurrence data for the area, and model relationships were tested on sub-sets of TEM data to assess model performance. Draft models were modified to reflect results of these evaluations and final model documentation updated (Appendix I).

3.1.5 Model Performance

In total, 54,902.2 hectares of the core study area were rated for their habitat value for the passerine and owl species selected for modeling. Area in suitable habitat for each species is summarized in Table X.

Table 13. Area in suitable habitat for model species.

	Area in Suitable Habitat				
Species	**High**	**Moderate**	**Low**	**Nil**	**Total Area of Suitable Habitat**
BTNW	1996.5	2872.0	27277.9	22755.8	32146.4
CAWA	253.3	10731.0	28716.4	15201.5	39700.7
CMWA	79.4	1698.7	1981.5	51142.6	3759.6
COWA	5745.9	5240.0	11037.9	32878.4	22023.8
PHVI	12.8	14335.2	7597.9	32956.2	21945.9
BAOW	*715.7*	*496.4*	*270.5*	*43419.6*	1482.6
BOOW	1229.0	619.9	14909.8	38143.5	16758.7

Maps of HSI outputs for each species are provided in Appendix XI.

HSI models general have a density related performance indicator (e.g. number of breeding pairs per hectare), and model outputs are frequently reported as Habitat Units to facilitate estimates of breeding density in geographic areas modeled. Habitat Units are calculated by multiply the HSI score for the polygon by the number of hectares. The current poor state of information on model species for the Peace River study area does not allow the estimation of breeding or population densities related to habitat value. In addition, the 0 to 1.0 HSI values were re-classified to a four-point provincial scale. Therefore, Habitat Units were not calculated for the project.

3.2 Butterflies

Butterflies were identified from 64 sample sites within the Peace River study area, 33 in the Core stratum, 28 in the Periphery stratum, and three unknown. Fifty-four unique locations, for which grid references were collected, are presented in Map 1; 30 of these were located in the Core stratum and 24 in the Periphery (Map 1).

Sample sites were not evenly distributed throughout the study area. The majority of sample sites were located on the north side of the Peace River (46 sites). Only 16 sites were located on the southern side of the river due to limited road access and poor weather during the sampling period allocated to this side of the river. In addition to the southern side of the Peace River west of Highway 37 (particularly around the Pine River), other sampling gaps evident from Map 1 include: Hudson's Hope, the Halfway River, Charlie Lake and areas to the north and north-east of Charlie Lake, the Beatton River, the Alces River, and the Kiskatinaw River.

Seven Broad Ecosystem Inventory (BEI) Units of the 14 BEI Units present in the Peace Lowland Ecosection (Resources Inventory Committee 1998) were sampled for butterflies, with most sites located in Boreal White Spruce – Lodgepole Pine (BP) and Cultivated Fields (CF) (Fig. 2). This latter result is a product of the coarse resolution of the BEU data (1:250 000); in reality these sites were located in disturbed roadside areas containing remnant native vegetation adjacent to cultivated fields. No Montane Shrub/Grassland BEI Unitss were sampled in the Periphery stratum (Fig. 2), primarily because this Unit is poorly represented in this stratum (Fig. 3).

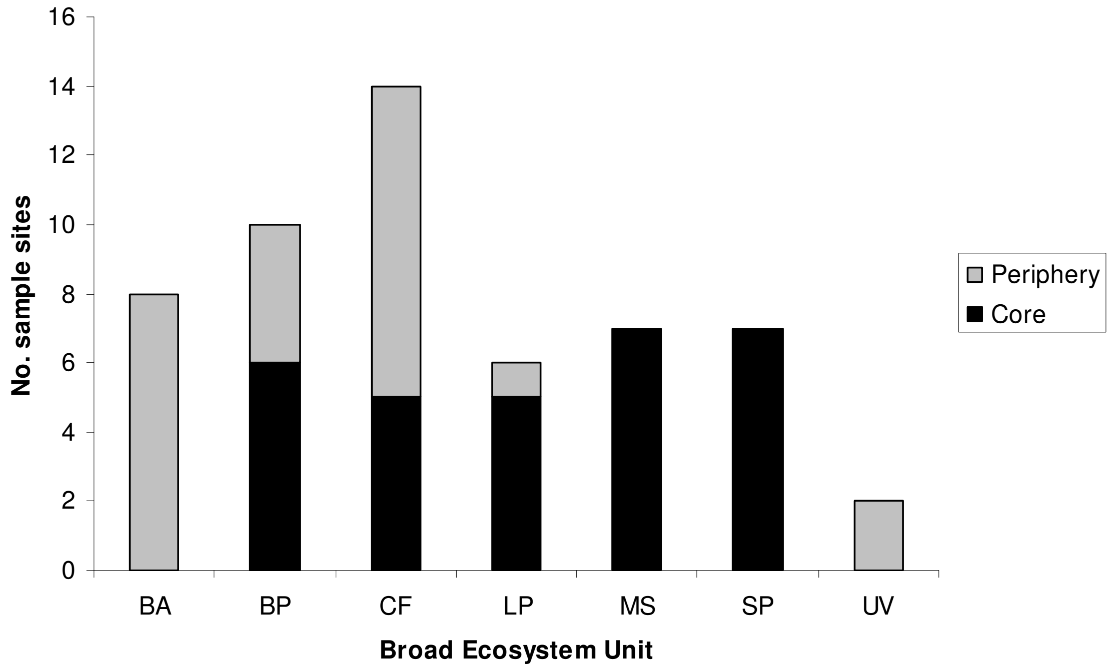

Figure 2. Distribution of Core and Periphery butterfly sample sites by Broad Ecosystem Units (RISC 1998). BA: Boreal White Spruce – Trembling Aspen; BP: Boreal White Spruce – Lodgepole Pine; CF: Cultivated Field; LP: Lodgepole Pine; MS: Montane Shrub/Grassland; SP: Slow Perennial Stream; UV: Unvegetated.

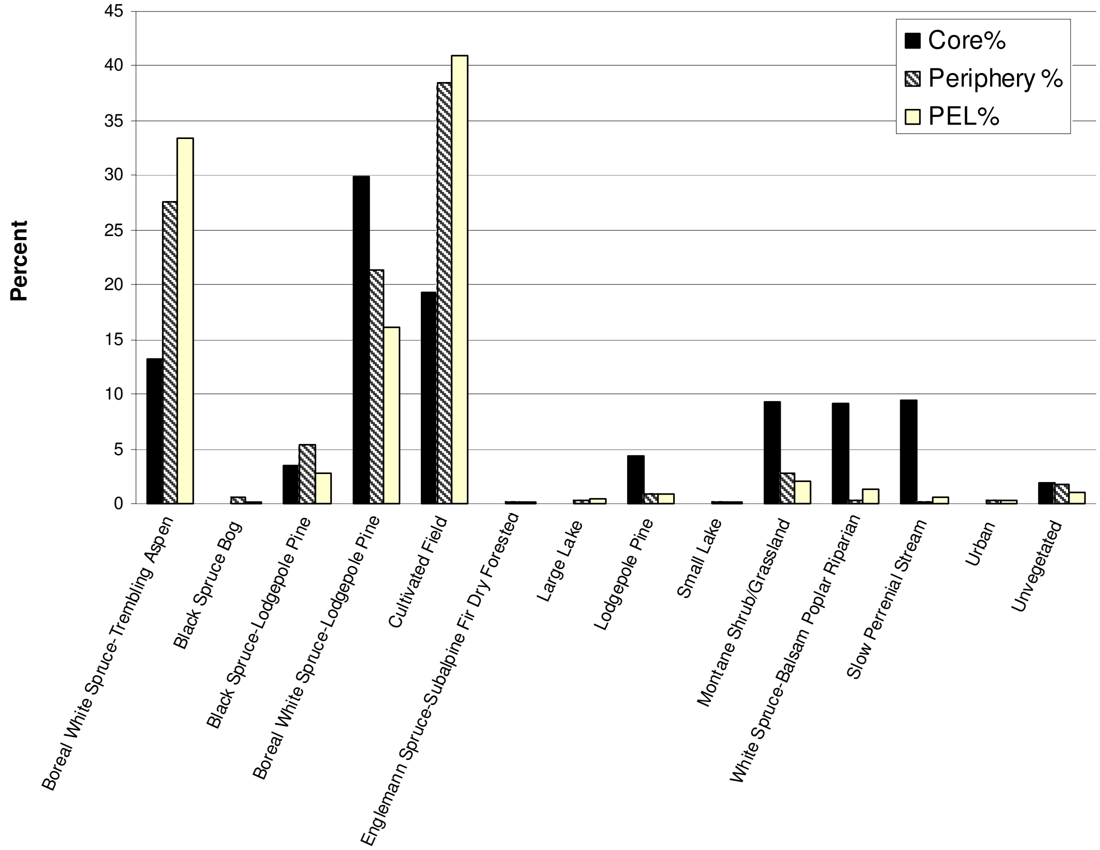

Figure 3. Percentage of Broad Ecosystem Inventory (BEI) Units within the Core stratum (a 4-km-wide buffer centered on the Peace River; 57,400 ha), in an area approximating the Periphery stratum (a 20-km-wide buffer around and excluding the Core stratum; 299,700 ha), and in the entire Peace Lowland Ecosection (PEL; 917,310 ha). BEI (including ecosection information) data were obtained 4 July 2003 from http://srmwww.gov.bc.ca/ecology/bei/base_data.html.

Butterflies were identified from within 13 Terrestrial Ecosystem Units (Keystone Wildlife Research 2006) within the Core stratum (Table 14). More sites (8) were located in White Spruce Trembling Aspen - Step moss than in other TEM Units. Six TEM Units were sampled only once.

In all, 264 butterfly specimens (of ~305 that were collected or photographed) were given an identification status of "certain" or "probable". Of those, 54% were from the Core stratum and 41% were from the Periphery stratum. From these sites, 41 butterfly (sub) species were recorded in the entire study area (Table 14), of which 17 species were unique to the Core stratum, six were unique to the Periphery stratum, and 18 were common to both. A complete list of butterfly species that have been recorded from the Peace River area in this and other studies is presented in Appendix III.

Table 14. Species list of butterflies detected in the Peace study area in 2005. The confidence-level of each specimen identified was rated as probable or certain. Status from the BC CDC.

Species	Common Name	Identification	Status
Boloria bellona	Meadow Fritillary	Certain	
Boloria chariclea	Arctic Fritillary	Certain	
Carterocephalus palaemon mandan	Arctic Skipper	Certain	Blue
Celastrina ladon lucia	Boreal Spring Azure	Certain	
Cercyonis oetus	Small Wood-nymph	Certain	
Cercyonis pegala ino	Common Wood-nymph	Certain	Blue
Coenonympha tullia benjamini	Common Ringlet	Certain	Blue
Colias christina	Christina's Sulphur	Certain	
Colias gigantea	Giant Sulphur	Certain	
Colias interior	Pink-edged Sulphur	Certain	
Colias philodice	Clouded Sulphur	Certain	
Erebia epipsodea	Common Alpine	Certain	
Erynnis persius	Persius Duskywing	Certain	
Everes amyntula	Western Tailed-blue	Certain	
Glaucopsyche lygdamus	Silvery Blue	Probable	
Hesperia comma assiniboia	Common Branded Skipper	Certain	Blue
Limenitis arthemis arthemis	White Admiral	Certain	
Lycaeides idas	Northern Blue	Certain	
Lycaena dorcas	Dorcas Copper	Certain	
Lycaena hyllus	Bronze Copper	Certain	
Nymphalis antiopa	Mourning Cloak	Certain	
Nymphalis milberti	Milbert's Tortoiseshell	Certain	
Oarisma garita	Garita Skipperling	Probable	
Papilio canadensis	Canadian Tiger Swallowtail	Certain	
Papilio machaon pikei	Baird's Swallowtail	Certain	Blue
Papilio rutulus	Western Tiger Swallowtail	Probable	
Phyciodes campestris	Field Crescent	Certain	
Phyciodes tharos	Pearl Crescent	Certain	
Pieris napi	Mustard White	Certain	
Pieris rapae	Cabbage White	Certain	
Plebejus saepiolus	Greenish Blue	Certain	
Polygonia faunus	Green Comma	Certain	
Polygonia satyrus	Satyr Angelwing	Certain	
Satyrium titus titus	Coral Hairstreak	Certain	Blue
Speyeria aphrodite manitoba	Aphrodite Fritillary	Certain	Blue
Speyeria atlantis hesperis	Northwestern Fritillary	Certain	
Speyeria atlantis hollandi	Atlantis Fritillary	Probable	
Speyeria cybele pseudocarpentari	Great Spangled Fritillary	Certain	Blue
Speyeria mormonia	Mormon Fritillary	Certain	
Thorybes pylades	Northern Cloudywing	Certain	
Vanessa cardui	Painted Lady	Certain	

Just over half (22) of the 41 butterfly species identified from the study area were found at only one or two sample sites (Figure 4). Four species, *Phyciodes campestris* (Field Crescent), *Cercyonis oetus* (Small Wood-nymph), *Speyeria atlantis hesperis* (Northwestern Fritillary), and *Phyciodes tharos* (Pearl Crescent) were relatively widely distributed, occurring in ten or more sample sites.

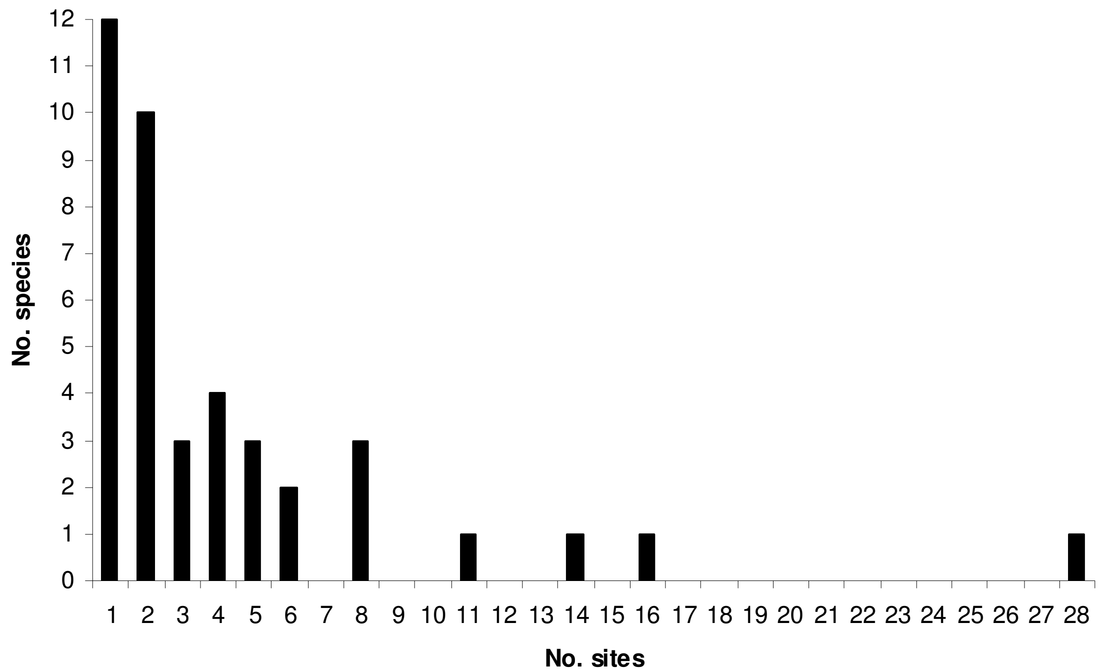

Figure 4. Frequency of occurrence of butterfly species identified in the Peace River study area.

More species were identified from disturbed roadside areas containing remnant native vegetation adjacent to cultivated fields (CF) than any other BEI Unit (Figure 5). Sixteen species were collected from Montane Shrub/Grassland (Figure 5).

More than five butterfly species were identified from each of four TEM Units in the Core stratum: White Spruce Trembling Aspen - Step moss (AM), Exposed soil (ES), Red-osier dogwood – Floodplain (RD), and Wolf willow - Fuzzy-spiked Wildrye (WW) (Table 15).

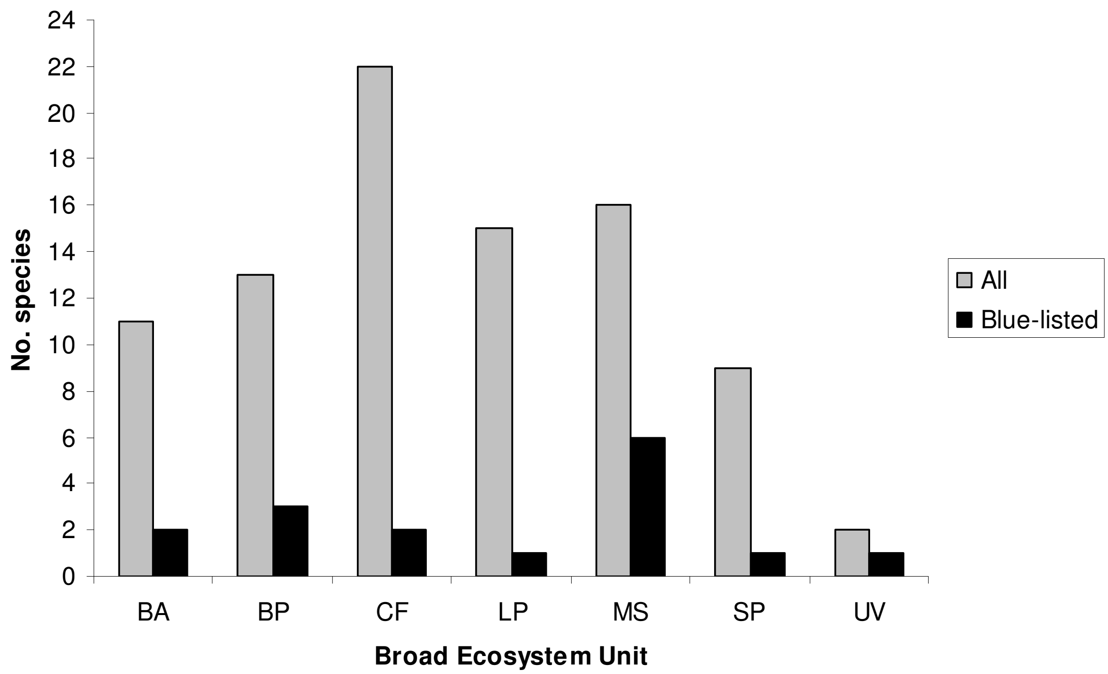

Figure 5. Total number of butterfly species and number of Blue-listed butterfly species identified from the seven Broad Ecosystem Units (RISC 1998) sampled in the Peace River study area. BA: Boreal White Spruce – Trembling Aspen; BP: Boreal White Spruce – Lodgepole Pine; CF: Cultivated Field; LP: Lodgepole Pine; MS: Montane Shrub/Grassland; SP: Slow Perennial Stream; UV: Unvegetated.

Table 15. Distribution of Core butterfly sample sites, total number of butterfly species and number of Blue-listed butterfly species by Terrestrial Ecosystem Unit (Keystone Wildlife Research 2006).

TEM Unit	TEM name	No. sites (Core only)	No. species	No. Blue species
AH	Alder – Horsetail - Floodplain	2	4	0
AM	White Spruce Trembling Aspen - Step moss	8	11	1
AS	White Spruce Trembling Aspen – Soopolallie	1	2	2
CF	Cultivated field	3	3	0
ES	Exposed soil	1	8	1
GB	Gravel bar	1	3	0
RD	Red-osier dogwood - Floodplain	2	9	1
RI	River	2	3	1
SE	Sedge Fen	1	2	0
SH	White Spruce - Currant – Horsetail	3	4	0
SW	White Spruce - Wildrye - Peavine	1	4	2
WF	Willow – Bluejoint - Floodplain	1	1	0
WW	Wolf willow - Fuzzy-spiked Wildrye	4	10	4

Forty-nine of the 64 sites from which butterflies were identified were surveyed systematically, with opportunistic surveys conducted at the remaining 15 sites. Sample times at those sites systematically surveyed varied widely, with sample times ranging between 20 and 165 minutes, but averaging 64 ± 39 minutes (n = 46). There was no clear trend in the number of butterfly species identified at each site and sample time (Figure 6). However it was apparent that more than 60 minutes of sampling was required at a site to collect five or more butterfly species. The transect distances surveyed at each site were also quite variable, ranging from 60 meters to 2000 m, and averaging 404 ± 411 m (n = 29).

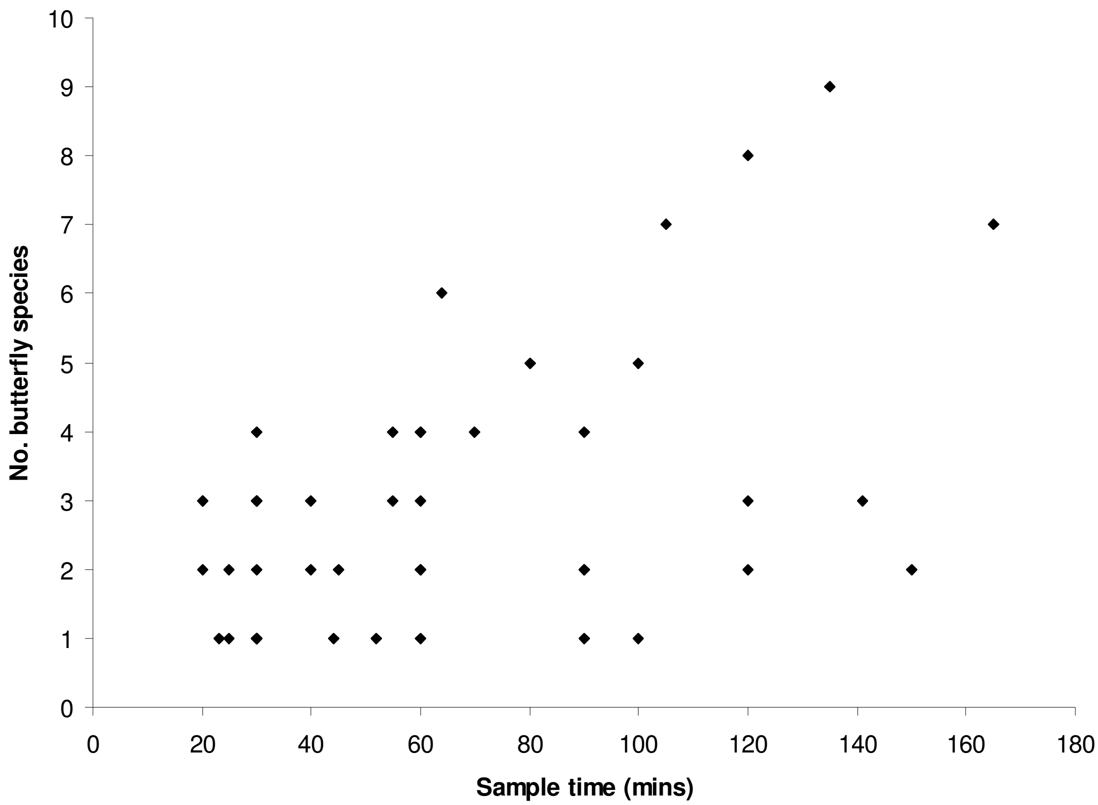

Figure 6. Number of butterfly species identified versus the sample time at each site systematically surveyed in the Peace River study area.

Of the 15 Blue-listed species of butterfly considered likely to occur in the study area, eight species were confirmed during the present study (Map 2), including four of the species closely associated with grassland habitat on south-facing slopes (Table 15). All eight Blue-listed species found in this study were recorded in the Core stratum; two of those species, *Cercyonis pegala ino* (Common Wood-nymph) and *Hesperia comma assiniboia* (Common Branded Skipper), were also confirmed in the Periphery, and there was a possibility of a third species also in the Periphery, *Speyeria cybele pseudocarpentari* (Great Spangled Fritillary), based on a Probable identification (Table 16).

According to distribution information presented on the Government of Canada's Canadian Biodiversity Information Facility[1], none of the 8 (sub) species of Lepidoptera in B.C. that are classified as at-risk by COSEWIC[2] were expected to occur in the project area and none were recorded during the present study. The CDC's Rare Element Occurrence database lists 6 records of only one species in the project area, *Papilio machaon pikei* (Baird's Swallowtail). Four of

[1] http://www.cbif.gc.ca/spp_pages/butterflies/index_e.php

[2] http://www.cosewic.gc.ca/eng/sct1/SearchResult_e.cfm?commonName=&scienceName=&boxStatus=All&boxTaxonomic=8&location=1&Board=All&change=All&Submit=Submit Accessed September 2005

those records occur in the Core stratum and two in the Periphery stratum in this study. That species was previously identified as the Old World swallowtail by Kondla *et al.* (1994). One specimen was detected in the Core stratum in the present study (Table 16).

Table 16. Blue-listed species of butterflies detected in the Peace study area, showing the number of sites in each of the stratum in which they were found. The confidence-level of each specimen identified was rated as probable or certain. The species closely associated with native grassland habitat on south-facing slopes are highlighted.

Blue-listed species	Common Name	Core		Periphery		Total sites
		Certain	Probable	Certain	Probable	
Carterocephalus palaemon	Arctic Skipper	2	0	0	0	2
Cercyonis pegala ino	Common Wood-nymph	1	1	1	0	3
Coenonympha tullia benjamini	Common Ringlet	2	0	0	0	2
Hesperia comma assiniboia	Common Branded Skipper	3	0	1	0	4
Papilio machaon pikei	Baird's Swallowtail	1	0	0	0	1
Satyrium titus titus	Coral Hairstreak	2	0	0	0	2
Speyeria aphrodite manitoba	Aphrodite Fritillary	4	1	0	0	5
Speyeria cybele pseudocarpentari	Great Spangled Fritillary	3	0	0	1	4

All Blue-listed butterfly species identified in this study were found in only a handful of the sites sampled (Table 15). Two of the most common Blue-listed species were the grassland-associated species, *Hesperia comma assiniboia* (Common Branded Skipper) and *Speyeria aphrodite manitoba* (Aphrodite Fritillary) which were found at four and five sites respectively.

Blue-listed butterfly species were identified from all seven of the Broad Ecosystem Units sampled in this study Figure 5). Significantly more species were collected from Montane Shrub/Grassland, with six of the eight Blue-listed species found in this BEI Unit.

Blue-listed butterfly species occurred in seven of the 13 TEM Units sampled in the Core stratum (Table 154). More Blue-listed species were associated with Wolf willow - Fuzzy-spiked Wildrye (WW) than with any other TEM unit.

Map 1. Distribution of butterfly sampling sites in the Peace River study area.

Map 2. Distribution of Blue-listed butterfly species found in this study in the Peace River area. Yellow dots represent records from this study; blue dots are records of Baird's Swallowtail from the CDC's Rare Element Occurrence Database.

3.3 Songbirds

We sampled songbirds from 187 unique songbird pointcount stations distributed throughout the study area (Map 3; Appendix IV). Of these, 118 (63%) were in the core stratum (2000 m buffer either side of the Peace River) and 69 (37%) were in the periphery (**Error! Reference source not found.**). Each station was visited between 1 and 6 times with 65.8% of all stations visited 4 or more times (Figure 7). Within the core stratum, 51% (*n* = 60) of all stations were visited 4 or more times and in the periphery stratum, 91% (*n* = 63) of all sites sampled were visited 4 or more times (Table 17).

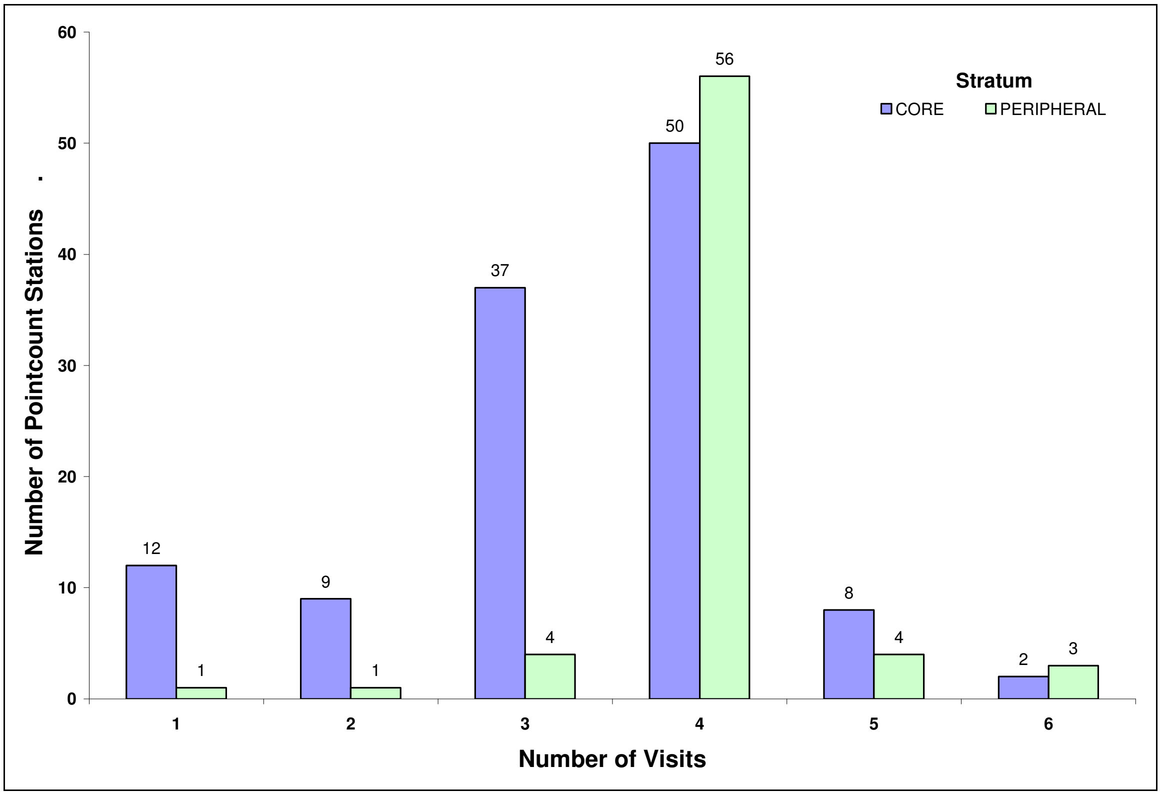

Figure 7. Number of visits to all pointcount stations in each strata during spring 2005 songbird surveys.

Table 17. Number of visits and percent of total songbird pointcount station visits per strata in the Peace River study area during spring 2005 songbird surveys.

Visits	1		2		3		4		5		6	
Stratum	Stations	%	Stations	%	Stations	%	Stations	%	Stations	%	Stations	%
Core	12	10	9	8	37	31	50	42	8	7	2	2
Periphery	1	1	1	1	4	6	56	81	4	6	3	4
Both[a]	13	7	10	5	41	22	106	57	12	6	5	3

[a] Both refers to both strata combined

Map 3. Distribution of songbird pointcount stations on the north and south side of the Peace River.

In total, we made 4,580 observations of 114 species (i.e., songbirds and non-songbirds) at all songbird pointcount stations with 2,538 observations of 95 species in the core and 2,042 observations of 88 species in the periphery. Fifteen species were unique to the core, 8 to the periphery, and 69 species occurred in both strata (Appendix V). The difference in total observations in the core versus the periphery was not significant result (t-test; $p = 0.6814$). Of the total observations, 4,411 (96.3%) were songbirds of 82 species with 2,446 (55.4%) observations in the core and 1,965 (44.5%) observations in the periphery (Table 18). In addition to songbirds, we documented water-associated birds (shorebirds and waterfowl), owls, raptors, and upland game birds (Wilson's Snipe and Ruffed Grouse) at songbird pointcount locations (Table 18). A complete species list can be found in Appendix V. The data in Table 18 represent all observations, including birds that were outside the pointcount radius (i.e., > 75 m from the pointcount center). A breakdown of species by distance from pointcount center is found in Table 19.

Table 18. Total observations and species of birds (by group) detected per strata in the Peace River study area, spring 2005.

	Core			Periphery					
Group	**Obs.[a]**	**Species**	**% of Obs.**	**Obs.**	**Species**	**% of Obs.**	**Total**	**% of Obs.**	**Total Species**
Songbirds	2446	73	96.4	1965	72	96.2	4411	96.3	82
Raptors	30	7	1.18	4	2	0.20	34	0.74	7
Owls	2	2	0.08	1	1	0.05	3	0.07	3
Water-associated	45	11	1.77	49	11	2.40	94	2.05	20
Upland Game	15	2	0.59	23	2	1.13	38	0.83	2
Totals	**2538**			**2042**			**4580**		**114**

[a]Obs. = Observations

Table 19. Total songbird observations by distance from pointcount center. Those observations between 0 and 75 m are used for most analyses. C = core; P = periphery.

Distance	**0-10**		**11-20**		**21-30**		**31-40**		**41-50**		**51-75**		**>75**	
Stratum	**C**	**P**	**C**	**P**	**C**	**P**	**C**	**P**	**C**	**P**	**C**	**P**	**C**	**P**
Total Observations	34	31	162	142	244	213	315	249	426	296	829	620	436	414
Total Species	13	19	34	40	41	45	47	45	52	52	66	62	51	46

Of the 82 species of songbirds documented, 3,561 observations of 81 species occurred within the 75 m pointcount radius (Appendix VI). Initially, we evaluated species occurrence between the core and the periphery strata. Of the 81 bird species documented at songbird pointcount stations, 90.1% ($n = 73$) were found in the core and 81.5% ($n = 66$) occurred in the periphery. The difference in species occurrence between the core and periphery strata was not statistically different (1-way ANOVA, $F = 2.49$, $p = 0.1165$), which is not surprising given that many of the habitats contained in the core study area overlap with those in the periphery.

3.3.1.1 Frequency of Occurrence

The frequency of occurrence (i.e., the proportion of pointcounts that a species was detected at) was calculated for each of the 81 species detected within the 75 m pointcount stations for all sites combined ($n = 187$), only the core ($n = 118$) and only the periphery ($n = 69$) (Appendix VI). Overall, the Red-eyed Vireo was detected at the most sites (58.8%; $n = 110$). In the core study area, the Red-eyed Vireo had the highest frequency of occurrence (69.5%; $n = 82$) and within the periphery, the American Robin had the highest encounter frequency (59.4%; $n = 41$). The most commonly encountered species are listed in Table 20. Encounter frequencies for Red- and Blue-listed songbirds are presented in Table 21.

Certain species were documented in only 1 of the 2 strata (Table 22). The lack of detection in either stratum for a given species does not preclude its presence. It is interesting to note that of the species that occurred in only the core or periphery, 2 have conservation status (i.e., are Blue-listed in BC): Philadelphia Vireo and Cape May Warbler (Table 22).

Table 20. The top ten most commonly encountered songbird species detected in the core and periphery stratum and in both strata of the Peace River study area.

Core Stratum			Periphery Stratum			Core and Periphery Strata		
Common Name	**Sites**	**FO[1] (%)**	**Common Name**	**Sites**	**FO (%)**	**Common Name**	**Both**	**FO**
Red-eyed Vireo	82	69	American Robin	41	59	Red-eyed Vireo	110	59%
Yellow-rumped Warbler	71	60	Least Flycatcher	34	49	Yellow-rumped Warbler	102	55%
Swainson's Thrush	57	48	Yellow Warbler	31	45	Yellow Warbler	88	47%
Yellow Warbler	57	48	Yellow-rumped Warbler	31	45	American Robin	87	47%
American Robin	46	39	Black-capped Chickadee	30	43	Least Flycatcher	74	40%
American Redstart	42	36	Swainson's Thrush	30	43	Dark-eyed Junco	61	33%
Dark-eyed Junco	40	34	Chipping Sparrow	29	42	Yellow-breasted Sapsucker	59	32%
Least Flycatcher	40	34	Red-eyed Vireo	28	41	Ovenbird	58	31%
Ovenbird	36	31	White-throated Sparrow	28	41	American Redstart	57	30%
Western Tanager	35	30	Tennessee Warbler	26	38	White-throated Sparrow	56	30%
			Warbling Vireo	26	38			

[1] FO = Frequency of Occurrence

Table 21. Frequency of Occurrence for Red- and Blue-listed songbird species documented in each stratum of the Peace River study area.

Common Name	Core	Periphery	All	Core	Periphery	Both
Black-throated green Warbler	17	11	28	14.4%	15.9%	15.0%
Canada Warbler	20	5	25	16.9%	7.2%	13.4%
Cape may Warbler		3	3		4.3%	1.6%
Connecticut Warbler	1	6	7	0.8%	8.7%	3.7%
Le Conte's Sparrow	1	1	2	0.8%	1.4%	1.1%
Philadelphia Vireo	1		1	0.8%	0.0%	0.5%

Table 22. Bird species detected within the 75 m pointcount radius in only the core or periphery stratum within the Peace River study area. Bold codes denote species with conservation status.

Core		Periphery	
Code	**Common Name**	**Code**	**Common Name**
B-AMCR	American Crow	**B-CMWA**	**Cape May Warbler**
B-BBMA	Black-billed Magpie	B-EAPH	Eastern Phoebe
B-CLSW	Cliff Swallow	B-HAFL	Hammond’s Flycatcher
B-EVGR	Evening Grosbeak	B-NRWS	Northern rough-winged Swallow
B-FOSP	Fox Sparrow	B-RUBL	Rusty Blackbird
B-MODO	Mourning Dove	B-SWSP	Swamp Sparrow
B-MOWA	Mourning Warbler	B-VESP	Vesper Sparrow
B-OSFL	Olive-side Flycatcher	B-WBNU	White-breasted nuthatch
B-PHVI	**Philadelphia Vireo**		

Core		Periphery	
Code	**Common Name**	**Code**	**Common Name**
B-PIWO	Pileated Woodpecker		
B-RTHU	Ruby-throated Hummingbird		
B-VATH	Varied Thrush		
B-WCSP	White-crowned Sparrow		
B-WIWA	Wilson's Warbler		
B-WIWR	Winter Wren		

3.3.1.2 Relative Abundance

To investigate differences in bird species occurrence between the core and periphery strata we categorized each songbird pointcount location into 1 of 10 habitat types (Table 6). Of these, the 187 songbird pointcount locations occurred in 1 of 6 habitat types (Table 23) with Mixed-wood forest dominated by deciduous trees sampled more than any other habitat. The disproportionate sampling of habitat types was not a result of sampling design. In many cases, the availability of, or accessibility to habitat was problematic. Additionally, we did not have access to the draft TEM prior to sampling, so it was difficult to pair sample points in the core with those in the periphery or to sample proportionately among habitat types present in both the core and periphery strata. Five of the 17 sites include in habitat-type 10 (unclassified) were sites that were sampled only once. See Appendix VII for a complete list of songbird species by habitat type and stratum.

Table 23. Habitat categories assigned to the 187 pointcount stations sampled during spring 2005.

	Total Sites Sampled		
Habitat	**CORE**	**PERIPHERY**	**ALL**
Deciduous Forest	25	17	42
Shrub (willow) habitat	2		2
Mixed wood Coniferous	30	12	42
Mixed wood: deciduous	26	33	59
Edge (grass/forest)	21	4	25
Unclassified	14	3	17
Total SBPC	118	69	187

The relative abundance of songbirds was assessed for the core and periphery strata for five of the habitat types sampled. Relative abundance was calculated by first summing the total observations of each species per habitat type then summing the total number of times each songbird point count location was sampled. The total number of observations for each habitat type was then divided by the total number of visits to that habitat type to obtain a measure of relative abundance (in this case, mean number of individuals per visit) (Appendix VIII). This approach enabled us to use all data collected regardless of the number of times a songbird pointcount was visited. Appendix VIII presents the relative abundance for each species documented in the core and periphery strata and in both strata combined. Table 24 presents the relative abundance of Red- and Blue-listed songbirds documented in the Peace River study area.

Table 24. Relative abundance (detections per visit) for Red- and Blue-listed songbirds documented in the core and periphery strata during spring 2005 surveys of the Peace River project area. Shading indicates higher relative abundance for that species and habitat type.

Habitat Type[a]	2		3		4		5		9	
Species Code	C	P	C	P	C	P	C	P	C	P
B-BTNW	0.012	0.014	0.000		0.135	0.174	0.144	0.067	0.000	0.000
B-CAWA	0.098	0.000	0.000		0.125	0.000	0.093	0.052	0.101	0.000
B-CMWA	0.000	0.000	0.000		0.000	0.043	0.000	0.000	0.000	0.000
B-COWA	0.000	0.057	0.000		0.000	0.000	0.000	0.060	0.013	0.000
B-LCSP	0.000	0.000	0.500		0.000	0.000	0.000	0.000	0.000	0.100
B-PHVI	0.000	0.000	0.000		0.000	0.000	0.010	0.000	0.000	0.000

[a] Habitat Type: 2 = deciduous forest; 3 = Riparian Shrub (Willow) habitats; 4 = Mixed: Coniferous-Deciduous; 5 = Mixed: Deciduous-Coniferous; 9 = Edge

A two-way ANOVA with stratum and habitat code as model terms was used to test for differences in relative abundance for each species between strata and habitat type. The interaction term (stratum X habitat code) was removed from the model because it was not significant for all species. Fifteen of the 83 songbird species assessed showed significant relationships with stratum, habitat type, or both stratum and habitat type (Table 25). Tukey HSD was used to account for experiment-wise error. Of the 8 species of songbirds with provincial conservation status, only the Canada Warbler and Black-throated Green Warbler show an association with a stratum or habitat type (Canada Warbler: core; Black-throated Green Warbler: mixed-wood: coniferous forests (habitat type 4)).

Table 25. Species of songbirds showing a significant association with stratum, habitat type, or both.

Species	Model Term	F	*P*	Interpretation
Alder Flycatcher	Stratum	37.9	0.0086	Higher relative abundance in periphery
Black-throated Green Warbler	Habitat	9.32	0.0497	Association with mixed-wood: coniferous stands
Canada Warbler	Stratum	25.9	0.0147	Higher relative abundance in core
Golden-crowned Kinglet	Habitat	51.1	0.0045	Association with mixed-wood: coniferous stands
Gray Jay	Habitat	321	0.0003	Association with mixed-wood: deciduous stands
Hermit Thrush	Stratum	15.6	0.0289	Higher relative abundance in periphery
Least Flycatcher	Habitat	23.5	0.0138	Association with primarily deciduous forest
Magnolia Warbler	Stratum	14.6	0.0134	Higher relative abundance in core
Mourning Warbler	Stratum	10.1	0.0505	Higher relative abundance in core
Pacific-slope Flycatcher	Stratum	63.9	0.0041	Higher relative abundance in core
Ruby-crowned Kinglet	Habitat	122	0.0012	Association with mixed-wood: coniferous stands
Red-eyed Vireo	Stratum	14.7	0.0312	Higher relative abundance in core
Song Sparrow	Habitat	23.9	0.0135	Association with edge habitat (grass/forest)
Western Tanager	Habitat	8.79	0.0537	Association with mixed-wood: coniferous stands
Yellow-rumped Warbler	Stratum	22.2	0.0181	Higher relative abundance in core
	Habitat	14.5	0.0273	Association with mixed-wood: coniferous stands

3.3.1.3 Red- and Blue-listed Songbirds

We made 155 observations of 6 red- and / or blue-listed songbird species from 99 locations in the Peace River study area. Of the 155 observations, 102 from 66 locations occurred within 75 m of the pointcount center. Map 4 shows the distribution of rare songbirds in the study area, including those that occurred > 75 m from the pointcount center as well as rare bird records from the Rare Element Occurrence (REO) database.

Map 4. Distribution of red-and blue-listed songbirds in the Peace River study area.

Table 26. Conservation status for species of songbirds documented in the Peace River study areas during spring 2005 surveys.

Common Name	Stratum[a]	COSEWIC Status	BC CDC Status[1]
Black-throated Green Warbler	C, P	Not Assessed	Blue
Canada Warbler	C, P	Priority Group 1 Candidate Species	Blue
Cape May Warbler	P	Not Assessed	Red
Connecticut Warbler	C, P	Not Assessed	Blue
Le Conte's Sparrow	C, P	Not Assessed	Blue
Philadelphia Vireo	C	Not Assessed	Blue

[a] Stratum: C = Core; P = Periphery; [1] BC Conservation Data Centre: http://srmwww.gov.bc.ca/cdc/

In 2005, the most commonly encountered rare songbird was the Black-throated Green Warbler followed closely by the Canada Warbler (Table 27). Taking data from the REO database into consideration and plotting them onto a map of the study area, a similar trend is seen with Canada Warblers occurring slightly more frequently than Black-throated green Warblers (Table 27). When these two species were detected, they occurred in both the core and periphery strata, with both the Black-throated green and Canada Warblers detected more in the core in 2005. Data from the REO show an equal number of detections of Black-throated greens in the core and periphery and more Canada Warblers in the core. Some of the sites where we documented rare warblers in 2005 were the same as sites in the REO (Map 4). Connecticut Warblers were not documented as often as Black-throated greens or Canada Warblers and the number of sites documented in 2005 was greater than the REO. The Bay-breasted and Cape May Warblers, Le Conte's and Nelson's sharp-tailed Sparrows and Philadelphia Vireo appear to be uncommon in the study area with very few records from 2005 or the REO. We documented Philadelphia Vireo from only 1 location in 2005 and Nelson's sharp-tailed Sparrow was not detected.

Pooling data from the REO and 2005 appears to indicate that Canada Warblers are more closely associated with the core stratum than any other species and Connecticut Warblers appear to prefer habitats in the periphery stratum. In contrast, Black-throated green Warblers occur in both strata and are not clearly associated with one or the other (Table 27). This mirrors the results in Table 25. When detected, Bay-breasted and Cape May Warblers and Nelson's sharp-tailed Sparrow occurred only in the periphery stratum.

Table 27. Number of detection locations of rare birds detected in 2005 and from the rare Element Occurrence database.

	2005		REO		Total	
Common Name	Core	Periphery	Core	Periphery	Core	Periphery
Bay-breasted Warbler	-	-	-	1	-	1
Black-throated Green Warbler	26	14	10	10	36	24
Canada Warbler	32	5	14	1	46	6
Cape May Warbler	-	3	-	1	-	4
Connecticut Warbler	1	15	-	2	1	17
Le Conte's Sparrow	1	1	-	-	1	1
Nelson's Sharp-tailed Sparrow	-	-	-	3	-	3
Philadelphia Vireo	1	-	-	10	1	10
Total Locations	61	38	24	28	85	66

3.3.1.4 Habitat Associations

A t-test was used to test whether or not the total number of species detected per habitat type was different between the core and periphery (Table 28). The number of species documented was equal in habitat-type primarily coniferos forests, higher in the core for riparian, mixed conifereous-deciduous, and edge habitats and higher in the periphery for mixed deciduous (Table 28). Differences between total species documented was statistically different for habitats 3 and 9 (*p* <0.0001 and 0.0040; Table 28). Species differences associated with habitat-type 10 (unclassified) are not ecologically meaningful.

Table 28. Total number of species detected per habitat type for the core and periphery strata sampled during spring 2005 songbird pointcounts in the Peace River area.

	Habitat Code											
	Deciduous		Shrub*		Mixed: Coniferous		Mixed: Deciduous		Edge		Unclassified	
Strata	**C**	**P**	**C**	**P**	**C**	**P**	**C**	**P**	**C**	**P**	**C**	**P**
Total Species	42	42	14	-	48	45	46	51	49	31	33	14
t-test *p*	1		**<0.0001**		0.6303		0.4171		**0.0040**		N/A	

* Sampling occurred in both the periphery and core strata in the shrub habitat.

3.3.1.5 Ecological Similarity

Morisita's index of similarity values were calculated for songbird communities in the core and periphery and only songbird observations that occurred within the 75 m pointcount radius were used. In the Peace River study area, the songbird communities documented in the core and periphery strata were fairly similar, with a Morisita's coefficient of 0.84 (Table 29). Within each habitat type, the songbird communities were also relatively similar. Some divergence of similarity is evident in habitat 5, which is likely due to a greater availability of habitat 5 in the periphery relative to the core. Songbird communities were the least similar in habitat 9, or edge habitats, which again may be a reflection of habitat supply.

Table 29. Morisita's index calculated for the core and periphery combined and for each habitat sampled within the core and periphery.

Habitat Code	Description	C
-	ALL	0.84
2	Deciduous Forest	0.85
3	Shrub (willow) habitat	0.00
4	Mixed wood Coniferous	0.87
5	Mixed wood: deciduous	0.75
9	Edge (grassland/forest)	0.56
10	Unclassified	N/A

Although different species comprised the species lists for each habitat type within the core and periphery and for the core and periphery as a whole, the bird communities are not that different, and where differences occur, there is still >40% overlap in community similarity (e.g., the ecological similarity for habitat 9 is the lowest, with 44% similarity). Further studies in 2006 will assist with increasing our understanding of the ecological similarity between bird communites in the core and periphery and will provide additional data with which to make comparisons of the communtieis in which rare songbirds occur.

3.4 Raptors

Raptor distribution and occurrence information was collected using a number of survey methods including: call-playback surveys, road-transect surveys, aerial surveys, boat surveys, and incidental observations. This section is organized by survey type because the results are dependent upon the target species and spatial extent of the surveys.

3.4.1 Call Play-back Surveys

The opportunity for conducting call-playback surveys was limited because of the other duties of the field crews. Until 12 July the focus of the study was on collecting breeding bird data which required early morning point counts making it impractical to also collect late-night owl data. As a result, only nine call playback/passive listening surveys were conducted.

Each playback survey consisted of one or more stations in which a recorded owl call was broadcast over a speaker. Call playback stations and observations are presented in Map 5 and tabulated below (Table 30). Responses were heard from one Barred Owl and two Northern Saw-whet Owls. Results were likely limited by the timing of call playbacks. Best results are expected to be obtained during the spring period. However, because the study did not begin until 2 June 2005, call playbacks were conducted at the end of the nesting season during which time birds are expected to be less responsive than during the early part of the breeding season.

Table 30. Raptor call-playback surveys and results.

Date	Location	No. Stations	Call Played	Response
13-Jun-05	Johnson Road	5	Barred Owl	Barred Owl
26-Jun-05	Boudreau Lakes	1	Boreal Owl	No Response
27-Jun-05	Jct of 401 & 400 Road (daytime)	1	Barred Owl	No Response
27-Jun-05		3	Boreal Owl	No Response
27-Jun-05		1	Great Gray Owl	No Response
2-Jul-05	Boudreau Lakes	1	Great Gray Owl	No Response
17-Jul-05	Johnson Road (SE of Taylor)	11	Barred Owl & Northern Saw-whet Owl	No Response
19-Jul-05	Upper Cache Road (off Hwy 29 between Hudson Hope & Charlie Lake	12	Barred Owl & Northern Saw-whet Owl	2 Northern Saw-whet Owls
23-Jul-05	Big Bam Road (W of Taylor)	6	Barred Owl & Northern Saw-whet Owl	Northern Saw-whet Owl

Map 5. Owl call playback sites and species detection locations.

3.4.2 Road Transect Surveys

Ten road transects to survey raptors were conducted from 12 June-24 July 2005 (Map 6**Error! Reference source not found.**). Eight of those transects were conducted twice (and one three times) either in whole or in part. Transects ranged from 9.9 to 74.5 km and a total of 535 km were surveyed. Seven species of raptors were sighted during road surveys. The most abundant species was American Kestrel which accounted for 58% of the total raptors sighed. On average, one American Kestrel was seen every 7.7 km or road traveled. Red-tailed Hawks accounted for 19% of the raptor sightings made during road surveys and an average of one Red-tailed Hawk was seen every 25 km of road transect. Merlins comprised 12% of the sightings and one was seen every 50 km of road transect. The number of raptors sighted during each road survey and the corresponding density (birds per linear kilometre) are presented in **Error! Reference source not found.**. Red-tailed Hawks were more abundant (on the basis of density) in the periphery portions of the study area. Conversely, Bald Eagles and American Kestrels were most abundant (by density) in the core areas of the study area. A summary of each road survey is presented in Table 32.

Table 31.Raptor numbers and density in the core and periphery strata of the Peace River study area.

Species	Core	Core Density (birds/km)	Periphery	Periphery Density (birds/km)
Bld Eagle	3 (7%)	0.02	0	0.00
Red-tailed Hawk	3 (7%)	0.02	16 (26%)	0.04
Northern Harrier	1 (2%)	0.01	4 (7%)	0.01
Sharp-shinned Hawk	1 (2%)	0.01	0	0.00
Coopear's Hawk	1 (2%)	0.01	0	0.00
American Kestrel	29 (67%)	0.17	34 (56%)	0.09
Merlin	5 (12%)	0.03	7 (11%)	0.02

Map 6. Road transect survey routes and raptor sightings.

Table 32. Road transects for raptors and number of raptors observed. Number in parentheses indicated the number of birds observed per kilometre driven).

Transect	Date	Length	SSHA	COHA	RTHA	BAEA	NOHA	MERL	AMKE
1. Shell Road/Golata Creek Road	6/19/05	48.1	0	0	0	0	0	0	6 (0.12)
2. Clayhurst Road	6/19/05	36.4	0	0	1 (0.03)	0	0	0	5 (0.14)
2. Clayhurst Road	7/23/05	36.4	0	0	1 (0.03)	0	0	0	4 (0.11)
3. Bison Road	6/24/05	28.1	0	0	0	0	0	1 (0.04)	1 (0.04)
4. Taylor to Beatton River	6/24/05	31.1	0	0	0	0	0	1 (0.03)	1 (0.03)
4. Taylor to Beatton R.	7/01/05	31.1	0	0	3 (0.10)	0	2 (0.06)	1 (0.03)	4 (0.13)
5. Johnson Road	7/01/05	9.2	0	0	0	2 (0.22)	0	1 (0.11)	1 (0.11)
5. Johnson Road	7/20/05	9.2	0	1 (0.11)	0	0	0	1 (0.11)	0
5. Johnson Road	7/21/05	9.2	1 (0.11)	0	0	0	0	1 (0.11)	1 (0.11)
6. 271 Road	6/12/05	10.2	0	0	0	0	1 (0.10)	0	0
6. 271 Road	6/25/05	10.2	0	0	0	0	0	0	1 (0.10)
7. Lower Cache Road	7/24/05	24.5	0	0	2 (0.08)	0	0	0	0
8. Upper Cache Road	7/18/05	18.8	0	0	4 (0.21)	0	2 (0.11)	0	0
9. Addition to Upper Cache Road	7/21/05	20.4	0	0	1 (0.05)	0	0	0	2 (0.10)
10. Bear Flats to Lynx Creek	7/18/05	49.9	0	0	0	2 (0.04)	0	0	8 (0.16)
10. Bear Flats to Lynx Creek	7/23/05	49.9	0	0	1	1 (0.02)	0	1 (0.02)	14(0.28)
11. Golata Creek Road	7/22/05	43.4	0	0	7 (0.16)	0	0	2 (0.05)	8 (0.18)
11. Golata Creek Road	7/23/05	43.4	0	0	0	0	0	4 (0.09)	8 (0.18)
12. Taylor	7/21/05	25.6	0	0	0	0	0	0	3 (0.12)
Totals (% of Total)			**1 (1%)**	**1 (1%)**	**20 (18%)**	**5 (4%)**	**5 (4%)**	**13 (12%)**	**67 (60%)**
Linear Density (Birds/km)		535.1	**<0.01**	**<0.01**	**0.04**	**0.01**	**0.01**	**0.02**	**0.13**

3.4.3 Aerial and Boat Surveys

One aerial survey was conducted along the Peace River on 4 July 2005. The primary purposes of the survey were to document waterfowl broods on the Peace River and raptor nest sites in the Peace River valley. Of primary significance, 23 Bald Eagles were observed and 21 active nests were located (**Error! Reference source not found.**). In addition, three Red-tailed Hawks and one nest were seen, as well as two Merlins, two American Kestrels and three Broad-winged Hawks. The aerial survey was conducted almost exclusively in the core stratum.

Surveys along the Peace River were conducted by boat on 19 days between 15 June and 18 July 2005 (Map 8). Although these surveys were principally designed to survey waterfowl, they were also well-suited to surveys of diurnal raptors. The results of those surveys are presented in Table 33. Although only four species were observed, 33 adult Bald Eagles were sighted and five active nests were located.

3.4.4 Incidental Observations

A number of raptor sightings were made during the course of this study, but not during actual survey periods. Those sightings have been noted as incidental sightings and are listed below (Table 34) as well as being presented in Map 9 For completeness, raptors sighted during the various surveys have also been included in the Table as shaded cells. A total of 15 species of raptors were sighted during field activities in Spring 2005. Bald Eagles comprised 22% of the incidental sightings. Small falcons comprised 27% of the incidental sightings. Most incidental sightings were made along the Peace River reflecting the significant time spent along the river.

Map 7. Raptor sightings made during the aerial survey of the Peace River.

Map 8. Boat based survey routes.

Table 33. Raptor observations from boat surveys of the Peace River.

Transcect	Date	Distance (km)	American Kestrel	Merlin	Red-tailed Hawk	Red-tailed Hawk Nest	Broad-winged Hawk	Bald Eagle	Active Bald Eagle Nest	Old Bald Eagle Nest
Aerial	7/4/05	490	2	2	3	1	3	23	21	1
W004	6/15/05	19.3						3		
W005	6/16/05							5	2	
W001	6/24/05	17.3	1					1		
W006	6/24/05	10.6						1		
W007	6/25/05		1					6	2	1
W008	6/27/05		1		1			1		
W010	6/30/05							1	4	
W011	7/1/05		1					4		
W012	7/2/05	29.6	1					2		
W013	7/3/05	20.6						1		
W014	7/4/05	79.5	4					2		2
W015	7/5/04	16.4	2					1		
W016	7/7/05	42.7						2	1	
W017	7/8/05	25.9		1				15	1	
W18&19	7/9/05	36.6						4		
W20&21	7/10/05	40.5	2					5		
W022	7/11/05		1					1	2	
W23	7/15/05									
		TOTAL	**16**	**3**	**4**	**1**	**3**	**78**	**33**	**4**

Table 34. Raptor sighting including incidental observations made during wildlife investigations of the Peace River, spring 2005.

Species	Number Seen	Species	Number Seen
Bald Eagle	64	Sharp-shinned Hawk	10
Active Bald Eagle Nest	4	Osprey	3
Old Bald Eagle Nest	1	American Kestrel	37
Golden Eagle	1	American Kestrel Nest	1
Broad-winged Hawk	6	Merlin	13
Red-tailed Hawk	23	Barred Owl	4
Northern Goshawk	2	Great Horned Owl	1
Northern Harrier	4	Northern Pygmy Owl	1
Cooper's Hawk	2	Northern Saw-whet Owl	3
	107		73

Map 9. Incidental observations of raptors made during surveys of the Peace River study area.

3.5 Waterfowl and Other Birds

Fourteen species of waterfowl were observed during surveys of the Peace River (Table 35). A total of 58% of the waterfowl seen were Canada Geese. About one-quarter of the ducks observed were dabbling ducks. About three-fourths of the dabbling ducks were Mallards. Of the diving ducks seen, Common Goldeneyes and Common Mergansers each comprised approximately one-quarter of the total.

Of all waterfowl seen during aerial surveys, 63% were observed above the confluence with the Moberly River (Map 10). Approximately 57% (83 of 146 km) of the Peace River in the Study Area lies above the confluence of the Moberly River. The main difference in numbers seen above and below the confluence of the Moberly River occurred with diving ducks in which 71% of the sightings were above the Moberly whereas on 46% of the Canada geese and 57% of the dabbling ducks were located above the Moberly.

3.5.1 Water-associated Birds

Eighteen species of water-associated birds were observed during surveys of the Peace River (Table 36). A total of 1,066 waterbirds were seen during aerial surveys (Map 11) and 3,953 waterbirds were seen during boat surveys. Of the 5,019 waterbirds observed, 60% of the waterbirds seen were Franklin's Gulls. Ring-billed Gulls, California Gulls and Bonaparte's Gulls collectively made up another 16% of the waterbird sightings. The only other relatively abundant waterbirds seen were Bank swallows and Spotted Sandpipers.

Of 3,953 waterbirds seen during boat-based surveys of the Peace River, 98% were observed on transects surveyed above the confluence with the Moberly River. Only 70 birds were observed on transects surveyed below the Moberly River, mostly Bank Swallows and Spotted Sandpipers.

Incidental observations of water-associated birds are shown in Table 37 and Map 12.

Map 10. Waterfowl sightings made during the aerial survey of the Peace River.

Map 11. Water-associated bird sightings made during the aerial survey of the Peace River.

Map 12. Incidental observations of water-associated birds made during surveys of the Peace River study area.

Table 35. Waterfowl Observations during Aerial and Boat-based Surveys of the Peace River.

TRANSECT	DATE			DABBLING DUCKS						DIVING DUCKS											
		Trumpeter Swan	Canada Goose	American Wigeon	Green-winged Teal	Mallard	Northern Pintail	Gadwall	Unidentified Dabbling Duck	Bufflehead	Barrow's Goldeneye	Common Goldeneye	Unidentified Goldeneye	Common Merganser	Ring-necked Duck	Unidentified Scaup	White-winged Scoter	Unidentified Diving Duck	Unidentified Duck	**TOTAL DUCKS**	**TOTAL WATERFOWL**
Aerial	7/4/09		14	1	1	19	1	1	3	15		3	15	10	1	1		1	3	**75**	**89**
W04	6/15/09		4											4						**4**	**8**
W05	6/16/09					1						4		3						**8**	**8**
W06	6/24/09													4						**4**	**4**
W07	6/25/09		4	1	1	2				3		4		2						**13**	**17**
W08	6/27/09					9						9								**18**	**18**
W10	6/30/09									1				5						**6**	**6**
W11	7/1/09		57									2								**2**	**59**
W12	7/2/09		30							2	2			1						**5**	**35**
W13	7/3/09											1		1						**2**	**2**
W14	7/4/09		3							1		2								**3**	**6**
W15	7/5/08			1																**1**	**1**
W16	7/7/09													3						**3**	**3**
W17	7/8/09		12		1	1				2		1		1						**6**	**18**
W18 & W19	7/9/09		72											1						**1**	**73**
W20 & W21	7/10/09											1								**1**	**1**
W022	7/11/09	1				1					1	1					1			**4**	**5**
W23 & W24	7/15/09			2						2	1									**5**	**5**
W25 & W26	7/17/09			1	2						1									**4**	**4**
W27	7/18/09									1					1					**2**	**2**
	Total	**1**	**184**	**3**	**2**	**25**	**1**		**3**	**21**	**3**	**25**	**12**	**30**	**1**		**1**		**3**	**167**	**364**

Table 36. Observations of water-associated birds during aerial and boat-based surveys of the Peace River.

			LOONS	COOTS	GREBES	TERNS	GULLS							SHOREBIRDS				KING-FISHER	SWALLOWS				
TRANSECT	**DATE**	Distance Traveled	Common Loon	American Coot	Horned Grebe	Black Tern	Franklin's Gull	Bonapart's Gull	California Gull	Herring Gull	Mew Gull	Ring-billed Gull	Unidentified Gull	Greater Yellowlegs	Lesser Yellowlegs	Spotted Sandpiper	Killdeer	Belted Kingfisher	Violet-green Swallow	Cliff Swallow	Bank Swallow	Unidentified Swallow	Total Birds
Aerial	7/4/09	490		2	1	1	587			1		165	12			102	6	5			184		1066
W004	6/15/09	19.3														5			5	2	74	11	97
W005	6/16/09							6				3		1		2		1					13
W001	6/24/09	17.3														1							1
W006	6/25/09	10.6	2													2		1	4	10	3		22
W007	6/27/09						313	2			1	251				3					40	3	613
W008	6/30/09					5	1385	90				54			2	9	1				1	4	1551
W010	7/1/09							5								10			3	40	30		88
W011	7/2/09															3					60		63
W012	7/3/09					1	240		60			49				4		2			20		376
W013	7/4/09						100									5		1					106
W014	7/5/08	79.5														11					184		195
W015	7/7/09															6					51		57
W016	7/8/09	42.7							1							9			6	1	156		173
W017	7/9/09	25.9	1					13				29				3		1					47
W018&019	7/10/09	36.6					373	1	54			14				19		2			18		481
W020&021	7/11/09	40.5										3				11					1		15
W022	7/15/09															5					50		55
W23&024	7/17/09																						0
W25&026	7/18/09																						0
W27	7/5/09																						0
Total			3	2	1	7	2998	117	115	1	1	568	12	1	2	210	7	13	18	53	872	18	5019
Percent of total			0%	0%	0%	0%	60%	2%	2%	0%	0%	11%	0%	0%	0%	4%	0%	0%	0%	1%	17%	0%	
Density (Birds/km) aerial			0	.004	.002	.002	1.2	0	0	.002	0	.3	.02	0	0	.2	.01	.01	0	0	.4	0	2.2
Density (birds/km) boat																							

Densities calculated only for those transects for which the exact length of survey is known.

Table 37. Incidental observations of water-associated birds in the Peace River study area.

DATE	Common Loon	American Coot	Pied-billed Grebe	Red-necked Grebe	Black Tern	Common Snipe	Lesser Yellowlegs	Sandhill Crane	Sora	Solitary Sandpiper	Spotted Sandpiper	Upland Sandpiper	Cliff Swallow	Total
6/18/05												4		4
6/23/05			1			2				1	7		1	12
6/24/05			1			1			1	1	1			5
7/3/05	1				15									16
7/4/05												1		1
7/5/05		4	3											7
7/11/05												1		1
7/23/05	2	1		2	1			2						8
7/25/05							8			1				9
Total	3	5	5	2	16	3	8	2	1	3	8	6	1	63

3.6 Amphibians and Reptiles

3.6.1 Search Effort

Amphibian searches consisted of time-constrained searches for adults, dipnetting surveys for tadpoles and metamorphs, and time-constrained searches for reptiles. Searches were conducted in both the core and periphery strata throughout the study area (Map 13). Searches were generally combined with survey efforts for other groups such as butterflies or songbirds. In addition to focused searches for amphibians and reptiles, incidental observations of snakes, frogs, or toads were recorded. Total time-constrained search time for amphibians (adults and tadpoles) totaled 30.75 hours at 83 unique locations (42 core and 41 periphery), dipnetting totaled 5.9 hours at 3 locations (all core), and snake searches totaled 14.96 hours at 18 locations (12 core and 5 periperhy) (Table 38). Dipnet searches were not conducted as frequently as time-constrained searches due to the timing of field surveys and the probability that metamorphs and/or adults would be encountered more often than tadpoles (because tadpoles had already emerged).

Table 38. Total surveys and time searched for amphibians and reptiles in the Peace River study area during 2005.

		Strata		
Group		**Core**	**Periphery**	**Total**
Pond-breeding Amphibians: Adult	Surveys	42	51	83
	Time (hrs)	11.56	19.18	30.75
Pond-breeding Amphibians: Larval	Surveys	3	0	3
	Time (hrs)	5.88		5.88
Snake Encounter Transects	Surveys	12	5	17
	Time (hrs)	13.38	1.58	14.96

3.6.2 Amphibians

3.6.2.1 Distribution

Western toads and wood frogs were detected in both the core and periphery strata (Map 14). Western toads were documented from 21 unique locations (13 core; 8 periphery) and wood frogs were documented from 56 unique locations (22 core; 34 periphery). The only other species of amphibian documented in the study area was the long-toed salamander, and tadpoles of this species were documented from 3 locations, all of which were in the core stratum (Map 14) (Table 39). To augment the distribution of wood frogs and western toads documented in the study area in 2005 we added 13 locations (11 western toads and 2 wood frogs) from Hawkes and Fraker (1999) to the distribution map. The long-toed salamander was not detected in 1999 and only the core stratum was sampled. Boreal chorus frogs were not detected probably because field sampling occurred too late in the year and they are typically hard to detecte after they have finished breeding, which usually begins in mid-April and ends around the end of May.

Table 39. Number of sites per strata for each amphibian species detected in the Peace River study area in 1999 and 2005. C = core; P = periphery.

	A. macrodactylum		*B. boreas*		*R. sylvatica*	
Year	**C**	**P**	**C**	**P**	**C**	**P**
1999	0	N/A	11	N/A	2	N/A
2005	3	0	13	8	22	34
Total Sites	3	0	24	8	24	34

Map 13. Amphibian and reptile sampling locations in the Peace River study area.

Map 14. Amphibian and reptile detection locations from this survey and 1999 (Hawkes and Fraker 2000).

Several analyses were performed on the 2005 data. A 1-way ANOVA was used to test for differences in total observations between strata of all amphibians combined (F = 1.52; *P* = 0.2197). A t-test was used to test for differences in the number of sites occupied by frogs and/or toads in the core versus the periphery. The number of sites occupied by either toads or frogs was not significantly greater in either stratum (wood frogs: *P* = 0.0761; western toads, *P* = 0.3328). However, the total number of sites occupied by wood frogs was greater than the total number occupied by western toads (1-way ANOVA; F = 35.7; *P* < 0.0001) irrespective of stratum.

3.6.2.2 Abundance

We counted 8 long-toed salamander tadpoles, 16,327 western toads of 5 age classes (+ 1 unclassified category) and 1,340 wood frogs in 4 age classes (+ 1 unclassified category) for a total of 17,675 observations (Table 40). The large number of western toads can be attributed to the detection of two large egg masses (the total number of eggs in each egg mass was estimated) Juveniles western toads (recently emerged metamorphs) were abundant in both strata. The relative abundance for western toads and wood frogs was not calculated because of the search method employed (time-constrained searches). Similarly, although we did use dipnetting to sample for long-toed salamanders, the timing, duration and extent of sampling did not permit the development of a relative abundance estimate. Breeding populations of the long-toed salamander must occur, at least in two locations within the core stratum and breeding populations of both wood frogs and western toads occur in both strata and throughout the Peace River study area.

Table 40. Total number of individuals of each amphibian species detected in the Peace River study area. C = Core; P = Periphery.

	A. macrodactylum		*B. Boreas*		*R. sylvatica*	
Age Class	**C**	**P**	**C**	**P**	**C**	**P**
Eggs			12,960[1]			
Larvae	8		56[2]		2	1,100[2]
Juveniles			1,280[2]	2,010[2]	5	97
Sub-adults				8	3	14
Adults			1	4	24	53
Unclassified			8		15	27
Total	**8**	**0**	**14,305**	**2,022**	**49**	**1,291**

[1] Number of eggs estimated from 2 egg masses
[2] Number of larvae estimated
[3] Number of juveniles (metamorphs) estimated via visual estimation

3.6.3 Body Condition

Body condition can be used to assess the health of a population of amphibians. In this case the difference in mean snout-urostyle length (the length from the anterior tip of the snout to the posterior tip of the bony projection on the back) was compared for both western toads and wood frogs between the core and periphery strata. A 1-way ANOVA was used to test the hypothesis of no difference, which was accurate for western toads (F = 1.3; *P* = 0.5854). However, mean snout-urostyle length for wood frogs was greater in the core than it was in the periphery (F = 3.73; *P* = 0.0554) (Figure 8).

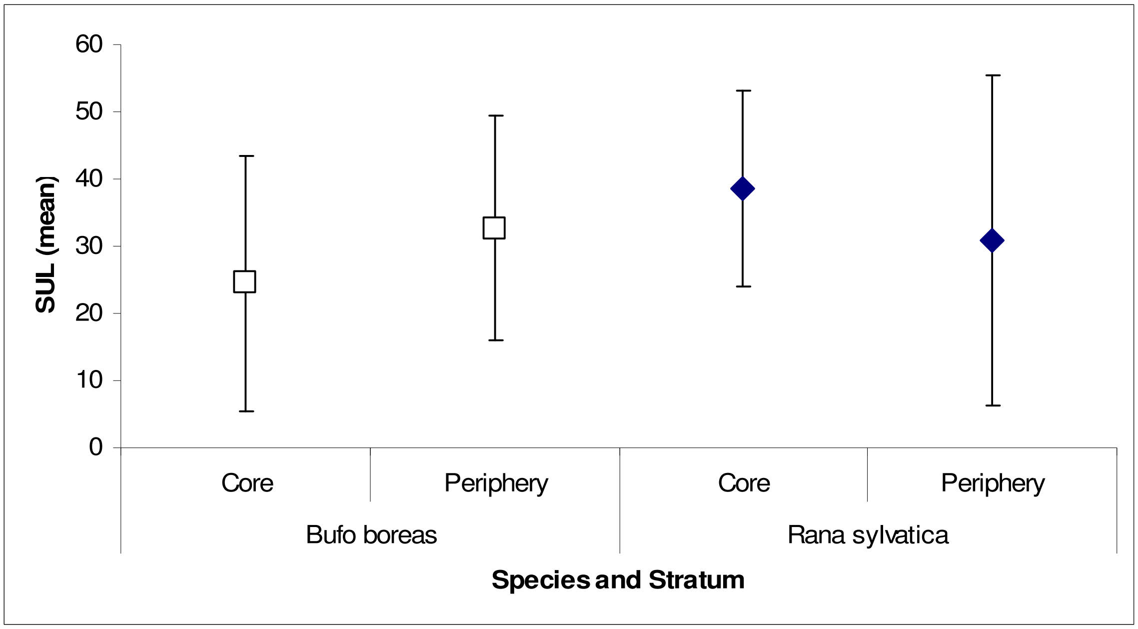

Figure 8. Mean (± SD) snout-urostyle length for western toads and wood frogs in the core and periphery stratum of the Peace River study area.

3.6.3.1 Reptiles

3.6.4 Distribution

Two species of garter snake were detected in the Peace River study area: *Thamnophis sirtalis parietalis* (common garter snake, red-sided subspecies) and *T. elegans* (western terrestrial garter snake). Garter snakes were detected at 17 sites. The common garter snake was detected at 7 sites (2 core; 5 periphery), the western terrestrial garter snake was documented from 5 sites, all in the core, and garter snakes not identified to species were documented from an additional 5 sites in the core (Map 14). There were not enough data to do any statistical testing on the distribution and / or presence of snake species in either stratum or study area.

3.7 Rare and Endangered Plants and Plant Communities

Vegetation sampling occurred between 20 July and 06 August 2005 from 214 locations, 170 in the core and 44 in the periphery (Map 15). Over 400 species of vascular plants were recorded in the study area (Appendix IX). Of these, 21 species are considered rare in British Columbia by the British Columbia CDC (Table 41; Map 16). Six of those rare species have not been previously found in the Peace River area. We increased the number of known locations for several of the rare species previously recorded in the Peace River area.

In addition to the 22 species we documented, the CDC list several other rare species in the study area that we did not document during our surveys:

1. *Lomatium foeniculaceum* var. *foeniculaceum* from Bear Flats, Golata Creek, and Kistkatinaw River. This is an early spring plant that would not be found in the time of our survey;

Map 15. Distribution of vegetation sampling sites in the Peace River study area.

Map 16. Distribution of rare plant detection locations in the Peace River study area.

2. *Polygala senega* from "N of Peace River" – old collection, recently not confirmed;
3. *Ranunculus cardiophyllus*, *Ranunculus pedatifidus* subsp. *affinis*, and *Ranunculus cordiophyllus* – old collections from the 1930's, recently not confirmed;
4. *Townsendia hookeri* - the only locality is at the Alces River; we did not survey this particular site.

Rare plants were documented from 53% of all sites (n = 114), 82 in the core and 32 in the periphery (Table 41). Nine species were documented only in the core, with 3 unique to the periphery. Species documented in only the core or periphery strata were documented at only a few sites (< 44 sites / species).

Table 41. Rare vascular plants located during surveys of the Peace River study area. Species with an asterisk (*) have not been previously recorded from the Peace River area. Species in bold indicate occurrence in only one stratum.

Species	Global/Provincial Rank	Status in BC[1]	Stratum		Total Sites
			Core	Periphery	
Anemone virginiana var. *cylindroidea*	G5 T? S1	RED	13	1	14
***Arabis lignifera* ***	**G5 S2S3**	**BLUE**	**1**	**-**	1
Arnica chamissonis* subsp. *incana	**G5 T? S3**	**BLUE**	**1**	**-**	1
Artemisia longifolia	G5 S2	RED	13	2	15
Atriplex nuttallii	**G5 S1**	**RED**	**1**	**-**	1
***Botrychium crenulatum* ***	**G3 S2S3**	**BLUE**	**-**	**1**	1
Calamagrostis montanensis	G5 S1	RED	3	5	8
Carex torreyi	G4 S2S3	BLUE	2	1	3
Carex xerantica	G5 S2S3	BLUE	6	2	8
Cirsium drummondii	**G5 S1**	**RED**	**2**	**-**	2
Eleocharis tenuis*	**G5 S2S3**	**BLUE**	**1**	**-**	1
Epilobium saximontanum*	**G5 S2S3**	**BLUE**	**2**	**-**	2
Glyceria pulchella	**G5 S2S3**	**BLUE**	**-**	**3**	3
Helictotrichon hookeri	G5 S2S3	BLUE	11	5	16
***Juncus confusus* ***	**G5 S1**	**RED**	**2**	**-**	2
Oxytropis jordalii* subsp. *davisii	**G4 T3 S3**	**BLUE**	**1**	**-**	1
Penstemon gracilis	G5 S2	RED	10	2	12
Salix serissima	**G4 S2S3**	**BLUE**	**-**	**4**	4
Schizachyrium scoparium *	G5 S1	RED	7	5	12
Selaginella rupestris	**G5 S1**	**RED**	**1**	**-**	1
Silene drummondii var. *drummondii*	G5 T5 S3	BLUE	5	1	6
		Total Sites / Stratum	82	32	114

[1] BC Conservation Data Centre: http://srmwww.gov.bc.ca/cdc/

We documented 24 species of native vascular plants (including several that appear in Table 41) that had not been previously documented in the Peace River study area and two of these species (*Carex umbellata* and *Chenopodium salinum*) do not appear in the *Illustrated Flora of British Columbia* indicating that they had not been documented within BC until this study. In addition, two introduced species, *Caragana arborescens* and *Lonicera tatarica,* have not been previously listed in the *Illustrated Flora of British Columbia* and another 5 introduced species had not previously been documented in the study area (Table 43).

Table 42. Native vascular plants that had not been previously documented in the Peace River study area. Species in bold appear in Table 41 and species indicated by * do not appear in the *Illustrated Flora of British Columbia.*

Scientific Name	Scientific Name
Arabis lignifera	***Epilobium saximontanum***
Arctagrostis latifolia subsp. *arundinacea*	***Juncus confusus***
Aster modestus	*Lithospermum incisum*
Botrychium crenulatum	*Lycopus uniflorus*
Carex garberi subsp. *garberi*	*Monotropa uniflora*
Carex lanuginosa	*Orthilia secunda*
Carex tracyi	*Oxytropis maydelliana*
Carex umbellata *	*Puccinellia distans*
Chenopodium atrovirens	***Schizachyrium scoparium***
Chenopodium salinum *	*Stellaria longifolia*
Dracocephalum parviflorum	*Veronica anagallis-aquatica*
Epilobium ciliatum subsp. *glandulosum*	*Woodsia oregana*

Table 43. Introduced species that had not been previously documented in the study area. Species indicated by * are not included in the *Illustrated Flora of British Columbia*.

Scientific Name
Apera interrupta
*Caragana anagyroides**
Fagopyrum esculentum
Inula helenium
Kochia scoparia
*Lonicera tatarica**
Trifolium hybridum

3.7.1 Distribution of the rare plants in the study area

Three vegetation complexes account for most, if not all rare vascular plant species in the Peace River study area. The following describes the three complexes by name and indicates the plants that would commonly occur in those complexes:

1. Valley bottom, shore of the Peace River, and islands in the river:

Arnica chamissonis subsp. *incana*
Artemisia longifolia
Cirsium drummondii
Eleocharis tenuis
Epilobium saximontanum
Juncus confusus

2. Breaks above the Peace and Beatton Rivers and their tributaries:

Anemone virginiana var. *cylindroidea*
Arabis lignifera
Artemisia longifolia

Atriplex nuttallii
Calamagrostis montanensis
Carex torreyi
Carex xerantica
Cirsium drummondii
Helictotrichon hookeri
Oxytropis jordalii subsp. *davisii*
Penstemon gracilis
Schizachyrium scoparium
Selaginella rupestris
Silene drummondii

3. Wetland complexes on the plateau above the Peace River

Botrychium crenulatum
Glyceria pulchella
Salix serissima

Complex 2 (breaks above the Peace and Beatton Rivers) had the highest number of rare plants. Sites with high concentrations of rare plants include the ecological reserve near Clayhurst, the confluence of John Creek and the Beatton River, and Bear Flats (Map 16).

4. Discussion

4.1 Habitat Capability / Suitability Modeling

A detailed species account was compiled for each model species to identify habitat attributes related to key species life requisites (Appendix I). Habitat Suitability Index (HSI) models were then developed to define the relationships between these attributes. The utility of HSI models is their transparency and repeatability, with all assumptions, transformations, and relationships clearly documented. This allows the models to be easily evaluated and adjusted, as well as improved as the knowledge base improves. In addition, HSI models can be tailored to run on any inventory by establishing relationships between the model habitat variables and the attributes available in whatever vegetative or ecological inventory base is available, such as TEM, PEM, Forest Cover, Biophysical Habitat Mapping, or thematic imagery. This is particularly relevant in the case of the Peace, where TEM is available for a very limited area (the core study area). The HSI models developed for this project can be tailored for application to whatever inventory types might be available for the surrounding Periphery (e.g. biophysical habitat mapping or forest cover).

Black-throated Green Warbler (BTNW)

The BTNW is an area sensitive species associated with mature to old mixedwood forests. Next to Canada Warbler, the BTNW was the second most frequently detected blue-listed passerine during the 2005 survey period. 32,146.4 hectares were found suitable for BTNW, of which 1,996.5 hectares were considered high value habitat. High value habitat was generally found in older (structural stage 6) spruce-dominated mixedwood. Value was given to deciduous leading mixedwood however on average, these stands tended to be younger (i.e., lower structural stages) and so scored moderate to low in value. Model outputs are consistent with 2005 point count survey results where most detections occurred within the broad habitat classes of mixed deciduous-coniferous and coniferous-deciduous.

Limits to the amount of high and moderate habitat available resulted from the need for older stands of sufficient size to offer interior forest conditions. There are only 470 polygons in the entire TEM dataset (+5000) that are primarily structural stage 6 or 7 (leading decile). Only 51 of those are greater than the 28.3 ha area cutoff above which stands are considered optimal, and only 44 of those 51 are not in a complex with younger ecosystems resulting a decrease in habitat value. Stand area values were calculated based on the area individual polygons and did not consider the combined area of similarly valued adjacent polygons. Therefore, model outputs likely underestimate the amount of optimal habitat in the core study area. Model resolution can be improved by incorporating a spatial adjacency function into the stand area variable.

An examination of current model outputs (Appendix XI) illustrates more suitable habitats are located in the western half of the core study area, west of Fort St. John, and more predominant around the Halfway River confluence and west to Hudson’s Hope. This would appear to reflect the prominence of older spruce dominated mixedwood to the west, while aspen dominated mixedwood begins to predominate downstream towards the Alberta border.

Canada Warbler (CAWA)

Canada warblers are found mainly in upland mature to old deciduous mixedwood stands on steep slopes, and floodplains with adjacent slopes containing mature to old deciduous mixedwood stands. Canada warblers are an area sensitive species which forage and nest in dense, shrubby understory. The CAWA was the most frequently detected blue-listed passerine during the 2005 survey period.

39,700.7 hectares were found suitable for CAWA, of which 253.3 hectares were considered high value habitat. High and moderate value habitat was generally found in deciduous mixedwood where a lush understorey of tall shrubs and tree saplings (1.5m to 4.0 in height) dominates. These sites tend to be older (> structural stage 6), though pole-sapling and young forest sites can provide the shrubby nature required to support CAWA. Model outputs are consistent with 2005 point count survey results documenting CAWA at 20 different point count sites within the core area, primarily within mixed deciduous leading stands. Suitable habitat appears to be distributed through the core study area, from Hudson's Hope to the Alberta border

Most suitable habitat is of moderate to low quality, with some limited high value habitats occurring on islands. This model, weighted heavily in favour of the tall shrub variable, relies on the VPro cover data from the TEM field validation and bias may result from the approach to summing plot cover percentages for tall shrub species (potentially overestimate the actual % cover from tall shrubs). Despite this, % tall shrub cover values rarely exceeded 50% and the model was adjusted to reflect the actual shrub cover percentages from the data. In addition, stand area values were calculated based on the area individual polygons and did not consider the combined area of similarly valued adjacent polygons. Therefore, model outputs likely underestimate the amount of optimal habitat in the core study area, reducing potentially high value habitat down to moderate. Model resolution can be improved by incorporating a spatial adjacency function into the stand area variable.

Floodplain habitats with adjacent suitable slopes are presumed to be highly valuable (see model documentation in Appendix I). Model resolution can be improved by incorporating a spatial adjacency function into calculating the habitat value of floodplain polygons. In the absence of a spatial adjacency function, it is assumed that the TEM identifies and separates out floodplain associated ecosystems and that those floodplain types are valued separately (presumably higher) based on their associated plant communities. Currently, many of the floodplain polygons may be rated lower than they should as the influence of adjacent high value slope habitat is not being factored into the value of floodplain sites.

Cape May Warbler (CMWA)

The Cape May Warbler is associated with mature to old white spruce dominated forests. There were no 2005 detections in the core study area; however, CMWA were detected in upland periphery sites in mixed coniferous/deciduous and coniferous habitats. Only 3,759.6 hectares were found suitable for CMWA, of which only 79.4 hectares were considered high value habitat. The remainder was split relatively evenly between moderate and low suitability (Table 13). High value habitats were limited to those very few mature to old stands that contained a high proportion of spruce. Model outputs were consistent with the very limited survey results for the periphery.

The model requires >50% white spruce for stands to rate as optimal, and only structural stages 6 and 7 are given value. As discussed above for the BTNW, there were only 470 polygons in the entire TEM dataset (+5000) that were structural stage 6 or 7 in the leading decile, of which only 392 are not complex (i.e. only one ecosystem type in the polygon). There were some complex polygons split evenly between young and mature/old forest that would get moderate value. In addition, only 4 ecosystem types in the TEM data have > 50% white spruce (Sw) in the tree canopy (Sw-current-bluebells (SC), Sw-current-horsetail (SH), Sw-current-oak fern (SO), and Sw-wildrye-peavine (SW)) and only SC has the > 80% Sw required for optimal habitat. More accurate tree canopy species composition field data will allow for refinements of the predicted % tree species composition by ecosystem unit that may improve model resolution.

Similar to the BTNW, suitable CMWA habitat tends to be more prevalent west of Fort St. John (see map in Appendix XI), particularly in the area of the Halfway River confluence, reflective of the distribution of old spruce stands in the study area.

Connecticut Warbler (COWA)

Connecticut warblers are forest interior, ground dwelling birds found in pure and mixedwood aspen stands with predominantly herbaceous understories. The species nests and feeds in herbaceous vegetation and shrubs at ground level. 22,023.8 hectares were found suitable for COWA, of which 5,745.9 hectares were considered high value habitat.

Compared to BTNW and CAWA (the most frequently detected blue-listed passerines in the core study area), there was much less suitable COWA habitat in the core area, but more of it was of higher value (Table 13). This is likely because the COWA model allocates value to aspen stands within a much broader range of age classes. In addition, the model identifies stands with 25-90% herbaceous understorey cover as optimal. Estimates of herbaceous cover from the TEM validation field data produced relatively high results, with values ranging from 10 to 100%. These calculated herbaceous cover values are assumed to overestimate the actual amount of herb cover in stands (see Appendix X). The breadth of cover values for which optimal scores are possible, in combination with likely overestimates of herbaceous cover, resulted in fully three quarters of the ecosystems within the study area with sufficient herbaceous cover to rank optimally for that model variable. Further field data collection and model refinements may improve model resolution.

The availability of optimal COWA habitat is, therefore, limited only by the availability of aspen-dominated stands of sufficient size. Similar to BTNW, stand area values were calculated based on the area of individual polygons and did not consider the combined area of similarly valued adjacent polygons. Model outputs likely underestimate the amount of optimal habitat in the core study area. Model resolution can be improved by incorporating a spatial adjacency function into the stand area variable.

Overall, the core study area appears to have a good supply of highly suitable habitat which appears to be much more broadly and evenly distributed along the length of the Peace River (Appendix XI). There was only one detection in the core study area during the 2005 point count surveys, on the north side of the river in what was reported as edge habitat, with a pure aspen overstorey at the site. However, COWA are highly secretive and difficult to detect during surveys.

Philadelphia Vireo (PHVI)

Philadelphia vireos are found mainly in younger to mature deciduous dominated stands with high canopy closure. Again, there was only one detection in the core study area during the 2005 point count surveys and this was reported on the south side of the river in a mixed deciduous-leading habitat type. Fifty percent of the overstorey at the point count location was reported to be paper birch, with a mixed component of white spruce and balsam poplar. There were no other PHVI detections in the 2005 survey outside of the one detection in the core area.

21,945.9 hectares were found suitable for PHVI, most of which was of moderate value. There was only 12.8 hectares of high value habitat in the core study area. The model requirement for extremely high canopy closure (>60% is optimal) restricts the amount of optimal habitat possible. Predictive estimates of total treed canopy closure for forested ecosystems in the study area based on the VPro data analysis rarely exceed 30% indicating that stands in the study area are relatively open. This discrepancy between model canopy closure requirements and predicted stand values could be an artifact of how the VPro data was analyzed and / or the assumptions used to develop canopy closure estimates. However, model outputs might accurately reflect the more open nature of stands in the Peace River area.

Because PHVI require younger deciduous leading stands, much of the suitable habitat tends to occur in the eastern half of the study area, east of Fort St. John, through to the Alberta border (see map in Appendix XI).

Barred Owl (BAOW)

High quality reproductive habitat for the Barred Owl includes large diameter trees in adequate decay condition in structurally diverse, mixedwood forests to provide suitable nest cavities and roosting opportunities. Such forests are expected to be of sufficient age, composition, height and canopy closure to provide for foraging opportunities. The habitat model for BAOW indicated that very little suitable habitat is available in the Peace River core area. Only 1,482.6 hectares were found suitable for BAWA; of which only 715.7 hectares were high value habitat. Most of the high value habitat was located in the area of Cache Creek and the Halfway River confluence, on the south side of the river, where most of the un-roaded, older spruce-dominated forests occur (see map in Appendix XI).

Barred owls have been extensively studied in mixedwood forest and there are several versions of existing habitat suitability models available (see model documentation in Appendix I). This model developed for the Peace study area assumes that BAOW rely on both big deciduous and big spruce trees for nesting. It also follows the model developed by Olsen et al (1999) for the Foothills Model Forest in west-central Alberta in assuming that a minimum conifer component is required to provide cover at nesting, and roosting, sites. Based on current knowledge of BAOW reproductive habitat use, the model requires that all habitat variables are required for a stand to have value.

The current model reflects the tight association of BAOW with mature and old forests located away from disturbance and away from openings where they might potentially interact with Great Horned Owls (Takats 1998, Olsen *et al*. 1999). Forests below structural stage 6 have no habitat value. Due to the relatively 'young' composition of the Peace River core study area (i.e. only 470 polygons in the entire TEM dataset (+5000) that were primarily structural stage 6 or 7 (leading decile), of which only 392 are not complex (i.e. only one ecosystem type in the polygon)), suitable BAOW is limited in supply within the core. Reductions in value for adjacency to open habitats, which occur frequently in the study area, and roads, particularly on the north side of the river, further limit the available supply. There is no suitable habitat on the north side of the river due to high road densities and the predominance of cultivated fields and other openings. It is anticipated that the periphery surrounding the river valley may offer more habitat opportunities.

Following the recommendations of Olsen et al. (1999), the BAOW model documentation (Appendix I) provides direction to calculate Habitat Units by multiply the HSI score for the polygon by the number of hectares. As per Mazur (1997), Takats (1998), Olsen *et al*. (1999), and Higgelke and MacLeod (2000), the home range size of breeding Barred Owls is assumed to be 150 ha. According to Mazur (1997) and Olsen *et al*. (1999), at least 40 hectares of the breeding home range should be optimal reproductive habitat (40 ha of HSI=1) or some combination of less suitable habitats equivalent to 40 ha of optimal reproductive habitat. Since the 0 to 1.0 HSI values for BAOW were re-classified to a four-point provincial scale, Habitat Units were not calculated for the project. In addition, the narrow spatial scope of the mapping (i.e. 4 km wide corridor centred on the Peace River) and the apparent lack of suitable habitat, in conjunction with the need to apply a moving windows analysis, limited the applicability and logistic feasible of applying this spatial composition analysis.

Barred Owls were not detected in the core area, and only one Barred Owl was detected during the 2005 survey period, playback surveys were conducted late in the year (from mid-June onward) during nesting and fledging, likely resulting in low response rates. Though Barred Owls have been found in other studies to select mixedwood stands of White Spruce, Balsam Poplar and Trembling Aspen and to be found at lower elevations associated with large riparian systems where Balsam Poplar are present (Takats 1998), modeling results indicate that they are not likely to be found in any significant numbers in the Peace River core study area, and should not be considered a suitable species for future modeling.

Boreal Owl (BOOW)

High quality reproductive habitat for the Boreal Owl requires large diameter trees in adequate decay condition in structurally diverse, conifer-leading forests to provide suitable nest cavities and roosting opportunities. Such forests are expected to be of sufficient age, composition, height and canopy closure to provide for foraging opportunities. Boreal owls were not detected during the 2005 survey period but have been recorded in the area (Campbell et al. 1990).

16758.7 hectares were found suitable for BOOW, of which 1,229 hectares were considered high value habitat. Most of the suitable habitat was of low value. The model reflects the assumption that BOOW rely on big deciduous and spruce trees for nesting and heavily weights this nesting requirement. The need for mature to old conifer for roosting is considered, but does not limit the ability for a younger deciduous-leading stand which can, on the appropriate growing site, produce the big trees required for nesting. This broad approach reflects the reported use of both pure deciduous and coniferous as well as mixed stands by BOOW. However, the model does considered the weighted average of nesting to roosting and the lack of suitable coniferous roosting value in a polygon will significantly reduce the overall habitat value resulting in far more low values than moderate.

Model output is consistent with the current understanding of BOOW as a old conifer-associated species. Overall, the older spruce-dominated stands around the confluence of the Halfway River offer the best reproductive habitat for BOOW (see map in Appendix XI).

Model and Data Assumptions and Biases

As documented in the discussions above for individual species models, as well as in the Results section, there are a number of assumptions inherent in the models as well as issues related to the quality and nature of available inventory data. These can cause potential bias in the model outputs. General issues are listed below.

1. TEM data quality: a draft version of the TEM was used and there were a number of attribute field errors that resulted in polygons getting a default value of Nil. In addition, complex polygons where deciles added up to > 10 were not given a rating. When cleaned, model runs would ascribe true habitat values to these polygons.

2. VPro data on which predicted relationships between ecosystem type and habitat variable were established were limited in terms of sampling intensity, with many ecosystem associations having less than 5 plots. Data on structural attributes such as tree height and diameter were not collected and canopy closure data was deemed too variable to be informative (Lauren Simpson, Keystone, personal communication).

3. Canopy closure estimates were premised on the assumption that the VPro data source provided cover information for mature stands. Canopy closure estimates applied across structural stages were derived from values for mature stands.

4. Predictive relationships between habitat variables and TEM attributes were based on an understanding of factors such as tree form and site index (Appendix X). These relationships are untested.
5. 2005 bird survey data was limited in its utility for testing model assumptions. The TEM was not available in time for use during the analysis of the 2005 bird survey data. Only limited numbers of detections were recorded for blue-listed species (Table 20) and owl species (Table 29). Habitat data systematically collected at point count locations was limited in its usefulness for testing habitat variable assumptions as there was often only one site where blue-listed birds were recorded. No habitat data was available for Barred Owl detections.
6. Where stand area was applied to modify habitat value, stand area values were calculated based on the area individual polygons and did not consider the combined area of similarly valued adjacent polygons. Model outputs likely underestimate the amount of optimal habitat in the core study area. Model resolution can be improved by incorporating a spatial adjacency function into the stand area variable
7. Where slope was applied to modify habitat value, slope was derived from the site modifiers. This may double-count the influence of slope on habitat value for some seral associations where the VPro data provided separate vegetative characteristics based on slope modifiers (i.e., SCab-k, AMap-k, and AMap-w).

4.2 Butterflies

Forty-one species of butterfly were recorded from the Peace River study area. Eight of these were Blue-listed species, including four species closely associated with native grassland habitat on south-facing slope – a habitat type specifically targeted for sampling in this study. All eight Blue-listed species were recorded from the Core stratum, with only two (and possibly three) species also recorded in the Periphery stratum. However, insufficient data was collected to draw conclusions on the probable distributions of the eight Blue-listed species across the study strata. Additional sampling effort may reveal that adults of all eight Blue-listed species found in this study might be detected in both strata, and may reveal listed species that were not detected during the 2005 study season. There are significant sampling gaps in a number of areas of the Peace River study area, and particularly in the Periphery stratum that need filling.

However, there are substantial differences in ecosystem composition between the two strata and this will need to be taken into account in designing an additional sampling program. The best habitats for those species whose larvae depend on grasses are more abundant in the Core than in the Periphery. Data in Figure 3 indicate that the Broad Ecosystem Inventory Unit of Montane Shrub/Grassland, while present in the Periphery stratum, is proportionally more abundant in the Core stratum than in either the Periphery stratum or in the entire Peace Lowland Ecosection (PEL; which is the only ecosection in the Peace River Basin Ecoregion [PRBE]) (9.3% *cf*. 2.7% and 2.0%, respectively; Figure 3). Montane Shrub/Grassland occurs primarily along south facing slopes along the Peace River and along the lower elevations of major tributaries to the Peace River. Conversely, Cultivated Field forms a much greater proportion of the Periphery stratum than the Core stratum or the PEL (i.e., 38.4% *cf*. 19.2% and 40.9%, respectively). Figure 9 shows the Core stratum (i.e., a 2-km-wide buffer on both sides of a stretch of the Peace River) in relation to the Peace Lowland Ecosection within B.C. As indicated by Guppy and Shepherd (2001) and Hervieux (2002), agricultural expansion since the early 1900s has eliminated most of the native grasslands of the prairies of the Peace region, including those within the PEL. Native grasslands that do remain tend to be confined to the slopes of the Peace River valley and its adjoining tributaries. As a result of the reduced effects of wildfire (due to provincial policies of fire suppression), many of those grasslands are experiencing successional changes into shrublands and forests (Guppy and Shepherd 2001).

To make comparisons between the distribution of butterflies and to be able to relate this to habitat availability in the Core and Periphery strata, a stratified sampling design is required. At present, there are no vegetation coverages available at a sufficient resolution to stratify a sampling regime at a scale meaningful to butterflies. It is recommended that the Terrestrial Ecosystem Mapping conducted for the Core stratum (Keystone Wildlife Research 2006) is extended to encompass the Periphery stratum to enable this to be done. In the absence of this, further work on the butterfly fauna of the study area should be expanded to map the distribution, patch-size, floristic-composition, and quality of native grassland habitats in the study area, including road-side remnants. Given that many of the Blue-listed species are associated with grassland habitat, this may be useful surrogate information for predicting the likely occurrence of these species throughout the study area. It is also likely to be more cost-effective than trying to capture specimens of species that, by their nature, are generally rare in the landscape.

Figure 9. Location of the Peace Lowland Ecosection (black polygon) within British Columbia (grey). The Core stratum recognized in the present study is indicated as a white strip within the PLE.

The presence of adult butterflies is not an adequate indicator of the habitat requirements of a species. Most adult butterflies can forage on the nectar of a wide variety of flowers. However, the larval stage has strict dietary requirements in that most species will consume only one or a few plant species at this life-stage. Larvae of the Blue-listed species of butterfly recorded in the study area during the present study depend on a wide range of plant species, but the precise larvae-host plant relationships in B.C. are poorly understood (Guppy and Shepherd 2001). In general, plant species in the grass, sedge, rush, rose, violet, primrose, legume, saxifrage, mallow, and sunflower families are important larval hosts, with grasses being important to the majority of species of conservation concern in the study area (Table 44). To identify the full suite of habitats utilised by all life-stages of a species, and to inform predictions of the likely occurrence on Blue-listed species not closely associated with native grasslands, future work should also attempt to map the availability of larval host-plants throughout the study area.

Table 44. Provincial distribution and larval host-plant information for the 15 Blue-listed[a,b] butterfly species expected to occur in the Peace study area. Larval host-plant information was sourced from http://www.cbif.gc.ca/spp_pages/butterflies/larvalfood_e.php. Presence in the Peace River Basin Ecoregion (PRBE)[c]: 1=confined to PRBE; 2=occurs primarily in PRBE; 3=occurs in PRBE and other parts of B.C.; 4=occurs in other parts of B.C. but not in PRBE. The species identification of all but one species-stratum combination was "certain" (i.e., confirmed).

Scientific Name	Common Name	Occurrence in PRBE[c]	Species Confirmed in Present Study	Important Larval Host(s)
Agriadus glandon lacustris[d]	Arctic Blue, *lacustris* subspecies	1		Primulaceae (primroses); Fabaceae (legumes); Saxifragaceae (saxifrages)
Carterocephalus palaemon mandan	Arctic Skipper, *mandan* subspecies	1	Core	Poaceae (grasses)
Cercyonis pegala ino	Common Wood-nymph, *ino* subspecies	1	Core & Periphery	Poaceae (grasses)
Coenonympha tullia benjamini	Common Ringlet, *benjamini* subspecies	2	Core	Poaceae (grasses)
Erebia discoidalis	Red-disked Alpine	3		Poaceae (grasses); Cyperaceae (sedges)
Hesperia comma assiniboia	Common Branded Skipper, *assiniboia* subspecies	1	Core & Periphery	Poaceae (grasses)
Oeneis alberta	Alberta Arctic	1		Poaceae (grasses)
Oeneis uhleri	Uhler's Arctic	2		Poaceae (grasses)
Papilio machaon pikei	Baird's (Old World) Swallowtail, *pikei* subspecies	1	Core	*Artemisia dracunculus* (tarragon)
Phyciodes batesii	Tawny Crescent	2		*Aster* spp. (asters)
Pyrgus communis[d]	Checkered Skipper	4		Malvaceae (mallows)
Satyrium liparops	Striped Hairstreak	1		Rosaceae (roses: *Prunus* spp., *Crataegus* spp.)
Satyrium titus titus	Coral Hairstreak, *titus* subspecies	1	Core	Rosaceae (roses: *Prunus* spp., *Crataegus* spp., *Amelanchier alnifolia*)
Speyeria aphrodite manitoba	Aphrodite Fritillary, *manitoba* subspecies	1	Core & Periphery	Violaceae (violets)
Speyeria cybele pseudocarpenteri	Great Spangled Fritillary, *pseudocarpenteri* subspecies	1	Core (probable in periphery)	Violaceae (violets)

[a] http://srmapps.gov.bc.ca/apps/eswp/ accessed September 2005
[b] Indigenous species or subspecies considered to be of Special Concern (formerly Vulnerable) in B.C. Taxa of Special Concern have characteristics that make them particularly sensitive or vulnerable to human activities or natural events. Blue-listed taxa are at risk, but are not Extirpated, Endangered or Threatened.
[c] This assignment is based on a visual interpretations of (sub)species distribution mapping in Guppy and Shepherd (2001). The Peace River Basin Ecoregion (PRBE) is a wide plain that lies between rolling uplands to the north and south; it is dissected by the Peace River and its tributaries. In British Columbia this Ecoregion is represented by only one Ecosection: the Peace Lowlands Ecosection (Demarchi 1996).
[d] Recorded from the Peace River valley in Alberta; all BC records from the SW corner of BC (Guppy and Shepherd 2001).

4.3 Songbirds and Allied Species

Of the 79 species of songbirds documented in the Peace River study area during 2005 surveys, six have designated BC Provincial Conservation Status (**Error! Reference source not found.**). One species, Canada Warbler, is a Priority Group 1 COSEWIC candidate species, meaning that this species has not yet been assessed by COSEWIC but has been identified as being potentially at risk in Canada. Species that occur on the Priority Group 1 Candidate list are expected to be at high risk of extirpation in at least part of their historical range in Canada. Other songbird species are being considered for COSEWIC status reports. The Olive-sided Flycatcher is being considered because of noted population declines throughout its range in Canada. This species has apparently been declining at a rate of 3.5% per year for the last 30 years with measurable declines as high as 9.5% per year in some areas. As much as 90% of the world's population of this species resides in Canada. Additionally, the COSEWIC status report for the Rusty Blackbird is currently under review. Both of these species appear to be adversely affected by large scale habitat alterations throughout their range.

During the 2005 point counts, 74 passerine bird, five woodpecker species, one dove species and one hummingbird species (81 passerine and "near passerine" species) were detected (Appendices II and III). This was slightly more than the 69 passerine species detected in a previous study (Robertson and Hawkes 2000) that was conducted in late August. Numbers of species detected in 2005, with numbers detected in the previous study in parentheses were: tyrant flycatchers: 7(6), swallows 5(4), corvids 5(6), titmice 2(3), nuthatches 2(1), wrens 3(0), dippers 0(1), kinglets and thrushes 6(8), waxwings (1), vireos 4(3), wood warblers 16(17), tanagers 1(1), cardinalid grosbeaks 1(1), emberizid sparrows 12(8), blackbirds and orioles 4(5) and cardueline finches 4(4). Point counts provide a good measure of the breeding populations of most species within a given area, but unless they are exhaustive will likely miss a few localized or scarce species within the study area, as well as species of unsampled habitats.

Most passerine species identified in the study area, but not on the point counts were either scarce in the area or restricted to urban habitats and/or farmyards, neither of which were sampled. The omission of Brewer's Blackbird from the counts is surprising; however, our incidental observations concur with Siddle's (1982) characterization of this species as common in the area during the summer, both in Fort St. John and along rural roads, including sites between some of our point count sites. Its tendency to nest somewhat colonially (Williams 1958; Skutch 1996; Martin 2002) probably contributed to this omission.

The following sections describe the known habitat associations for each of the 8 red- of blue-listed passerines that occur in the Peace River study area. Siddle (1982) listed the Black-throated Green Warbler as an uncommon summer resident of the Peace River area and all seven of the other provincially-listed red and blue-listed species known to occur in the area as "rare summer" birds. Our 2005 surveys detected six of these eight species.

Bay-breasted Warbler: We did not encounter this species at any study sites or incidentally anywhere within the study area in 2005. Bay-breasted Warblers "undergo… significant changes in population density correlated with outbreaks of spruce budworm…" in eastern parts of their range (Williams 1996) and may similarly fluctuate in numbers in the study area (Cooper et al. 1997a). Charlie Lake is known as a site to look for them (George 1993) and was the first site at which they were reported in BC (Cooper et al. 1997a). Beatton Provincial Park and Stoddard Creek Woods in Fort St. John are considered sites of regular occurrence of them (Enns and Siddle 1996). They have been observed in riparian habitat near Fort St. John (Siddle 1979) and riparian coniferous or mixed forest with a multi-layered canopy and frequent openings primarily farther north in BC (Campbell et al. 2001). Nesting is usually in "thick stands" of conifers, less often mixed forests of deciduous and coniferous trees (Harrison 1984; Enns and Siddle (1996) or even primarily deciduous forests (Enns and Siddle 1996).

Black-throated Green Warbler: We detected Black-throated Green Warblers primarily in mixed deciduous-coniferous and coniferous-deciduous habitats, with no detections in riparian habitat (Appendix VII). Some previous authors (e.g. Blood and Backhouse 1998; Enns and Siddle 1996; Cooper et al. 1997b) have stressed the importance of riparian habitat to this species in the Peace River lowlands, but our survey results support the findings of Phinney (1998, 2003) that this species is found primarily in mature non-riparian mixed-woods habitat in the Dawson Creek area. Our results are also consistent with the species' depiction as a "characteristic inhabitant of boreal coniferous forest and transitional deciduous forests, associated with conifers…" (Morse 1993), and Enns and Siddle's (1996) detections of Black-throated Green Warblers mainly in sites of mixed aspen or balsam poplar in Northeastern BC.

Canada Warbler: We documented Canada Warblers at 20 point count sites within the core area and five in the periphery (Appendix V), primarily in mixed deciduous-coniferous and "edge" habitats (Appendix IV). This is consistent with their usual deciduous to deciduous-dominated mixed woods habitat in BC (Cooper et al. 1997c; Blood and Backhouse 1998, Phinney 1998). (Enns and Siddle 1996) also found Canada Warblers occurred in mixed spruce/aspen and spruce/balsam forests in northeastern BC. Our data support the comment of Cooper et al. (1997c) that the species occurs in "edge" habitat more often in BC than in more eastern parts of their breeding range. Salt (1973) also described its breeding habitat as "forest borders" rather than "forest depths."

Cape May Warbler: Cape May Warblers were singing at three periphery sites in mixed coniferous/deciduous habitat and coniferous habitat (Appendix VI). In addition to a male seen in one of our point count sites in Beatton Provincial Park on 23 June 2005, McNicholl observed another singing in a small spruce stand between the park's Willow Trail and 248 Rd. on 23 June 2005. This park is known as a site frequented by this species (George 1993; Enns and Siddle 1996). The mature white spruce and moderate shrub layer there is typical foraging and breeding habitat for this species throughout its range (Harrison 1984; Baltz and Latta 1998) and specifically in northern Alberta and adjacent parts of BC (Salt 1973; Enns and Siddle 1996; Cooper et al. 1997d; Blood and Backhouse 1998; Campbell et al. 2001). As populations of this species are considered by some authorities to fluctuate in response to budworm outbreaks (Harrison 1984; Enns and Siddle 1996; Cooper et al. 1997d), it may be more common in the study area in other years.

Connecticut Warbler: Connecticut Warblers were singing at one core and six periphery point count sites (Appendix V) in deciduous, mixed coniferous-deciduous and "edge" habitat (Appendix VII). The variety of habitats in which we documented this species is consistent with the array of mixed forests in which it nests in BC and elsewhere (Harrison 1984; Enns and Siddle 1996; Cooper et al. 1997e; Pitocchelli *et al.* 1997; Campbell *et al.* 2001) All the Beatton Park detections were in mature trees with shrubby understory habitat and considerable space between the understory and canopy, considered characteristic in BC (Enns and Siddle 1996; Cooper et al. 1997e; Blood and Backhouse 1998), where they sing in the canopy but nest in thick understory. Our results did not support other studies that found the species associated with a sparse shrub layer in the Dawson Creek area (Phinney 1998) and some other parts of their BC range (Campbell et al. 2001).

Philadelphia Vireo: The only Philadelphia Vireo detected during our surveys was in the core area (Appendix V) in mixed deciduous-leading habitat (Appendix VII), which is atypical for this species. Philadelphia Vireos are generally "edge" habitat breeders, nesting in early to mid-successional deciduous forests, especially those with aspen or balsam (Salt 1973; Moskoff and

Robinson 1996; Cooper et al 1997f). Nesting in mixed deciduous/coniferous is less common (Salt 1973; Moskoff and Robinson 1996). However, while Enns and Siddle (1996) found Philadelpia Vireo mainly in trembling aspen copses in the Fort St. John area, there were also sightings of the species in mixed spruce/aspen copses. Siddle (cited in Campbell *et al.* 1997) considered riparian forest along the Peace River as its preferred habitat in the Ft. St. John area. Phinney (1998) indicated that nesting in the Dawson Creek area is usually in the typical "pole-stage to mature trembling aspen or balsam poplar forests…" with some variation.

Le Conte's Sparrow: This sparrow was heard singing in one shrub-dominated site in the core study area and in edge habitat in one periphery site (Appendices III and IV). This species usually nests in marshy meadows or drier edges of marshes (Lowther 1996; Rising 1996), often interspersed with small alders or birches (Rising 1996), but occasionally also breeds in undisturbed pastures (Rising 1996). Sedge meadow shrub-carr edge was the most common habitat at five sites in northeastern BC, with conifers "within sight" (Enns and Siddle 1996:33; Campbell et al. 2001). Le Conte's sparrows are also known to occur at the Fort St. John sewage lagoon (George 1993). Numbers of the species may fluctuate with weather conditions, at least in peripheral parts of its range, as Phinney (1998:51) noted that "it is noticeably more common in wet years" in the Dawson Creek area.

Nelson's Sharp-tailed Sparrow: Neither our bird counts nor casual observations in 2005 produced any records of Nelson's Sharp-tailed Sparrows in the study area. This marsh-edge/wet meadow-breeding species is considered non-territorial (Greenlaw and Rising (1994), potentially reducing its tendency to sing. Nevertheless, singing bouts can be prolonged both from perches and in flight (Greenlaw and Rising 1994; Rising 1996), so observers are less likely to overlook it than LeConte's Sparrow. They also often sing at night (Rising 1996), so may be detected during owl surveys in suitable habitat. Phinney (1998) considered dead willows an important feature of nesting areas in the Dawson Creek area. Only one breeding site was located during a 1992 survey for this species in northeastern BC (Enns and Siddle 1996) near the Alberta/BC border east of Fort St. John, presumably at or near Boundary Lake, where they are reported regularly and have been found nesting (Campbell et al. 2001). They have also been documented during the breeding season irregularly at Cecil Lake and apparently nested at the south end of Charlie Lake before drainage and channeling made habitat there unsuitable (Campbell et al. 2001). Phinney (pers. comm..) indicated that this species nests in large sedge wetlands near Worth siding approxiamtley 2.5 km east of Worth Lake, which is located between the Pine and Moberely Rivers in the periphery stratum.

4.4 Raptors

An aerial survey on 4 July 2005 resulted in similar numbers of sightings of raptors as a similar aerial survey conducted 20 August 1999 by Fraker and Hawkes (2000). A total of 29 raptors of four species were seen during 1999 while 33 raptors of five species were seen during 2005. One Northern Goshawk was seen during the 1999 aerial survey and not in 2005, and two Merlins and three Broad-winged Hawks were seen during 2005 and not during 1999. Bald Eagles comprised 86% of the sightings during 1999 and 70% of the sightings during 2005. A total of 41% of the sightings during 1999 were below the confluence with the Moberly River whereas during 2005 52% of the sightings were made downstream of the Moberly. The major difference between surveys during the different years was in the number of Bald Eagle nests observed. Only four nests were seen during the 1999 survey and 21 were observed during the 2005 survey, but only 33% of the nest sites were located downstream of the Moberly River.

As expected, species that are commonly associated with agricultural fields, primarily Red-tailed Hawks and Northern Harriers, were seen predominantly in the periphery areas where large tracts of cultivated land occur. American Kestrels are also associated with agricultural lands and comprised over half of the raptors sighted during road surveys in periphery areas, but they comprised two-thirds of the sightings in the core portion of the study area along the Peace River, where they coincided with agricultural fields primarily along Hwy 29.

Because this study did not begin until early June, data on owls are considered to be non-representative of their presence and abundance in the study area. That said, we did hear or observe four species of owls. All owls were observed in the core area with the exception of the Great Horned Owl which was heard in the Boudreau Lakes area. One Northern Saw-whet Owl and the only sighting of a Northern Pygmy Owl were located below the confluence of the Peace and Moberly rivers. All other Northern Saw-whet Owls and all Barred Owls were observed upriver. No owls were observed or heard in the agricultural area east of Taylor.

4.5 Waterfowl and Other Birds

An aerial survey on 4 July 2005 resulted in many fewer sightings of waterbirds than during a similar aerial survey conducted 20 August 1999 by Fraker and Hawkes (2000). The differences may have been related to survey timing and the ability of post-nesting birds to move to the Peace River by late August from nesting sites outside of the study area. Thus the larger numbers of Trumpeter Swans (13 vs 0), Canada Geese (905 vs 14) and dabbling ducks (1265 vs 26) are likely the result of the previous survey counting migrant birds and the latter survey counting only resident birds. However, the former survey only sighted 42 diving ducks (of which 40 were identified as Common Mergansers) and our survey observed a similar number (46), but those consisted of at least six different species. Only 10 Common Mergansers were observed during the 2005 aerial survey. Fraker and Hawkes (2000) suggested that many diving ducks would have departed to moulting areas by the time their survey was conducted; however, although it is likely that male Common Mergansers and Buffleheads would have departed to moulting areas even by the time of our aerial survey, other species such as Common Goldeneye remain in their breeding areas until quite late in the season, even until freeze-up. This may account for Wiacek et al. (1998) reporting that Common Goldeneye was the most common diving duck along the Peace River during the breeding season. Our data indicate that there is not a clear separation in abundance among Common Goldeneyes, Buffleheads and Common Mergansers. Other species that are known from the area, such as Canvasback, Redhead, Harlequin Duck, Surf Scoter, Hooded Merganser, and Ruddy Duck were not seen during aerial or boat surveys during 2005.

Fraker and Hawkes (2000) found that 73% of all waterfowl occurred upstream of the Moberly River, a value that was 10% higher than our data indicated. The diving ducks observed during 1999 were almost all above the confluence (93%) whereas 74% of the diving ducks were found in the upper Peace during the 2005 aerial survey.

There was somewhat more similarity between the numbers of water-associated birds (other than waterfowl) sighted during the aerial surveys of 1999 (Fraker and Hawkes 2000) and 2005, but again numbers of birds sighted during 2005 were generally lower. We saw no Bonaparte's Gulls during the aerial survey while 82 were seen during 1999. The 1999 survey reported 864 unidentified gulls whereas we only reported 12 unidentified gulls. Total gulls observed during 1999 versus 2005 were 26% higher. Franklin's Gulls were by far the most common species during our aerial and boat surveys during 2005. More shorebirds were seen during 1999 which would be expected given the latter date of the survey and the onset of the shorebird migration. A total of 262 shorebirds (other than Kildeer) were seen during 1999 whereas only 102 were seen during aerial surveys in 2005 (all were Spotted Sandpipers). Fourteen Kildeer were seen in 1999 and only 5 were seen during the 2005 aerial surveys.

During 1999 aerial surveys, 81% of the water-associated birds occurred above the confluence with the Moberly River. Only 69% of the birds were sighted at upstream locations during the 2005 aerial survey.

Species that were seen during the aerial survey in 2005 but were not seen during 1999 include two American Coots, one Horned Grebe and one Black Tern. We saw no Great Blue Herons nor did we locate any evidence of a nesting colony.

4.6 Amphibians and Reptiles

4.6.1 Amphibians

Three species of amphibians were documented in the Peace River study area: long-toed salamander, wood frog, and western toads. Sampling for amphibians occurred in both the core and periphery strata of the Peace River study area. Habitats in the vicinity of Fort St. John, Charlie Lake, and Cecil Lake, as well as agricultural fields in the east and north were not sampled primarily due to limited access. Additionally, presence and/or abundance of certain species (e.g., western toad) have been shown to be negatively affected by urbanization. However, there are habitats with the Fort St. John area where wood frogs have been detected. For example Hawkes (pers. obs) observed wood frogs at the sewage lagoons near Fort St. John in both 1999 and 2005. Wood frogs were also detected in several small ponds near the Fort. St. John municipal airport in 1999, so although the prevalence of suitable habitats for amphibians may be lacking in urban areas, the presence of certain amphibians has not been affected. Western toads were not documented in the vicinity of Fort St. John except in the core stratum and these locations were in the floodplain of the Peace River (MAP).

The long-toed salamander was detected at only three sites in the core stratum with two sites upriver of the proposed site C location (i.e., upriver of the Moberly/Peace confluence) and one down river. The distribution of the long-toed salamander in the Peace River study area remains unknown primarily because of the time during which surveys were conducted. The Long-toed Salamander moves from upland areas to its aquatic breeding habitat as soon as the spring melt occurs and breeding can occur while ice persist on breeding ponds (Bishop 1943, Kezer and Farner 1955, Knudsen 1960, Ferguson 1961, Anderson 1967, Nussbaum et al. 1983, Cook 1984, Beneski et al. 1986). Spring 2005 surveys began in June, after breeding had occurred.

The distribution of the long-toed salamander is also poorly known in the Peace River region because few surveys have occurred in the area. Hawkes and Fraker (2000) reported on the occurrence of both western toads and wood frogs within the floodplain of the Peace River but they did not detect long-toed salamander. That work occurred during August 1999, which would have been too late to detect adults migrating to breeding ponds or to detect larval salamanders. Hawkes and Fraker (2000) also surmised that long-toed salamanders may be associated with upland rather than floodplain habitat. Historical data suggest that Long-toed salamanders occur near Taylor (Mr. G. Ryder, field notes, cited in Hawkes and Fraker (2000)) and anecdotal information suggests presence in around Hudson's Hope, BC. Data from our 2005 surveys confirms the presence of breeding populations of this species from at least two locations: ponds at Bear Flats and a pond on the south side of the Peace River, east of Taylor, BC (MAP). Tadpoles or larvae of long-toed salamanders were not detected elsewhere in the study area. The series of ponds at Bear Flats represents one of the larger pond / wetland complexes on the north side of the Peace River within the core stratum. Given that the Peace River study area is close to the northern extent of this species' range in BC (Figure 10), it is probable that long-toed salamanders have a patchy distribution in the Peace River study area. Further study is required to confirm this.

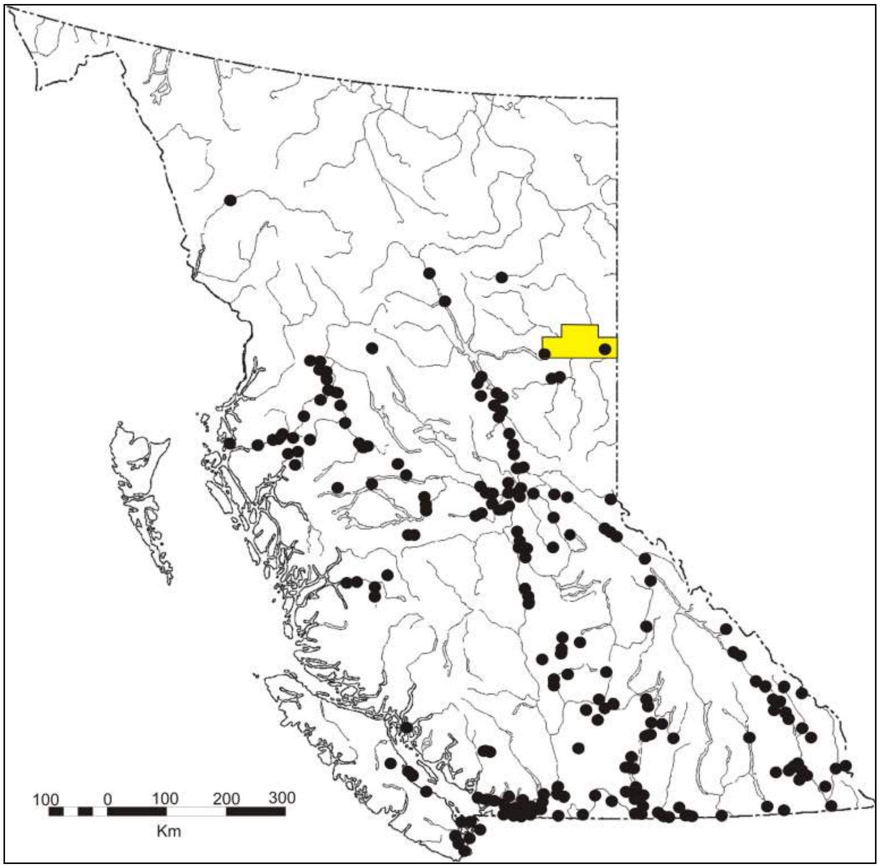

Figure 10. Distribution of the long-toed salamander in British Columbia (Matsuda et al. in press). The yellow shading represents the approximate location of the Peace River study area.

Both western toads and wood frogs were detected in the core and periphery strata of the study area (MAP). Wood frogs were more abundant than western toads but neither species occurred at more sites in the core compared to the periphery. The distribution of wood frogs appears to be cosmopolitan in the study area, with wood frogs occurring at virtually all sites sampled. It is likely that wood frogs occur in areas where breeding habitat is present, and in the case of the wood frog, breeding habitat is likely any body of water than contains water persisting through the period of tadpole development. For example, tadpoles, juvenile, subadult, and adult wood frogs were often found in road side ditches with emergent vegetation, in wet areas around the edge of gas drill platforms (especially in the vicinity Boudreau Lake and the Moberely River), and human-made depressions in forested habitats (Photo 1). Additionally, wood frogs were found in permanent ponds, beaver ponds, and wetlands with emergent vegetation around the margin (Photo 1). Because the wood frog is a freeze tolerant species (Costanzo et al. 1993) it is likely to be distributed throughout the enter project area. Our surveys confirmed the presence of this species within the core stratum from Hudson's Hope to the Alberta border and within most of the periphery stratum (MAP). It is likely that this species occurs throughout the core and periphery strata wherever suitable habitat occurs, which means that wherever there is semi-permanent and permanent water suitable for breeding, the wood frog will likely be present.

Photo 1. Examples of suitable wood frog breeding habitat encountered in both the core and periphery strata of the Peace River study area. A) beaver pond; B) permanent wetland with emergent vegetation around the margin; C) spruce swamp, and D) disturbed site in forested area.

The western toad was also abundant, although it did not occur at as many sites as the wood frog (Map 14). Unlike the wood frog, the western toad is not known to be freeze tolerant and over winters in small mammal burrows deep below the ground. In Canada literally nothing is known of hibernacula requirements for this species (Wind and Dupuis 2002). Based on montane populations in Colorado, upland areas near seeps, stream banks, and underground burrows are important areas for hibernation (Jones and Goettl 1998).

The western toad is a COSEWIC species of Special Concern (COSEWIC 2002). This species has suffered population declines and population extirpations in certain parts of BC (Davis and Gregory 2003). It is relatively intolerant of urban expansion and the conversion of habitat for agricultural use. Dependent upon oligotrophic and fishless ponds and small lakes for breeding, it is also sensitive to habitat deterioration, introduced exotic predators and competitors, and disease. This species remains widespread and locally abundant throughout most of its historic range in Canada despite its known vulnerabilities to urban expansion, conversion of habitat for agriculture, habitat deterioration, introduced exotic predators and competitors, and disease, all of which have severely reduced its abundance and range further south. In the Peace River study area, the western toad population appears to be healthy. Toads were documented in the floodplain of the Peace River from Lynx Creek to the Alberta border by Hawkes and Fraker (2000) and from approximately Lynx Creek to the Alberta border during this study. Toads ranged up to 15 km away from the Peace River in the north and 8 km in the south (straight line measurements from bank of Peace River). Adults, subadults, juveniles, tadpoles, and egg masses were documented. In one location (south of the Peace River near Boudreau Lakes) thousands of emerged toadlets were detected on the edge of a wetland on the southside of the Peace River in the vicinity of Boudreau Lake (Photo 2).

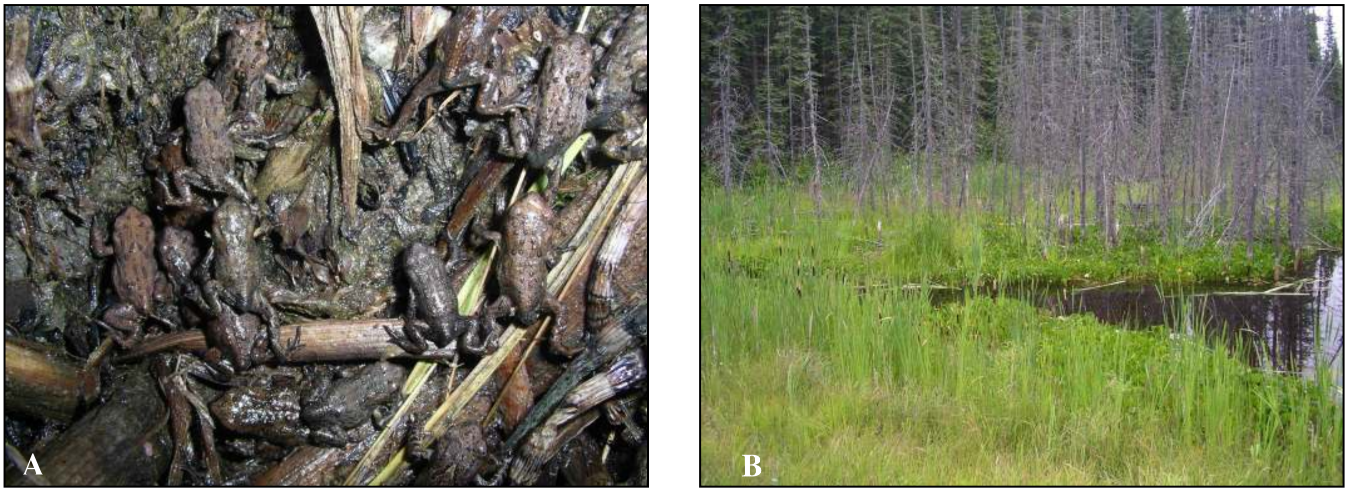

Photo 2. A) Emerged Western toad toadlets and B) rearing habitat on the south side of the Peace River study area (periphery stratum) in the vicinity of Boudreau Lake.

The utility of body condition to infer suitability of habitat in the core or periphery stratum has limited application primarily because of the similarity of habitats available within each strata. However, it was interesting to note that wood frogs in the core stratum were significantly larger than those in the periphery. The difference could be related to habitat connectivity between breeding and non-breeding habitats, with increased connectivity in the core relative to the periphery. Wood frogs move approximately 300 m between breeding and non-breeding ponds but can move up to 1,500 m (Berven and Grudzien 1990). The distance between these two important habitats may be shorter in the core than in the periphery. This would require adult animals to move greater distances to breeding habitats in the periphery. Post-breeding, adults would return to their non-breeding ponds. The young that emerge at a given breeding pond remain in or near the pond because it provides thermal, security, and feeding habitat. Therefore, when ponds or other breeding habitats are sampled in the periphery, the probability of encountering smaller animals (froglets or small adults that did not breed) should be greater than encountering adults. This assumption is partially substantiated by studies of wood frogs in other areas where over 80% of juvenile wood frogs remained in the pond of origin (e.g., Berven and Grudzien 1990). In contrast, sampling in the core should result in the capture of larger animals because the distance between breeding and non-breeding habitats is shorter, increasing the likelihood of encountering an adult frog at a breeding site. Additionally, if there are differences in habitat quality in the core versus the periphery, then an additional hypothesis is that because the habitats are better in the core, fewer juveniles disperse increasing the number of breeding adults at each pond, so the probability of encountering larger animals could be a function of density. Either of these hypotheses could explain why larger animals occurred in the core stratum relative to the periphery, but they require validation through field studies. A third possible explanation for the difference in body size is that the core stratum may have increased habitat connectivity, which could result in lower juvenile dispersal rates and an increase in the number of breeding adults occupying a given pond at any time. If this were true, then surveys conducted after breeding has occurred would not provide an accurate estimate of body size for animals in the periphery because the majority of animals would have returned to their non-breeding habitats leaving only emerging froglets and non-breeding small adults to be captured and measured. Surveys and animals capture that coincides with the breeding season would provide a more accurate indication of the average body size of wood frogs and could alleviate any perceived habitat differences between the core and periphery strata.

The following sections generally describe the habits and habitat requirements for each of the species of amphibians and reptiles that were detected in the Peace River study area in 2005 (from Hawkes and Fraker 2000).

4.6.1.1 Long-toed Salamander (*Ambystoma macrodactylum*)

The Long-toed Salamander is one of the most widely distributed species of salamander in British Columbia, inhabiting a wider range of habitats than any other salamander (Nussbaum et al. 1983). It can be found in semi-arid sagebrush deserts, dry woodlands, humid forests, and alpine meadows. This species is most often located under coarse woody debris (CWD), leaf litter, or in rock piles (Stebbins 1985). During hot, dry, or freezing weather, adults tend to remain underground in small mammal burrows (Nussbaum et al 1983). Most of their above ground activity occurs during spring or fall during wet weather (Green and Campbell 1984). The Long-toed Salamander has a biphasic life cycle, requiring temporary or permanent aquatic habitat during the breeding season, while occupying terrestrial habitats for the remainder of the year. Eggs are laid individually, or in small clumps attached to submergent vegetation (Green and Campbell 1984). At low elevations, eggs develop rapidly hatching in about two weeks and larvae may metamorphose by early summer (RISC 1998a). Larvae feed on zooplankton, aquatic insects, aquatic snails, and are occasionally cannibalistic. Adults feed on spiders, earthworms, flies, snails, slugs, aphids, and a variety of other insects and invertebrates, both terrestrial and aquatic (Nussbaum et al 1983; Stebbins 1985).

Recorded occurrences in the Peace River study area include the confluence of the Peace and Beatton Rivers (Green and Campbell 1984; Walsh 1998; Matsuda et al. in press). Walsh (1998) reported the discovery of a Long-toed salamander population in the Peace River region of Alberta, approximately 125 km east of the Beatton/Peace location. The long-toed salamander is yellow-listed in BC indicating that populations of this species are stable and not at risk. A COSEWIC status report for this species is currently under review. It is likely that the COSEWIC status report is being prepared for populations of the long-toed salamander in Alberta, where they are uncommon to rare and patchily distributed. There are 5 subspecies of long-toed salamander recognized (Shaffer et al. 1991; Jones et al .1993), with three occurring in BC (*A. m. macrodactylum*, *A. m columbianus*, and *A.m. krausei*). Two of the BC subspecies (*A. m. Krausei* and *A. m. macrodactylum*) have limited distributions with *A. m. macrodactylum* restricted to the southwest and Vancouver Island and *A. m. krausei* restricted to the eastern border of BC north to the Peace River region.

4.6.1.2 Western Toad (*Bufo boreas*)

The Western Toad occupies habitats such as streams, springs, grassland, woodland, and mountain meadows (Green and Campbell 1984; Stebbins 1985). Western Toads often move a considerable distance from standing water and can tolerate relatively dry conditions; however, they prefer damp conditions and cannot tolerate extreme dryness (Green and Campbell 1984). This permits Western Toads to use habitats from which more water-dependent species are excluded. Although they are often active during daylight, they are most active at night, when they can be seen foraging for worms, slugs, or insects (Green and Campbell 1984). Their diurnal activity may make Western Toads more easily detected than other amphibians. During the breeding season (spring and early summer), Western Toads congregate in small ponds or pools, preferring those with a sandy substrate (Green and Campbell 1984). Females lay up to 12,000 eggs in a long string that is usually entwined around submergent vegetation. Tadpoles develop into toadlets in six to eight weeks, depending on temperature.

The Western Toad is distributed throughout British Columbia, with the exception of the far northeast of the province (Green and Campbell 1984). In certain portions of the province, populations of the Western Toad have declined for inexplicable reasons (Davis and Gregory 2003).

4.6.1.3 Wood Frog (*Rana sylvatica*)

The Wood Frog can be found in forested, field, or muskeg habitat, though usually not far from water. The Wood frog has the ability to tolerate a range of temperature extremes, and can tolerate sub-zero temperatures (RISC 1998a). This species normally over winters by hibernating on land beneath forest litter and humus and it relies on the insulating capacity of snow to prevent the deep layers of soil from freezing (Green and Campbell 1984). The Wood Frog often breeds early in the spring, well before all the ice has disappeared from breeding ponds, and the breeding season at the northern extent of its range may last only a few days (Green and Campbell 1984). Tadpoles develop relatively quickly despite the cold water temperatures generally associated with early spring, and by mid-summer, they have transformed into froglets.

The Wood Frog is the most northerly distributed species of amphibian in Canada, and is the only North American amphibian to cross the Arctic Circle (Green and Campbell 1984). In BC, the wood frog is found throughout the northern half of the province and as far south as Clinton in the Cariboo Region. This species of frog is known to occur in the Peace River Region (Green and Campbell 1984) and was detected in 1999 (Hawkes and Fraker 2000).

4.6.2 Reptiles

Two species of garter snake occur in the Peace River study area: the western terrestrial (*T. elegans*) and common garter snake (*T. sirtalis*). Both of these species are close to the northern extent of their range in British Columbia (Figure 11). Most snake observations were in the core stratum, with only the common garter snake detected in the periphery (MAP). Garter snakes are generally cryptic and are easily missed, especially if they remain still when approached. Garter snakes also like to bask in areas where there is escape habitat nearby so that if they are approached they can avoid capture.

4.6.2.1 Common Garter Snake, *Thamnophis sirtalis parietalis*

The common garter snake is the most widespread species of snake in North America (Figure 11) and it is more cold-tolerant than other snakes (Gregory and Campbell 1984; Brown et al. 1995). This snake lives in a variety of habitats, but is more abundant near marshes, small lakes, river, ponds, and humid forests (Gregory and Campbell 1984). Like other species of garter snakes in BC, this species over-winters in traditional hibernacula, where several to thousands of snakes congregate each winter (Gregory and Stewart 1975; Gregory 1985; Shine et al. 2001). This live-bearing species produces litters of up to 85 young ($\bar{x}$ = 13-26) and populations in northern Canada rarely give birth in successive years (Larsen et al. 1993). These snakes can be detected near the edges of wetlands and shrub communities while basking in open areas near cover, and sometimes swimming in open water (CARCN 1999). In British Columbia this species is widespread and should have a fairly contiguous distribution in the Peace Rive study area (Figure 11). This species migrates up to 16 km between winter hibernaculum and summer range in at least some northern localities (Gregory and Stewart 1974; Fitch 1980; Gregory 1985; Larsen et al. 1993). In

Manitoba, females dispersed from a communal den in all directions, rather than following distinct migration corridors (Shine et al. 2001). Given that these animals will migrate considerable distances between summer and winter habitats, it may be that the Peace River corridor is providing high value forage / summer habitats. The location of winter hibernacula in the Peace River area are not known and connectivity between the core and periphery strata (between summer and winter habitat) may be an important landscape feature.

4.6.2.2 Western Terrestrial Garter Snake, *Thamnophis elegans*

The western terrestrial garter snake is rarely found far from water (Gregory and Campbell 1984), apparently prefers open areas such as meadows and estuaries, and is rarely found in forests. This live-bearing species mates in mid- to late spring and females produce litters of one to 19 in mid to late summer (Gregory and Campbell 1984; CARCN 1999). In British Columbia this species is widely distributed with a sizeable, but disjunct population occurring in the Peace River District (Gregory and Campbell 1984; CARCN 1999; Figure 11). Unlike the common garter snake, the western terrestrial garter snake does not migrate long distances between summer habitat and winter hibernacula. Local habitat patches that provide suitable summer forage habitat and proximity to suitable winter hibernacula are therefore important to this species. The ecology of western terrestrial garter snakes has not been studied in the Peace River region of British Columbia. This snake is live-bearing, producing 4-19 young in mid- to late summer. As with common garter snakes, communal over-wintering in traditional hibernacula is well documented, especially in the northern part of its range (Gregory and Campbell 1984). In the Peace River study area, the western terrestrial garter snake was only detected in the core stratum, and within the core stratum, it was only detected within the floodplain of the Peace River (MAP).

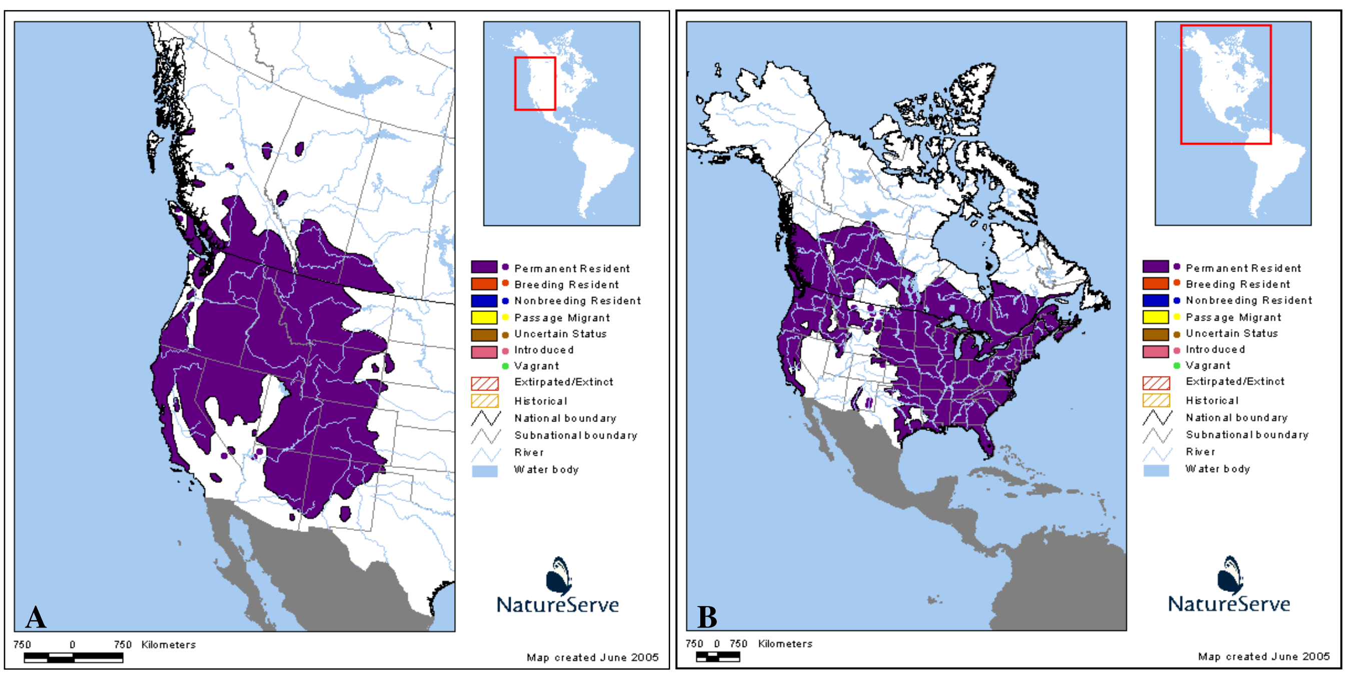

Figure 11. Range of A) the western terrestrial garter snake and B) the common garter snake in North America.

Both species of garter snake are on the BC CDC yellow-list and neither has COSEWIC designation.

4.7 Rare and Endangered Plants

Rare plants occurred at 114 sites; 82 in the core and 32 in the periphery. Thirteen species were documented in only one stratum (9 in the core and 3 in the periphery) and most of these species were documented from only 1 site. Rare plants have been documented from the Peace River area; however, we documented 6 rare plants that had not been previously documented in the Peace River. An additional 4 species that occur in the CDC database were not documented during these surveys because the timing was wrong or the locality data for the records in the CDC database are from old collections that have not been recently confirmed. We also detected native and non-native vascular plants that had not been reported in the area (n = 24 native; 5 non-native), or in BC (n = 2).

The presence of rare plants in the Peace River study area can be attributed to the presence of 1 of 3 vegetation complexes: 1) valley bottoms, shore of the Peace, and islands in the Peace, 2) breaks above the Peace and Beatton Rivers and their tributaries, and 3) wetland complexes on the plateau above the Peace River.

The following sections describe each of the rare and endangered plants documented in the Peace River study are in 2005 with some notes on global and provincial rank, habitat associations, and occurrence in the study area.

***1. Anemone virginiana* L. var. *cylindroidea* Boivin – Riverbank anemone**

Global/Provincial Rank: G5 T? S1
Status in BC: RED
Habitat: Dry slopes above the Peace River, and the Beatton River. Usually on the margins of shrubs with *Amelanchier alnifolia* and *Prunus pensylvanica*.

Eight populations and several subpopulations of this plant have been found in the study area. Previously known from two locations, one above Beatton River and the other from the vicinity of Taylor.

***2. Arabis lignifera* A. Nels. – Woody-branched rockcress**

Global/Provincial Rank: G5 S2S3
Status in BC: BLUE
Habitat: Dry grassy slopes.

In the study area it was found only on one site, on dry slopes above the Halfway River. This is the first record from the Peace River area.

***3. Arnica chamissonis* Less. subsp. *incana* (A. Gray) Maguire – Meadow arnica**

Global/Provincial Rank: G5T? S2S3
Status in BC: BLUE
Habitat: Sandy and gravely shores of the Peace River.

Arnica chamissonis subsp. *chamissonis* is a common arnica that occurs in long stretches along the shores of the Peace River. The rare *Arnica chamissonis* subspecies *incana* differs from the nominal subspecies by having entire leaves and dense soft hairs on stems and leaves. We found only one population of this hairy subspecies, but we believe that the more careful screening of *Arnica chamissonis* populations would reveal more sites of this subspecies. Since the taxonomical value of this subspecies is questionable (by various authors it is treated as a variety or just a mere form of *Arnica chamissonis*), tracking this subspecies does not seem worthwhile.

***4. Artemisia longifolia* Nutt. – Long-leaved mugwort**

Global/Provincial Rank: G5 S2
Status in BC: RED
Habitat: Most often as a pioneer species on slumping banks of the Peace River, but also a colonizer of open soil in dry open vegetation on the grassy slopes well above the river.

This species is common at the lower parts of slopes above the Peace River where it is abundant and grows in large stands. At higher parts of grassy slopes it is growing singly or in smaller groups, always on eroded parts of the slopes that lack other vegetation. Previous records of this species in the British are from the Clayhurst area, the area around Taylor, the Alces, Beatton, and Kiskatinaw Rivers.

***5. Atriplex nuttallii* S. Wats. – Wedgescale orach**

Global/Provincial Rank: G5 S1
Status in BC: RED
Habitat: Grassy areas at the lower parts of the south facing slopes.

This plant is known in British Columbia only from the Clayhurst Ecological Reserve and in the CDC data it is also reported from the area close to the mouth of Alces River.

***6. Botrychium crenulatum* W.H. Wagner – Dainty moonwort**

Global/Provincial Rank: G3 S2S3
Status in BC: BLUE
Habitat: Shrub carrs, black spruce thickets, and wet places in marshy meadows.

We found only one site for this rare species at the Alberta Plateau between the Halfway River and North Cache Creek. This is the first record of this species from the Peace River area.

***7. Calamagrostis montanensis* (Scibn.) Scribn. – Plains reedgrass**

Global/Provincial Rank: G5 S1
Status in BC: RED
Habitat: Dry open slopes.

All our sites of this plant (Beatton River, Clayhurst, and Taylor) have been previously documented and recorded in the CDC database. In addition, the CDC database has a record from the Alces River.

***8. Carex torreyi* Tuckerm. – Torrey's sedge**

Global/Provincial Rank: G4 S2S3
Status in BC: BLUE
Habitat: Moist grassy margins of thickets with *Amelanchier alnifolia* and *Prunus pensylvanica* that are in depressions on dry south-facing slopes.

We found *Carex torreyi* on Bear Flats and near Taylor. This sedge was previously recorded from Taylor and the Valley View Cemetery.

***9. Carex xerantica* Bailey – Dry-land sedge**

Global/Provincial Rank: G5 S2S3
Status in BC: BLUE
Habitat: Dry grassy slopes on breaks above the Peace and Beatton Rivers.

We recorded this species in several subpopulations at the slopes of the Beatton River and in the Clayhurst Ecological Reserve. In addition to those localities, *Carex xerantica* has been previously docuemnted from the slopes above Bear Flats.

***10. Cirsium drummondii* T. & G. – Drummond's thistle**

Global/Provincial Rank: G5S1
Status in BC: RED
Habitat: Forest margins.

We found *Cirsium drummondii* in the Bear Flats complex and on one island in the Peace River about 5.8 km east of the mouth of Farrell Creek. These are the first records of this species from the Peace River study area.

***11. Eleocharis tenuis* (Willd.) J.A. Schult. – Slender spike-rush**

Global/Provincial Rank: G5 S2S3
Status in BC: BLUE
Habitat: Shore of sloughs and backwaters along the river.

We found this species along the Peace River in the Peace River Park area near Taylor where it occurs with several other species typical for shores of sloughs and backwaters, such as *Eleocharis acicularis* and *Limosella aquatica*. This is the first record of this species from the Peace River area.

***12. Epilobium saximontanum* Hausskn. – Mountain willowherb**

Global/Provincial Rank: G5 S2S3
Status in BC: BLUE
Habitat: River banks and gravel bars, usually in higher elevations, but sporadically occurring. in lower elevations washed down from higher elevations.

Found only on an island in the Peace River near the mouth of Farrell Creek and in the Peace Island Provincial Park near Taylor. This is the first record of this species from the Peace River area.

***13. Glyceria pulchella* (Nash) K. Schum. – Slender mannagrass**

Global/Provincial Rank: G5 S2S3
Status in BC: BLUE
Habitat: Willow shrubs and wet meadows.

Found on upper benches between Lynx and Farrell Creek, west of Cache Creek and south of Shearer Dale. Previously known from the Cache Creek area and from an old collection (1948) near Taylor.

***14. Helictotrichon hookeri* (Scribn.) Henrard – Spike-oat**

Global/Provincial Rank: G5 S2S3
Status in BC: BLUE
Habitat: Upper parts of dry slopes above the river.

This species is relatively common in grassy parts of the breaks along the Peace and Beatton Rivers. Bear Flats area seems to be its western limit along the Peace River. *Helictotrichon hookeri* forms larger stands at the top of breaks above Beatton River.

Previously known from this area from only a few sites (breaks above Attachie, Bear Flats, and near Peace River Islands Provincial Park).

***15. Juncus confusus* Cov. – Colorado rush**

Global/Provincial Rank: G5 S1
Status in BC: RED
Habitat: Shores of rivers.

We collected this species in backwaters of the Peace River in the Taylor area and in the flats on the southern shore of the Peace River next to the Clayhurst Bridge. These are the first records of this species from the Peace River area.

***16. Oxytropis jordalii* subsp. *davisii* (Welsh) Elisens & Packer – Davis' locoweed**

Global/Provincial Rank: G4T3 S3
Status in BC: BLUE
Habitat: River banks and gravel bars in the river.

Found only once on the shore of the Peace River at the Peace River Islands Provincial Park near Taylor. Previously recorded from the Halfway River and from the old (1954) collection from the "East Pine River".

***17. Penstemon gracilis* Nutt. – Slender Penstemon**

Global/Provincial Rank: G5 S2
Status in BC: RED
Habitat: Open grassy slopes, usually at the margin of shrub carrs.

We found this species at seven sites on the Peace River from Bear Flats to the Alberta/BC border and on one site on slopes above the Beatton River. Most sites along the Peace River were known from the previous records; the Beatton River locality is a new one.

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18. Salix serissima (Bailey) Fern. – Autumn Willow

Global/Provincial Rank: G4 S2S3
Status in BC: Blue

Habitat: Wet thickets, meadows and fens in the montane zone

This species was found at 4 locations in the periphery stratum only: 2 locations on Upper Cache Road and 2 locations on Farrell Creek Road.

***19. Schizachyrium scoparium* (Michx.) Nash – Little bluestem**

Global/Provincial Rank: G5 S1
Status in BC: RED
Habitat: Open grassy slopes, usually at their lower parts.

We found this species at five localities from west of Halfway River to the BC/Alberta border and at two localities on the slopes above the Beatton River. This grass makes quite extensive stands in the colluvial parts of open dry slopes. In British Columbia this grass was previously known only from about three localities in the extreme southeast parts of British Columbia. It is difficult to explain how this species escaped the attention of quite a few botanists who collected plants on Bear Flats or in the Clayhurst Ecological Reserve without having noticed this plant. It might have been mistaken for some "*Stipa*" (*Achnatherum, Heterostipa*, or *Piptatherum*) species, since it blooms later than those species and it might have been misidentified as some of those species.

***20. Selaginella rupestris* (L.) Spring – Rock Selaginella**

Global/Provincial Rank: G5 S1
Status in BC: RED
Habitat: Open eroded soil on grassy slopes.

During our survey we confirmed the *Selaginella rupestris* site at the Clayhurst Ecological Reserve that was discovered by Frank Lomer in the year 2000. This is the only known locality of this species in British Columbia.

***21. Silene drummondii* Hook. – Drummond's campion**

Global/Provincial Rank: G5T5 S3
Status in BC: BLUE
Habitat: Open grassy slopes, margins of *Amelanchier alnifolia* bushes.

We recorded this species from Bear Flats, the vicinity of Taylor, Valley View Cemetery above the Kiskatinaw River, from the Clayhurst Ecological Reserve and from one site on Beatton River. Bear flats, Taylor, and Clayhurst Ecological Reserve were previously known localities; those from the Kiskatinaw River and Beatton River are new.

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5. Recommendations

Over the last 20+ years several wildlife studies related to Site C have occurred (Blood 1979, 1991; Simpson 1991, 1993; Diversified Environmental Services 1996; Wiacek et al. 1998; Fraker and Hawkes 2000; BC Hydro 2001). Most of these studies were either short term or poorly timed to provide representative data on habitat use and distribution of wildlife in proximity to Site C. One of the main objectives of this study was to fill information gaps related to the distribution of wildlife in the Peace River study area with an emphasis on red- and blue-listed species. In 2005, we conducted fairly extensive field surveys for wildlife throughout the Peace River area; however, more work is required to address data gaps and properly assess wildlife habitat use and distribution relative to Site C. Therefore, we make the following recommendations regarding wildlife work in the Peace River area:

1. **Bird Studies - duration:** Bird studies related to Site C in the Peace River study area have occurred during various seasons over the last approximately 10 years. For example, Robertson and Hawkes (2000) surveyed for water-associated birds in August 1999 and this study occurred in June and July 2005. From these studies, some patterns are beginning to emerge; however, at least one full calendar year of bird studies is required to see if these studies represent real patterns of bird habitat use and species distribution in the Peace River study area.
2. **Songbirds:** Songbird studies need to be conducted relative to the potential flood pattern for site C and a habitat loss calculation needs to be performed to identify the extent of habitat loss. Habitats used by rare songbirds should be the focus of this work. Additional songbird surveys should be done using the same sites established in 2005 to develop temporal trends for rare birds in the core and peripheral study areas. Additional sites should be established in habitats used by rare birds to determine the extent of occurrence of rare birds in the Peace River study area.
3. **Survey Timing:** Studies for various species groups needs to occur at the time of year when the species are most visible. This will increase the probability of detecting red- and blue-listed species and species of wildlife that are cryptic. The 1999 surveys (Fraker and Hawkes 2000) and this study were both conducted during the summer months, which is not the best time of year to survey for certain groups. The following species groups should be surveyed at other times of the year to increase the likelihood of detection:

a. **Owls:** Surveys should be conducted before the breeding season. This would require surveys to occur between the months of March and June using call playback methods for most species (Northern Hawk Owls are best detected using Roadside surveys).

b. **Waterfowl, shorebirds, and cranes:** data on spring migration numbers is lacking. Spring surveys that coincide with the spring migration of these groups are recommended.

c. **Pond-breeding amphibians:** Surveys for pond-breeding amphibians should occur earlier in the year, and possibly as early as March for some species (e.g., Long-toed salamanders). Studies that occur at the peak of the breeding season will provide valid population estimates for each species.

d. **Marsh-nesting birds:** Surveys for marsh-nesting birds could be paired with pond-breeding amphibian surveys.

3. **TEM-driven studies:** The surveys carried out in 2005 were done without the assistance of a TEM. This study needs to be re-done using the TEM so that habitats where red- and blue-listed species should occur can be surveyed more intensively. Additionally, re-doing the study using the TEM will provide an opportunity to better characterize the habitats where rare species occur. The TEM needs to be extended to include areas upriver of the Halfway and Moberly Roivers and in the vicinity of Bear Flats up Red and Cache Creeks.

4. **Wildlife Tree Surveys:** A survey of wildlife trees in the Peace River study area should be considered. Wildlife trees provide important habitat for many species of cavity nesting birds (including woodpeckers, owls, raptors, and ducks), roosting trees for raptors and owls, and habitat for furbearers like fisher and marten.
5. **Wetland and Pond Mapping:** Wetlands and ponds need to be mapped in the study area. These habitats support populations of pond-breeding amphibians, reptiles, marsh-nesting birds, shorebirds, waterfowl, cranes, small mammals, raptors, furbearers, large mammals, dragonflies, and bats. Wetland and pond habitats should be mapped using an aerial photography interpretation followed by ground-truthing. Mapping the distribution of these important habitats in proximity to Site C will enable a better assessment of the potential impacts on wildlife.
6. **Raptor Surveys:** Raptors (excluding owls) should be a component of, but not emphasized in future studies. Data collected in 2005 and augmented with data from 1999 have provided a fairly extensive overview of the species present in the study area and their distribution.
7. **Butterfly Surveys:** The distribution of butterflies is largely a function of host plant associations. More butterfly work is recommended for the Peace River study area to assess the distribution of hast plants associated with the red- and blue-listed butterfly species that occur in the study area. Flying butterflies should be captured and identified; but the focus should be on mapping habitats containing important host plants.
8. **Study Area:** The impacts of Site C should be framed in an upriver / downriver context. Because little change to habitat is anticipated downriver from site C, habitats important to wildlife that will be inundated should be identified and mapped within the river corridor. The mapped area should include the entire area that would be inundated, including the tributaries of the Peace, upriver from the Pine River.
9. **Mapping – extent:** Related to recommendation number 8 is the extent of habitat mapping for the Peace River study area. Currently, the TEM covers the core stratum only. Habitats important to wildlife that occur upriver of Site C should be identified outside of the core study area. This may require looking further afield than the area searched in 2005. A TEM of this large area would be costly. Therefore, an alternative means to identify habitats outside of the core stratum needs to be developed so that a comparison study of wildlife-habitat relationships within and outside the core can be developed. Only the results from a study that adequately pairs habitat types within and outside of the core stratum should be used to identify impacts on wildlife from the construction of Site C.
10. **Habitat Suitability Index Models**
    a. Future field data collection is required to allow for habitat variable testing, model calibration and model verification.
    b. Habitat model outputs should be used in conjunction with TEM to stratify sampling efforts for bird and raptor surveys to allow for sampling distribution and intensity sufficient to support model testing and refinement.
    c. It is recommended that a full suite of habitat attributes be collected at songbird point count locations and all any owl playback or incidental encounter detection locations. This will facilitate the testing of predictive relationships between habitat model variables and TEM attributes as well as the testing of the predictive accuracy of the models.
    d. In addition, data collection during any further TEM field verification activities should be expanded to incorporate systematic structural and vegetative sampling to allow for the testing of predictive relationships between habitat model variables and TEM attributes.

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7. Appendices

Appendix I. Habitat Suitability Index Models

Black-throated Green Warbler (*Dendroica virens*) Reproductive Habitat Suitability Index Model

Introduction

Habitat Suitability Index (HSI) models express the suitability of habitat to support a selected species as a numerical index based on an assessment of habitat conditions (e.g. stand age, structural attributes, spatial arrangement of habitats) related to key life requisites such as food, cover or reproduction. This HSI reproductive habitat model for the Black-throated Green Warbler (*Dendroica virens*) applies to habitats of the Boreal White and Black Spruce (BWBS) biogeoclimatic zone, specifically the Peace Moist Warm variant (mw1) which occurs around the Peace River in northeast British Columbia. Forests in the BWBSmw1 are generally dominated by white spruce or trembling aspen, though they may have a balsam poplar, lodgepole pine and black spruce component (DeLong *et al*. 1990). Tamarack, subalpine fir and paper birch may also be present. This model will be used to predict the spatial distribution of suitable Black-throated Green Warbler reproductive habitat in the core stratum of the Peace River study area. The core stratum covers an area of approximately 600 km^2 and includes the Peace River from Hudson's Hope to the Alberta border with a corridor of 2000 m on either side (north and south) of the Peace River. This model was developed based on a review of existing literature and expert opinion.

Species Description and Distribution

Black-throated Green Warblers are neotropical migrants that breed throughout Canada and the north-eastern United States, and winter in Mexico and Central America (Norton 1999). The species is at the northwest edge of its range in British Columbia, and occurs in low, but regular numbers in the northeast part of the province, particularly in the Peace Lowland area (Morse and Poole 2005). Black-throated Green Warblers are not considered at risk in Canada. However, concerns over impacts to its breeding habitat by timber harvesting have led to it being blue-listed in both Alberta and British Columbia (Cooper et al. 1997b, Norton 1999).

General Habitat

Black-throated Green Warblers are forest specialists that avoid small forest patches and edge habitat (Norton 1999). The species is found in a variety of habitats throughout its range; Black-throated Green Warblers are mainly associated with boreal coniferous forests, but can also be found in mixed coniferous-deciduous forests and pure deciduous forests (Cooper et al. 1997b, Morse and Poole 2005). Black-throated Green Warblers generally breed in middle aged to late seral stage forests (Cooper et al. 1997b, Morse and Poole 2005). The species is also known to foray into new habitats (e.g. regenerating forests) that are colonized when found suitable, although this behaviour has not been observed in British Columbia (Cooper et al. 1997b).

Black-throated Green Warblers in western Canada tend to be associated with mixed deciduous/coniferous stands (Norton 1999). (Norton 1999,). Studies in Alberta showed that aspen or white spruce dominated stands, but not pure aspen stands, were used by the species (Norton 1999).

In British Columbia, the Black-throated Green Warbler is found primarily in mature to old growth riparian white spruce and mixedwood forests (Cooper et al. 1997b). Sites need to contain some coniferous trees, with a small patch of white spruce sufficient to provide suitable habitat (L. Darling pers. comm. *In* Cooper et al. 1997b). Enns and Siddle (1996) found the species occurred mainly in tall mixedwood stands of spruce and poplar that were associated with middle aged aspen in the mid canopy. Black-throated Green Warblers tend to be associated with understories containing highbush cranberry (*Viburnum edule*), prickly rose (*Rosa acicularis*), bunchberry

(*Corus canadensis*), fireweed (*Epilobium angustifolium*), baneberry, kinnikinnick (*Arctostaphylos uva-ursi*), mosses, peavine and American vetch (Enns and Siddle 1996, Cooper et al. 1997b).

Black-throated Green Warblers are associated mainly with the white spruce-trembling aspen-step moss site series (01) in the BWBS mw1 biogeoclimatic zone variant found in the Peace River area (Cooper et al. 1997b). Surveys conducted by Phinney (2003) found the highest density of black-throated Green Warblers in the Peace River area occurred in mature to old aspen/spruce mixedwood upland stands. The species prefers intermediate levels of mixed spruce and aspen, and avoids pure spruce stands (J. Anderson, Ministry of Environment, pers. comm.; M. Phinney, Louisiana Pacific Forest Resources Division, pers. comm.)

There are inconsistent reports regarding the value of riparian habitat for this species. Cooper et al. (1997b) indicate that mature riparian forest along the south bank of the Peace River and smaller streams is important habitat, and Enns and Siddle (1996) indicate that BWBS balsam poplar riparian habitat is preferred by this species. However Phinney (2003) found that sightings of black-throated Green Warblers in the Peace River area were not closer to water bodies than random points, and concluded that the species is not associated with riparian forest. LGL's 2005 survey results appear to support Phinney's (2003) findings.

Food

The Black-throated Green Warbler feeds mainly on insects during the breeding season with Lepidopteron caterpillars forming the bulk of their diet (Cooper et al. 1997b, Morse and Poole 2005). The species gleans insects from coniferous small branches, hovers beneath and feeds on the undersides of vegetation, and occasionally hawks insects in mid-air (Morse and Poole 2005). Black-throated Green Warblers forage in the mid to upper canopy, with average heights of 13-15m reported (Cooper et al. 1997b, Norton 1999). Females forage approximately 2m higher in the canopy compared to males (Cooper et al. 1997b). Black-throated Green Warblers forage in younger stands compared to those they nest in (Cooper et al. 1997b).

Cover

There is no published information regarding security or thermal requisites for the Black-throated Green Warbler.

Reproduction

The Black-throated Green Warbler nest site selection is somewhat general, but the species tends to nest in mature, rather than young forests (Cooper et al. 1997b). The nest is a cup of grass, moss and twigs lined with hair and feathers (Cooper et al. 1997b). Nests are typically found mainly 2-8 m above ground in coniferous trees, although deciduous trees are also sometimes used (Cooper et al. 1997b). Black-throated Green Warblers only rear one brood with clutches containing from 3-5 eggs (Cooper et al. 1997b, Norton 1999). The incubation period is approximately 12 days and fledgling occurs after 9-11 days (Morse and Poole 2005).

Population densities (pair/ha) cited for the black-throated Green Warbler include 1.2 – 2.0 in Maine, an average of 0.9 in New Hampshire, and range from 0.3 to 2.2 in eastern Canada (Morse and Poole 2005). Male densities in west central Alberta were 4.2-5.6/100 ha (Cooper et al. 1997b). Densities of 2 pair/ha (i.e. the average Black-throated Green Warbler territory size is approximately 0.5 ha) have been found in good habitat in the Peace area (M. Phinney, Louisiana Pacific Forest Resources Division, Pers. Comm.).

The Black-throated Green Warbler is an interior forest bird, and populations of the species are known to decline in fragmented forests (Schmiegelow and Cummings 2004, Morse and Poole 2005). This may be due to loss of interior forest habitat. In addition, increased edge area is associated with fragmented forests, and species that engage in nest predation are also associated with edge habitat (Cooper et al. 1999b).

HSI Model

Model description

The HSI model for the Black-throated Green Warbler reproductive habitat is based solely on vegetative cover type suitability, as this is presumed to satisfy the life requisites of food and nesting sites. Black-throated Green Warblers are forest interior birds that are found primarily in mature to old white spruce and deciduous mixedwood stands in the Peace Lowlands area. These habitats are considered to satisfy requisites for feeding and reproduction, as the species usually nests 2-8 m high in mature, tall, coniferous trees and forages in coniferous trees at average heights of 13-15m. This model assumes that white spruce is the only suitable coniferous trees species for nesting and foraging by the Black-throated Green Warbler in the Peace Lowlands area. It is also assumed that mature to old seral stages have the tall white spruce preferred by the species for nesting and foraging.

The Black-throated Green Warbler model determines vegetative cover type suitability based on structural elements within the area. These variables define HSI components S_1 to S_3 (Table 45). Black-throated Green Warblers are associated with white spruce mixedwood stands so percent white spruce composition and percent deciduous trees in a stand are determined (S_1 and S_2). Structural stage (S_3) is used to identify seral stages that are preferred by the species for nesting and foraging, as well as acting as a proxy for tree height.

Table 45. Habitat variables for vegetative cover type for the Black-throated Green Warbler HSI model.

HSI Component	Habitat Variables	Habitat Variable Description
S_1	White Spruce in Tree Canopy (%)	Percent composition of white spruce in the stand. Black-throated Green Warblers are associated with mixed wood white spruce/deciduous sites. Optimal habitat is assumed to be in the middle ranges of mixing (40-60%), with good suitability (0.75) from 20-40% and 60-80%, then suitability decreasing linearly to 0 at both 0% and 100% white spruce (Figure 12).
S_2	Deciduous in Tree Canopy (%)	Percent composition of deciduous trees in the stand. Black-throated Green Warblers are associated with mixed wood white spruce/deciduous sites. Optimal habitat is assumed to be in the middle ranges of mixing (40-60%), with good suitability (0.75) from 20-40% and 60-80%, then suitability decreasing linearly to 0 at both 0% and 100% deciduous (Figure 12).
S_3	Structural Stage	One of seven pre-defined successional stages of an ecosystem. The species is found mainly in mature to old growth forest in British Columbia, breeding mainly in mature forest. However, it forages in stands younger than its nesting habitat. Consequently Mid to late structural stages (6 - Mature Forest, 7 - Old Forest) are assumed to be most suitable (1.0), with young forests (structural stage 5) providing moderate suitability (0.5) and pole/sapling stands (structural stage 4) having low suitability (0.25). Earlier seral stages (1 through 3) have no suitability (Figure 12).

Stand area (S_4) is used as a modifier of vegetative cover type suitability to ensure a minimum amount of interior forest habitat (Table 46). Edge effects occur up to 200m from the forest edge, and a minimum patch width of 600m is recommended to allow a core area of 200m wide in the patch center (Parminter 1995).

Table 46. Modifier variables for vegetative cover type for the Black-throated Green Warbler HSI model.

HSI Component	Modifier Variables	Modifier Variable Description
S_4	Stand area	Area (ha) of the stand polygon. For simplicity, the minimal fully suitable stand area is defined as the area of a circle. Any stand area with radial distance at least 300m, i.e. ~28.3 ha, is considered suitable (1.0) as this provides a minimum patch width of 600m. Suitability then decreases linearly to 0 at the average Black-throated Green Warbler territory size of 0.5 ha (Figure 12).

Graphical HSI components

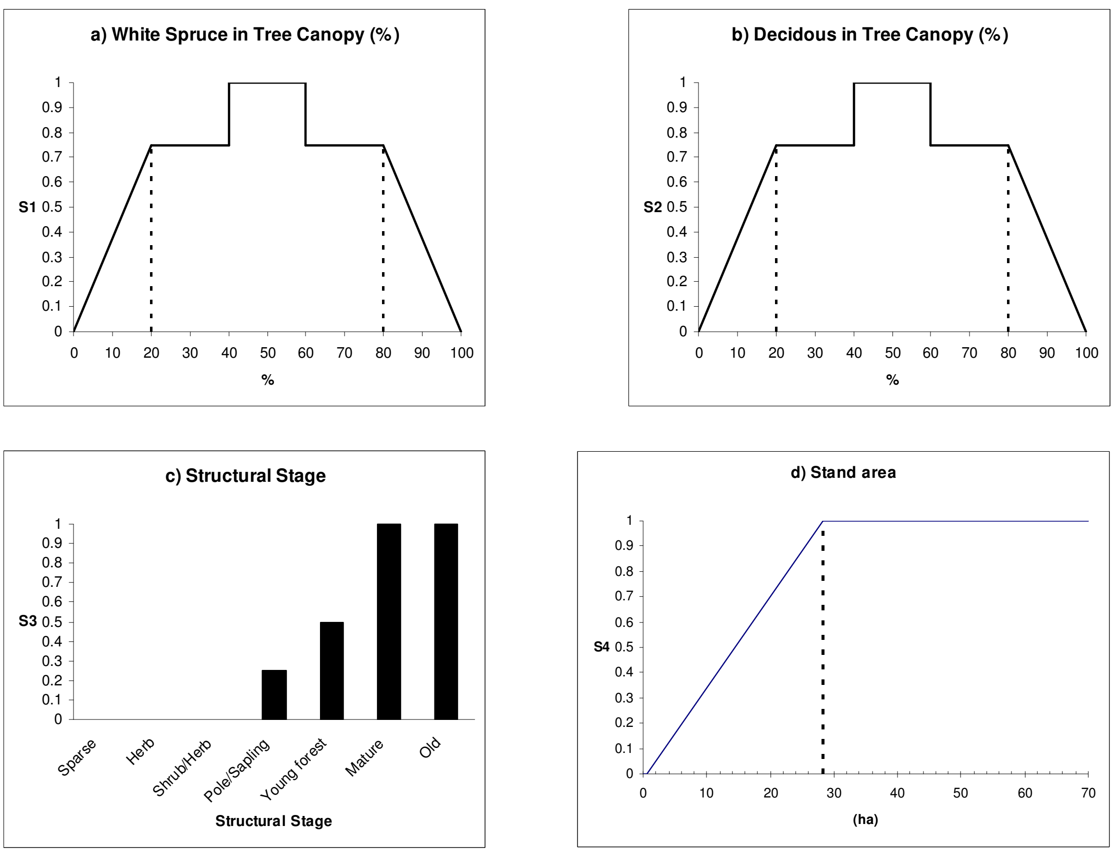

Figure 12. Graphical relationships between habitat variables and HSI components in the Black-throated Green Warbler model.

Model assumptions

1. The only coniferous tree species useful for nesting, foraging and cover in the Peace Lowlands area is white spruce.
2. The stand area (S_4) that is rated for a polygon does not incorporate suitable habitat in adjacent polygons. However, if S_4 is less than fully suitable (i.e. < 1.0), then the following algorithm could be used to determine if the current habitat polygon is part of a larger complex of suitable habitat and needs to have its stand area, and consequently S_4, adjusted to reflect this fact.

   Revised stand area = stand area of current habitat polygon.

   FOR each adjacent habitat polygon to the current habitat polygon

   IF adjacent habitat polygon $HSI_{cover\ type}$ >= $HSI_{cover\ type}$ of current habitat polygon THEN

   Add the stand area for the adjacent habitat polygon to the revised stand area.

   IF final revised stand area > stand area of current habitat polygon THEN

   Determine a new value for S_4 based on the revised stand area.

Equation

Vegetative Cover Type Suitability

Vegetative cover type suitability for a habitat patch is determined based on percent of white spruce composition (S_1), percent of deciduous composition (S_2) and structural stage (S_3). The model assumes that these three components are equally important to vegetative cover type suitability for the Black-throated Green Warbler, and consequently gives them equal weighting in the HSI model for vegetative cover type. Variables are not compensatory (a high value in one component cannot compensate for a low value in another).

$$\mathbf{HSI_{cover\ type} = S_1 \times S_2 \times S_3}$$

Overall Habitat Suitability

Overall habitat suitability for the Black-throated Green Warbler is determined by modifying the vegetative cover type suitability ($HSI_{cover\ type}$) for each habitat polygon by the stand area of that polygon (S_4) to reflect the need for interior forest conditions.

$$\mathbf{HSI_{overall} = HSI_{cover\ type} \times S_4}$$

Sources of Other Models

No other HSI models for the black-Throated Green Warbler were found.

Canada Warbler (*Wilsonia canadensis*) Reproductive Habitat Habitat Suitability Index Model

Introduction

Habitat Suitability Index (HSI) models express the suitability of habitat to support a selected species as a numerical index based on an assessment of habitat conditions (e.g. stand age, structural attributes, spatial arrangement of habitats) related to key life requisites such as food, cover or reproduction. This HSI reproductive habitat model for the Canada warbler (*Wilsonia canadensis*) applies to habitats of the Boreal White and Black Spruce (BWBS) biogeoclimatic zone, specifically the Peace Moist Warm variant (mw1) which occurs around the Peace River in northeast British Columbia. Forests in the BWBSmw1 are generally dominated by white spruce or trembling aspen, though they may have a balsam poplar, lodgepole pine and black spruce component (DeLong *et al*. 1990). Tamarack, subalpine fir and paper birch may also be present. This model will be used to predict the spatial distribution of suitable Canada warbler reproductive habitat in the core stratum of the Peace River study area. The core stratum covers an area of approximately 600 km^2 and includes the Peace River from Hudson's Hope to the Alberta border with a corridor of 2000 m on either side (north and south) of the Peace River. This model was developed based on a review of existing literature and expert opinion.

Species Description and Distribution

Canada warblers are forest dwelling neotropical migrants that breed across Canada's southern boreal region, southeast Canada, northeastern United States, Great Lakes area and at higher elevations along the Appalachian Mountains in the southern United States (Conway 1999). The species winters in South America (Conway 1999). Canada warblers are at the northwest edge of their range in British Columbia, and are found within the Boreal Plains and Taiga Plains ecoprovinces (Cooper et al. 1997c). Most sightings of Canada warbler in B.C. have been reported along the Peace River from Hudson's Hope to the Alberta border, and in the Fort Nelson vicinity (Cooper et al. 1997c). The Canada warbler is blue-listed in British Columbia due to its restricted habitat and low population size (Cooper et al. 1997c). COSEWIC reports a population decline of 73% over 30 years and 45% over the past 10 years and has identified (Fall 2005) Canada warbler as a Priority Group 1 Candidate Species for assessment, with a status report to be completed by May 2007.

General Habitat

The Canada warbler is found mainly in a wide variety of mixed deciduous/coniferous forests with dense understories (Conway 1999). The species breeding season habitat includes rhododendron in the south part of its range, aspen/poplar forests on steep slopes in the north, and forested wetlands/swamps in the central portion (Conway 1999). Canada warblers are often associated with stands having uneven canopy levels, and lush shrub and ground layers (Cooper et al. 1997c). Canada warblers are considered area sensitive in some parts of their range (Cooper et al. 1997c). One study in eastern North America found 187 ha to be the minimum size of forest fragment used as breeding habitat (Robbins et al. 1989 *In* Cooper et al. 1997c)

In British Columbia, Canada warblers are most commonly found on steep slopes of mature and old aspen/poplar deciduous forest (Cooper et al. 1997c). Deciduous forest habitat usually has white spruce associated with the main tree species (Cooper et al. 1997c). Shrubby understories with diverse foliage heights are a common habitat feature (Cooper et al. 1997c). Enns and Siddle (1996) found the species occurred most often in mixedwood forest (white spruce/aspen or white spruce/balsam poplar) with at least 8% birch. Canada warblers are also found in floodplains with adjacent slopes of dry to moist old aspen (Cooper et al. 1997c). Bennett et al. (1999) report Canada warbler sightings in British Columbia from 1996 to 1999 mainly occurred in mature aspen stands on upper slopes that had closed canopies, open mid-stories and dense understories dominated by alder and highbush cranberry.

Food

The Canada warbler is an insectivore that feeds mainly on flying insects in low shrubs and ground cover within 5 m of the forest floor (Cooper et al. 1997c, Conway 1999). Enns and Siddle (1996) found that Canada warblers in British Columbia often foraged on red-osier dogwood (*Cornus stolonifera*) and birch (*Betula* spp.) saplings within the understory. The species feeds mainly by gleaning prey from sapling and shrub foliage, but is also an active flycatcher and ground feeder (Cooper et al. 1997c, Conway 1999).

Cover

There is no published information regarding security or thermal cover requisites of Canada warblers.

Reproduction

There are little data on the breeding ecology of the Canada warbler in B.C., but in other parts of the species' range the clutch size is usually 4 eggs (range 3-5) with an incubation period ranging from 11-13 days (Cooper et al. 1997c). Canada warblers only rear one brood in B.C. (Cooper et al. 1997c). Canada warblers nests are cups of dry leaves, grass and plant fibre located on, or near the ground among ferns, stumps and fallen logs (Cooper et al. 1997c, Conway 1999). Dense cover appears to be an important nest site requisite for the species (Conway 1999).

There is little information on territory size for Canada warbler, with a range of 0.2 – 1.2 ha cited from a few studies (Conway 1999).

Cooper et al. (1997c) recommended that Canada warbler wildlife habitat areas be at least 500m in diameter to reduce parasitism by brown-headed cowbirds (*Molothrus ater*) and predation by corvids associated with edge effects due to fragmented habitat.

HSI Model

Model description

The HSI model for Canada warbler reproductive habitat is based on a combination of foraging and nesting suitability, and the presence of the most commonly used vegetative cover types. Canada warblers forage and nest in dense, shrubby understory. Nesting suitability is also affected by distance to a disturbed edge, as this affects the degree of brown-headed cowbird parasitism and corvid predation.

Canada warblers are associated with mature to old aspen mixedwood stands on steep slopes, or floodplains having adjacent deciduous stands with these characteristics. While there is no evidence that these habitat features satisfy life requisites for security, thermal cover, foraging or reproduction, few studies have been conducted on Canada warblers in the Peace Lowland area. Therefore, this model assumes that these habitat types provide some life requisites that have not yet been documented for Canada warblers, and includes them as variables in the model.

Foraging and nesting requisites

Understory cover (S_1) is essential for both foraging and nesting, and the model assumes that suitability increases with increasing cover (Table 47).

Table 47. Relationship between habitat variables and foraging/nesting life requisites for the Canada warbler HSI model.

HSI Component	Life Requisite	Habitat Variables	Habitat Variable Definition
S_1	Foraging/ Nesting	Tall Shrub Understory Cover (%)	Dense understory (tall shrubs 1.5 – 4.0 m) is associated with suitable habitat. Optimal habitat has at least 30% tall shrub understory cover. Habitat suitability decreases linearly to no suitability at 0% understory cover (Figure 13).

Stand area (S_2) is used as a modifier of overall habitat suitability to ensure a minimum amount of interior forest habitat (Table 48). Edge effects occur up to 200m from the forest edge, and a minimum patch width of 600m is recommended to allow a core area of 200m wide in the patch center (Parminter 1995). Cooper et al. (1997) also recommended that Canada warbler wildlife habitat areas be at least 500m in diameter.

Table 48. Relationship between modifier variables and overall habitat suitability for the Canada warbler HSI model.

HSI Component	Life Requisite	Modifier Variables	Modifier Variable Definition
S_2	Nesting	Stand area	Area (ha) of the stand polygon. For simplicity, the minimal fully suitable stand area is defined as the area of a circle. Any stand area with radial distance at least 300m, i.e. ~28.3 ha, is considered suitable (1.0) as this provides a minimum patch width of 600m. Suitability then decreases linearly to 0 at the estimated Canada warbler territory size of 0.5 ha. (Reported sizes for Canada warbler territories range from range of 0.2 – 1.2 ha (Conway 1999), so 0.5 ha is taken as a conservative estimate of territory size) (Figure 13).

Vegetative Cover type requisites

The Canada warbler model determines vegetative cover type suitability based on structural elements within an area. Canada warblers are found mainly in upland mature to old deciduous mixedwood stands on steep slopes, and floodplains with adjacent slopes containing mature to old deciduous mixedwood stands. It is assumed the TEM identifies and separates out floodplain associated ecosystems and that those floodplain types are valued separately (presumably higher) based on their associated plant communities. Consequently, vegetative cover type is modelled using percent stand composition of deciduous, structural stage and slope (S_3 to S_5, Table 49).

Table 49. Habitat variables for vegetative cover type for the Canada warbler HSI model.

HSI Component	Habitat Variables	Habitat Variable Definition
S_3	Deciduous in Tree Canopy (%)	Percent composition of deciduous tree species in the stand. Canada warblers are associated with sites having mainly a deciduous component. Optimal habitat has at least 25 % deciduous tree composition and no more than 75%. Suitability decreases linearly from the low and high ends of the optimal percentages (Figure 13).
S_4	Structural Stage	One of seven pre-defined successional stages of an ecosystem. Canada warblers are found mainly in mature and old deciduous stands. Consequently, mid to late structural stages (6 - Mature Forest, 7 - Old Forest) are assumed to be most suitable (1.0), with young forests (structural stage 5) providing moderate suitability (0.5), and pole/sapling stands (structural stages 4) having low suitability (0.25). The earliest seral stages (1-3) have no suitability (Figure 13).
S_5	Slope	Gentle to moderate slope (0 - 25 %) and steep slope terrain (25 - 100%) have optimal suitability. Flat terrain (0 %) has good suitability (0.8) and very steep (> 100%) has low suitability (0.2) (Figure 13).

Graphical HSI components

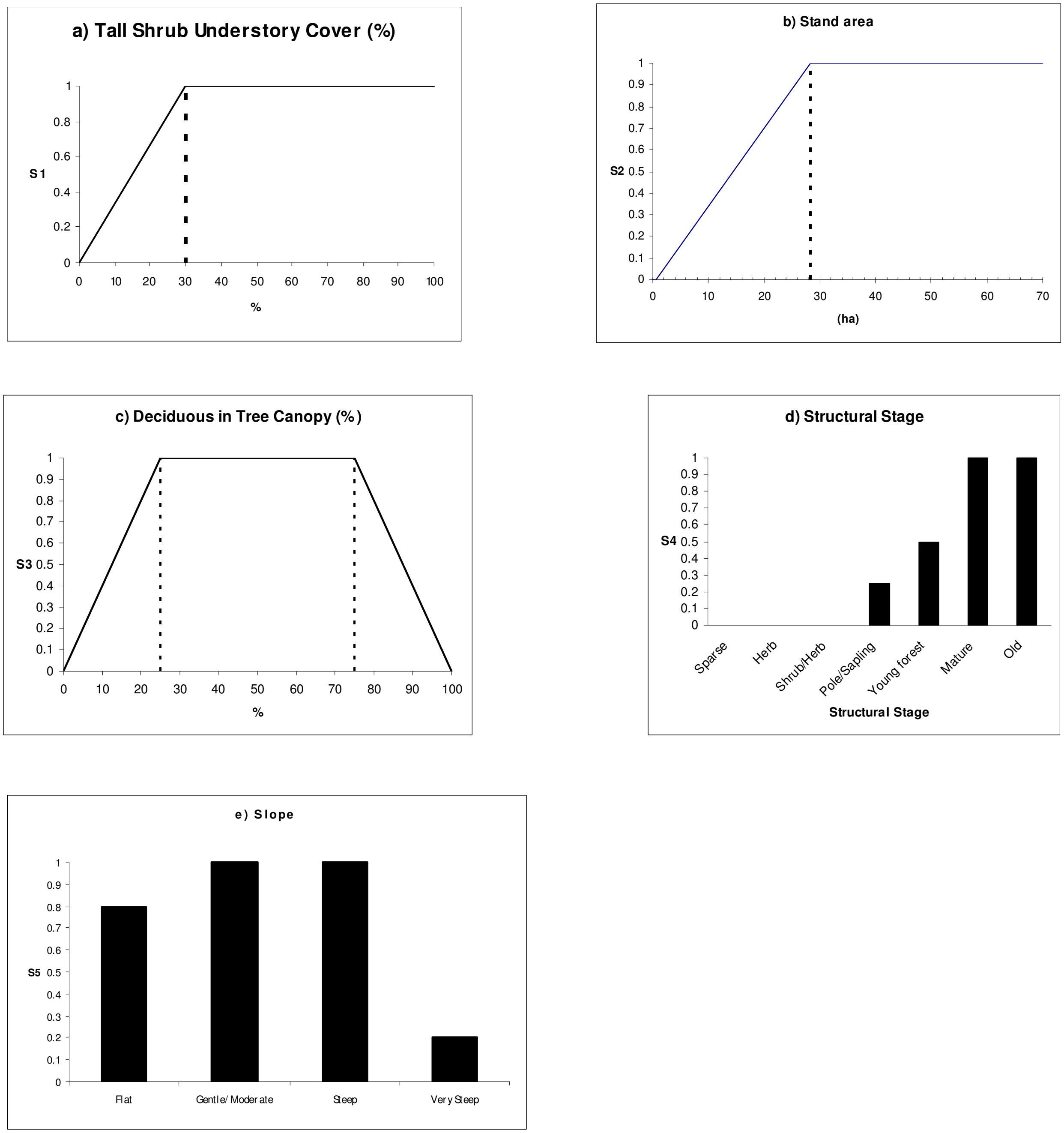

Figure 13. Graphical relationships between habitat variables and HSI components in the Canada warbler model.

Model assumptions

1. Only tall shrubs 1.5 to 4.0 m tall are useful for foraging and nesting.
2. Habitat suitability increases with increasing tall shrub understory cover.
3. The two habitat types (upland mature to old deciduous mixedwood stands and floodplains) are equally suitable to Canada warbler reproductive habitat.
4. It is assumed the TEM identifies and separates out floodplain associated ecosystems and that those floodplain types are valued separately (presumably higher) based on their associated plant communities.
5. The stand area (S_2) that is rated for a polygon does not incorporate suitable habitat in adjacent polygons. However, if S_2 is less than fully suitable (i.e. < 1.0), then the following algorithm could be used to determine if the current habitat polygon is part of a larger complex of suitable habitat and needs to have its stand area, and consequently S_2, adjusted to reflect this fact.

   Revised stand area = stand area of current habitat polygon.

   FOR each adjacent habitat polygon to the current habitat polygon

   IF adjacent habitat polygon $HSI_{cover\ type}$ >= $HSI_{cover\ type}$ of current habitat polygon THEN

   Add the stand area for the adjacent habitat polygon to the revised stand area.

   IF final revised stand area > stand area of current habitat polygon THEN

   Determine a new value for S_2 based on the revised stand area.

Equation

Overall habitat suitability

Overall habitat suitability for the Canada warbler is determined by weighting and combining the composition and structural stage vegetative cover type variables (S_3 and S_4) with the variable for tall shrub understory cover (S_1). Understory cover requirements satisfy foraging and nesting requisites for Canada warblers, and consequently this variable is heavily weighted at 80% in the overall HSI model. The resulting habitat value is modified by slope (S_5), then by a modification for stand area (S_2) to reflect the need for interior forest conditions.

$$\mathbf{HSI_{overall} = [[0.8(S_1) + 0.2(S_3 * S_4)] * S_5] * S_2}$$

Sources of Other Models

A habitat ratings model for the BWBSmw2 in northeastern BC (Teversham et al. 1998) was reviewed.

Cape May Warbler (*Dendroica tigrina*) Reproductive Habitat Suitability Index Model

Introduction

Habitat Suitability Index (HSI) models express the suitability of habitat to support a selected species as a numerical index based on an assessment of habitat conditions (e.g. stand age, structural attributes, spatial arrangement of habitats) related to key life requisites such as food, cover or reproduction. This HSI reproductive habitat model for the Cape May Warbler (*Dendroica tigrina*) applies to habitats of the Boreal White and Black Spruce (BWBS) biogeoclimatic zone, specifically the Peace Moist Warm variant (mw1) which occurs around the Peace River in northeast British Columbia. Forests in the BWBSmw1 are generally dominated by white spruce or trembling aspen, though they may have a balsam poplar, lodgepole pine and black spruce component (DeLong et al. 1990). Tamarack, subalpine fir and paper birch may also be present. This model will be used to predict the spatial distribution of suitable Cape May Warbler reproductive habitat in the core stratum of the Peace River study area. The core stratum covers an area of approximately 600 km^2 and includes the Peace River from Hudson's Hope to the Alberta border with a corridor of 2000 m on either side (north and south) of the Peace River. This model was developed based on a review of existing literature and expert opinion.

Species Description and Distribution

Cape May warblers are neotropical migrants that breed throughout the north-eastern United States and Canada's boreal forest, and winter in the West Indies and along Central America's east coast (Norton 2001). The species is at the northwest edge of its range in British Columbia, and small populations are only found in the northeastern part of the province (Cooper et al. 1997d). Populations may be largely limited by the spruce budworm (*Choristoneura fumiferana*), with densities and distributions increasing during budworm outbreaks (Cooper et al. 1997d, Baltz and Latta 1998). Cape May warblers are not considered at risk in Canada. However, concerns over impacts to its breeding habitat by timber harvesting and oil/gas development have led to it being blue-listed in Alberta and red-listed in British Columbia (Norton 1999, Cooper et al. 1997d).

General Habitat

The Cape May warbler breeds in a variety of coniferous habitats throughout its range (Baltz and Latta 1998). Stands usually contain spruce (*Picea* spp.) and balsam fir (*Abies balsamea*), and can be medium aged to old (Baltz and Latta 1998). The Cape May warbler is generally associated with mature to old growth, white spruce dominated stands in Alberta; however the species occasionally uses aspen dominated stands as well (Norton 2001).

In British Columbia, Cape May warblers are associated with mature white spruce dominated stands (Cooper et al. 1997d). Enns and Siddle (1996) found that the species was found mainly in tall white spruce stands on flat ground with open mossy (*Dicranum* sp. *Pleurozium* sp. *Rhytidiopsus* sp.) understories. Cape May warblers in the Fort Nelson forest district were also found in mature black and/or white spruce stands with open mossy understories (Bennett et al. 2000). Other common understory species include highbush cranberry (*Viburnum edule*), willow (*Salix* spp.), bunchberry (*Corus canadensis*), palmate coltsfoot, and twinflower (Enns and Siddle 1996).

Mature to old stands with at least 80% white spruce are the most suitable habitat for Cape May warblers in the Peace Lowlands, with the species not likely to be found in other habitats (M. Phinney, Louisiana Pacific Forest Resources Division, Pers. Comm.).

Food

The Cape May warbler forages mainly in the outer part of the upper canopy of spruce and firs, and feeds mostly on lepidopteran larvae and various small insects (Cooper et al. 1997d, Baltz and Latta 1998, Norton 2001). The species is also a major predator of spruce budworm *Choristoneura fumiferana*) and forest tent caterpillar (*Malacosoma disstria*) during outbreaks of these insects (Norton 2001).

Cover

There is no published information regarding security or thermal requisites of Cape May warblers.

Reproduction

There are no data on the breeding ecology of Cape May warblers in British Columbia (Cooper et al. 1997d). In other parts of its range, the Cape May warbler only rears one brood with clutches usually containing from 4-6 eggs (Cooper et al. 1997d). The incubation period is probably 11-13 days (Cooper et al. 1997d). The nest is a cup of grass, moss and small twigs that is lined with hair, fur and feathers, and typically found 10 to 20m above ground (Cooper et al. 1997d). Most nests are found near the top of spruce trees (Cooper et al. 1997d, Baltz and Latta 1998). Nests are usually hidden in dense foliage close to the main trunk of the tree (Baltz and Latta 1998). Males use very tall conifers that extend above the main canopy as singing perches (Cooper et al. 1997d, Bennett et al. 1999, Norton 2001). Cooper et al. (1997d) suggested that these singing perches are a critical feature of breeding habitat.

HSI model

Model description

The HSI model for the Cape May warbler reproductive habitat is based solely on vegetative cover type suitability, as this is presumed to satisfy the life requisites of food and nesting sites. Cape May warblers are found primarily in mature to old white spruce dominated stands (>50% white spruce in tree canopy). This habitat is considered to satisfy requisites for feeding and reproduction, as the species forages in spruce, nests 10 to 20 m high in spruce trees, and uses tall spruce as singing perches. The model assumes that only mature to old seral stages have the tall white spruce preferred by the species for nesting. The Cape May warbler model determines vegetative cover type suitability based on percent white spruce in a stand and structural stage. These variables define HSI components S_1 and S_2 respectively (Table 50).

Table 50. Habitat variables for vegetative cover type for the Cape May warbler HSI model.

HSI Component	Habitat Variables	Habitat Variable Description
S_1	White Spruce in Tree Canopy (%)	Percent composition of white spruce in the stand. Optimal habitat has at least 80% white spruce tree composition, with stands decreasing rapidly in value as white spruce percentage decreases. Stands with 70% white spruce have half the value of optimal stands, and those with 60% have a quarter of the value of optimal stands (M. Phinney, Louisiana Pacific Forest Resources Division, Pers. Comm.). Stand with less than 50% white spruce are considered unsuitable (Figure 14).
S_2	Structural Stage	One of seven pre-defined successional stages of an ecosystem. Only late structural stages 6 (Mature Forest) and 7 (Old Forest) are assumed to be suitable habitat (Figure 14).

Graphical HSI components

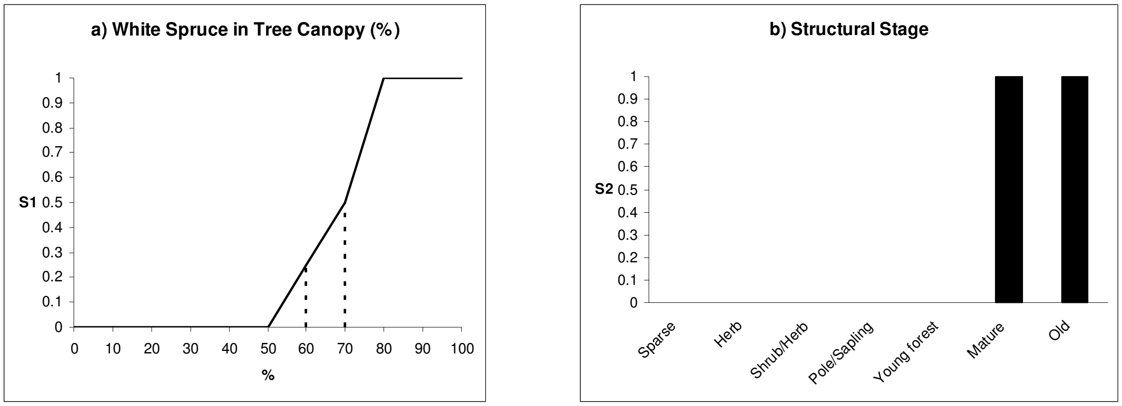

Figure 14. Graphical relationships between habitat variables and HSI components in the Cape May warbler model.

Model assumptions

None.

Equation

Vegetative cover type suitability for a habitat patch is determined based on the percent of white spruce composition (S_1) and structural stage (S_2). The model assumes that these two components are equally important to overall habitat suitability for the Cape May warbler, and consequently gives them equal weighting in the HSI model for vegetative cover type. Variables are not compensatory (a high value in one component cannot compensate for a low value in another).

$$\mathbf{HSI_{cover\ type} = S_1 \times S_2}$$

Sources of Other Models

A habitat ratings model for the BWBSmw2 in northeastern BC (Teversham et al. 1998) was reviewed.

Connecticut Warbler (*Oporornis agilis*) Reproductive Habitat Suitability Index Model

Introduction

Habitat Suitability Index (HSI) models express the suitability of habitat to support a selected species as a numerical index based on an assessment of habitat conditions (e.g. stand age, structural attributes, spatial arrangement of habitats) related to key life requisites such as food, cover or reproduction. This HSI reproductive habitat model for the Connecticut warbler (*Oporornis agilis*) applies to habitats of the Boreal White and Black Spruce (BWBS) biogeoclimatic zone, specifically the Peace Moist Warm variant (mw1) which occurs around the Peace River in northeast British Columbia. Forests in the BWBSmw1 are generally dominated by white spruce or trembling aspen, though they may have a balsam poplar, lodgepole pine and black spruce component (DeLong et al. 1990). Tamarack, subalpine fir and paper birch may also be present. This model will be used to predict the spatial distribution of suitable Connecticut warbler reproductive habitat in the core stratum of the Peace River study area. The core stratum covers an area of approximately 600 km^2 and includes the Peace River from Hudson's Hope to the Alberta border with a corridor of 2000 m on either side (north and south) of the Peace River. This model was developed based on a review of existing literature and expert opinion.

Species Description and Distribution

Connecticut warblers are elusive ground dwelling neotropical migrants (Cooper et al. 1997e). The species breeds in the boreal forest across western and central Canada, northern Minnesota, Wisconsin and Michigan, and winters mainly in the Amazon River basin in South America (Pitocchelli et al.1997). Connecticut warblers are at the northwest edge of their range in British Columbia, where the species is found only in the northeast part of the province (Cooper et al. 1997e). Connecticut warblers are not considered at risk in Canada, however, the species is red-listed in British Columbia due to its restricted distribution, small populations and threats to its breeding habitat by timber harvesting (Cooper et al. 1997e).

General Habitat

The Connecticut warbler is a forest interior species that is typically found in mature and old growth aspen dominated forest (Cooper et al. 1997e). Sites are typically associated with a well developed understory below 3m in height (Cooper et al. 1997e). A noticeable gap between the shrub understory and canopy layer is of particular importance (Enns and Siddle 1996, Janice Anderson Pers. Comm.). Connecticut warblers in the Fort Nelson forest district of British Columbia were found in variable aged, large and widely spaced aspen located on flat to gentle slopes (Enns and Siddle 1996). In the BWBSmw1 BEC subzone variant found in the Peace Lowlands, Connecticut warblers are found mainly in White spruce-Wildrye-Peavine (03) site series (Cooper et al. 1997e).

Connecticut warblers in the Peace Lowland area show some differences in habitat preference. The species is found in pole stage to mature (seral stages 4-6), rather than old aspen forest, as younger forests have more canopy closure that prevents a tall shrub understory from developing (J. Anderson, Ministry of Environment, pers. comm.). The species prefers stands with at least 80% aspen (J. Anderson, Ministry of Environment, pers. comm.; M. Phinney, Louisiana Pacific Forest Resources Division, pers. comm.). In addition, Connecticut warblers are associated with lush, herbaceous understories rather than the dense shrubbery described in other regions (J. Anderson, Ministry of Environment, Pers. Comm.; M. Phinney, Louisiana Pacific Forest Resources Division, Pers. Comm.). Connecticut warblers have also been found in mixed balsam poplar and white spruce islands in the Peace River (Penner 1976 *In* Cooper et al. 1997e).

Connecticut warblers are a forest interior species, and some studies suggest the species is area sensitive (Johns 1993, Thompson et al. 1993b *in* Cooper et al. 1997e).

Food

The Connecticut warbler feeds mainly on insects during the breeding season, with most foraging taking place along the ground and within the shrub layer (Cooper et al. 1997e).

Cover

There is no published information regarding security or thermal requisites of Connecticut warblers.

Reproduction

There are little data on the breeding ecology of Connecticut warblers in British Columbia (Cooper et al. 1997e). Connecticut warblers in other parts of the species' range rear one brood with clutch size from 3-5 eggs (Cooper et al. 1997e). The nest is a compact, deep cup of fine grass and rootlets that is lined with finer grass and hair (Cooper et al. 1997e). Nests are found on the ground among herbs and grass, a few inches off the ground at the base of saplings or shrubs (often wild rose), or in mossy hummocks (Cooper et al. 1997e). Males may perch in mid canopy when singing; otherwise they are rarely found more than 2 m above ground (Cooper et al. 1997e). The nest site requires an overstory of aspen that is at least late pole seral stage (Cooper et al. 1997e).

There is little information on territory size for the Connecticut warbler with one study in Minnesota reporting a range of 0.24 -0.48 ha (Niemi and Hanowski 1984 *In* Pitocchelli et al.1997) with a range of 0.2 – 1.2 ha cited from a few studies (Conway 1999). The average territory size in the Peace area is approximately 1.25 ha (M. Phinney, Louisiana Pacific Forest Resources Division, Pers. Comm.).

Cooper et al. (1997e) recommended that Connecticut warbler wildlife habitat areas be at least 500m in diameter to reduce parasitism by brown-headed cowbirds (*Molothrus ater*).

HSI Model

Model description

The HSI model for the Connecticut warbler reproductive habitat is based solely on vegetative cover type suitability, as this is presumed to satisfy the life requisites of food and nesting sites. Connecticut warblers in the Peace Lowlands are forest interior, ground dwelling birds that are found in pure and mixedwood aspen stands with predominantly herbaceous understories. The species nests and feeds in herbaceous vegetation and shrubs at ground level. Presence of aspen is also associated with nesting sites. Connecticut warblers are forest interior species that may be area sensitive. Including stand area in the model acts as a proxy for distance to a disturbed edge that influences nesting suitability due to parasitism by brown-headed cowbirds.

The Connecticut warbler model determines vegetative cover type suitability based on structural elements within the polygon. These elements define HSI components S_1 to S_3 (Table 51). Connecticut warblers are associated with sites having a mainly herbaceous understory, and percent of this cover (S_1) is used to describe this requisite. Since the species is associated with stands having aspen as the leading tree canopy species, percent aspen tree composition in a stand is used to develop S_2. Connecticut warblers prefer young and mature stands, which is indicated by structural stage (S_3).

Table 51. Habitat variables for vegetative cover type for the Connecticut warbler HSI model.

HSI Component	Habitat Variables	Habitat Variable Description
S_1	Herbaceous Cover (%)	Percent of ground covered by herbaceous vegetation. Cover from 25% to 90% is considered optimal. Habitat suitability decreases linearly to no suitability at 0% herbaceous cover. Suitability also decreases linearly to half the value at 100% herbaceous cover (Figure 15).
S_2	Aspen in Tree Canopy (%)	Percent composition of aspen in the stand. Connecticut warblers are associated with sites having aspen as the leading tree species. Optimal habitat has at least 80% aspen composition, with suitability decreasing linearly to a minimal level of 50%, as aspen is no longer the leading species below this point (Figure 15).
S_3	Structural Stage	One of seven pre-defined successional stages of an ecosystem. Connecticut warblers prefer young and mature forest (structural stages 5 and 6). Pole/sapling and old forest (structural stages 4 and 7 respectively) are less suitable and are given a suitability of 50%. Other structural stages have no suitability (Figure 15).

Stand area (S_4) is used as a modifier of vegetative cover type suitability to ensure a minimum amount of interior forest habitat (Table 52). Edge effects occur up to 200m from the forest edge, and a minimum patch width of 600m is recommended to allow a core area of 200m wide in the patch center (Parminter 1995). Cooper et al. (1997e) also recommended that Connecticut warbler wildlife habitat areas be at least 500m in diameter.

Table 52. Modifier variables for vegetative cover type for the Connecticut warbler HSI model.

HSI Component	Modifier Variables	Modifier Variable Description
S_4	Stand area	Area (ha) of the stand polygon. For simplicity, the minimal fully suitable stand area is defined as the area of a circle. Any stand area with radial distance at least 300m, i.e. ~28.3 ha, is considered suitable (1.0) as this provides a minimum patch width of 600m. Suitability then decreases linearly to 0 at the average Connecticut warbler territory size of 1.25 ha (Figure 15).

Graphical HSI components

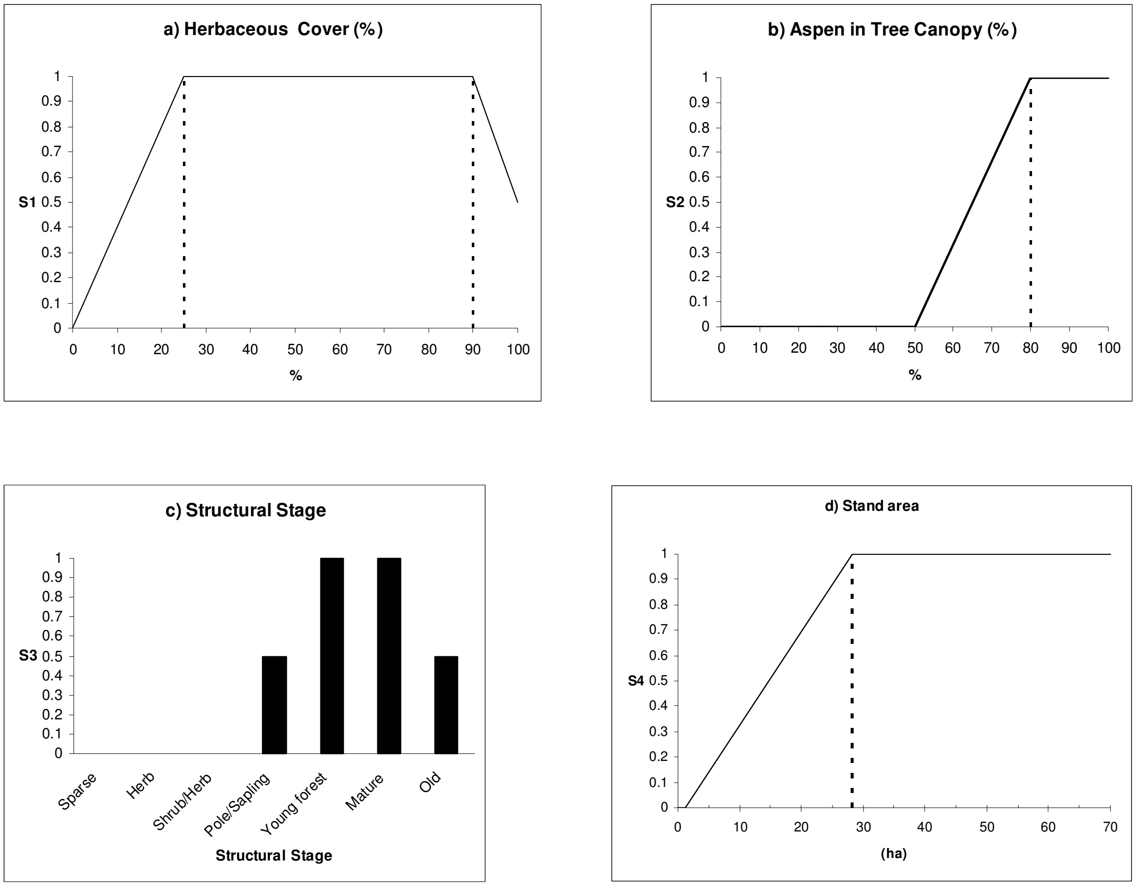

Figure 15. Graphical relationships between habitat variables and HSI components in the Connecticut warbler model.

Model assumptions

1. All herbaceous species are equally useful for nesting, foraging and cover.
2. The stand area (S_4) that is rated for a polygon does not incorporate suitable habitat in adjacent polygons. However, if S_4 is less than fully suitable (i.e. < 1.0), then the following algorithm could be used to determine if the current habitat polygon is part of a larger complex of suitable habitat and needs to have its stand area, and consequently S_4, adjusted to reflect this fact.

   Revised stand area = stand area of current habitat polygon.

   FOR each adjacent habitat polygon to the current habitat polygon

   IF adjacent habitat polygon $HSI_{cover\ type}$ >= $HSI_{cover\ type}$ of current habitat polygon THEN

   Add the stand area for the adjacent habitat polygon to the revised stand area.

   IF final revised stand area > stand area of current habitat polygon THEN

   Determine a new value for S_4 based on the revised stand area.

Equation

Vegetative Cover Type Suitability

Vegetative cover type suitability for a habitat patch is determined based on the percent herbaceous cover (S_1), percent aspen composition (S_2) and structural stage (S_3). The model assumes that these three components are equally important to habitat selection by Connecticut warblers, and consequently gives them equal weighting in the HSI model for vegetative cover type. Variables are not compensatory (a high value in one component cannot compensate for a low value in another).

$$HSI_{cover\ type} = S_1 \times S_2 \times S_3$$

Overall Habitat Suitability

Overall habitat suitability for the Connecticut warbler is determined by modifying the vegetative cover type suitability by stand area (S_4) to reflect the need for interior forest conditions.

$$HSI_{overall} = HSI_{cover\ type} \times S_4$$

Sources of Other Models

No other HSI models for the Connecticut warbler were found.

Philadelphia vireo (*Vireo philadelphicus*) Reproductive Habitat Suitability Index Model

Introduction

Habitat Suitability Index (HSI) models express the suitability of habitat to support a selected species as a numerical index based on an assessment of habitat conditions (e.g. stand age, structural attributes, spatial arrangement of habitats) related to key life requisites such as food, cover or reproduction. This HSI reproductive habitat model for the Philadelphia vireo (*Vireo philadelphicus*) applies to habitats of the Boreal White and Black Spruce (BWBS) biogeoclimatic zone, specifically the Peace Moist Warm variant (mw1) which occurs around the Peace River in northeast British Columbia. Forests in the BWBSmw1 are generally dominated by white spruce or trembling aspen, though they may have a balsam poplar, lodgepole pine and black spruce component (DeLong *et al*. 1990). Tamarack, subalpine fir and paper birch may also be present. This model will be used to predict the spatial distribution of suitable Philadelphia vireo reproductive habitat in the core stratum of the Peace River study area. The core stratum covers an area of approximately 600 km^2 and includes the Peace River from Hudson's Hope to the Alberta border with a corridor of 2000 m on either side (north and south) of the Peace River. This model was developed based on a review of existing literature and expert opinion.

Species Description and Distribution

Philadelphia vireos (*Vireo philadelphicus)* are neotropical migrants that breed across Canada, northeastern and north central United States, and winter in southern Central America (Moskoff and Robinson 1996). Philadelphia vireos are at the northwest edge of their range in British Columbia, and occur in small, isolated populations within the Boreal Plains and Taiga Plains ecoprovinces (Cooper et al. 1997f). The species is widespread in the Peace lowlands (Cooper et al. 1997f). Philadelphia vireos are not considered at risk in Canada. However, the species is blue-listed in British Columbia due to its small population size, restricted range and concerns over impacts to its breeding habitat by timber harvesting (Cooper et al. 1997f).

General Habitat

The Philadelphia vireo is found throughout its range in early to mid successional deciduous forest and forest edges, aspen parklands and shrub thickets (Moskoff and Robinson 1996). The species is often found in habitat with a rich sapling understory (Cooper et al. 1997f). Philadelphia vireos in British Columbia are most commonly found in deciduous dominated stands with 80-100% canopy closure, with Indian paintbrush (*Castilleja miniata*), fireweed, vetch, highbush cranberry, Sitka alder (*fruticosa* ssp.), willow (*Salix* spp), red-top (*Agrostis stolonifera*) and clover (*Trifolium hybridum*) in the understory (Enns and Siddle 1996). Enns and Siddle (1996) also found that Philadelphia vireos occurred in stands at a structural stage prior to self-pruning.

Food

The Philadelphia vireo is an insectivore during the breeding season, and feeds mainly on beetles and Lepidopteron caterpillars, and to a lesser extent, on a variety of insects (Cooper et al. 1997f). The species gleans insects from deciduous tree branches, and hovers beneath and feeds on the undersides of vegetation (Cooper et al. 1997f). Philadelphia vireos in British Columbia forage in both the canopy and understory (Cooper et al. 1997f). The species prefers to forage in early to mid successional trees (Moskoff and Robinson 1996).

Cover

There is no information regarding security or thermal requisites for the Philadelphia vireo.

Reproduction

There is little information about the Philadelphia vireo's breeding ecology in British Columbia (Cooper et al. 1997f). In other parts of its range, the species breeds in middle and late-seral stage forests, with its hanging nest cup found in the mid to upper canopy of deciduous trees (Cooper et al. 1997f). Philadelphia vireos only rear one brood with clutches containing from 3-5, but usually 4 eggs (Cooper et al. 1997f). The incubation period is approximately 14 days and fledgling occurs after 12-14 days (Cooper et al. 1997f).

HSI Model

Model description

The HSI model for the Philadelphia vireo reproductive habitat is based solely on vegetative cover type suitability, as this is presumed to satisfy the life requisites of food and nesting sites. Philadelphia vireos in the Peace Lowlands area are found mainly in younger to mature deciduous dominated stands with 80-100% canopy closure. This habitat is considered to satisfy requisites for feeding and reproduction, as the species nests and forages in deciduous trees. Philadelphia vireos also prefer to forage in early to mid successional trees.

The Philadelphia vireo model determines vegetative cover type suitability based on structural elements within the area. These variables define HSI components S_1 to S_3 (Table 53). Philadelphia vireos are associated mainly with dense deciduous dominated stands, so percent canopy closure and percent deciduous tree composition in a stand are used to develop S_1 and S_2 respectively. Philadelphia vireos are found in pole/sapling to mature stands, which is indicated by structural stage (S_3).

Table 53. Habitat variables for vegetative cover type for the Philadelphia vireo HSI model.

HSI Component	Habitat Variables	Habitat Variable Description
S_1	Percent canopy closure	Philadelphia vireos prefer dense stands with 60-100% canopy closure. Habitat suitability decreases stepwise from 0.5 between 20 and 60%, dropping down to no suitability below 20% canopy closure. (Figure 16).
S_2	Deciduous in Tree Canopy (%)	Percent composition of deciduous species in the stand. Philadelphia vireos are associated with deciduous dominated sites. Optimal habitat has at least 75% deciduous tree composition, with suitability decreasing linearly to a minimal level of 50% (Figure 16). Stands with less than 50% deciduous in the canopy are not considered to be deciduous dominated.
S_3	Structural Stage	One of seven pre-defined successional stages of an ecosystem. Self pruning begins at the young structural stage (Claudia Houwers, LGL Limited, pers. comm.) Consequently Pole/Sapling (structural stage 4) is fully suitable, Young Forest (structural stage 5) is 75% suitable and Mature Forest (Structural stages 6) has 50% suitability. Other structural stages have no suitability (Figure 16).

Graphical HSI components

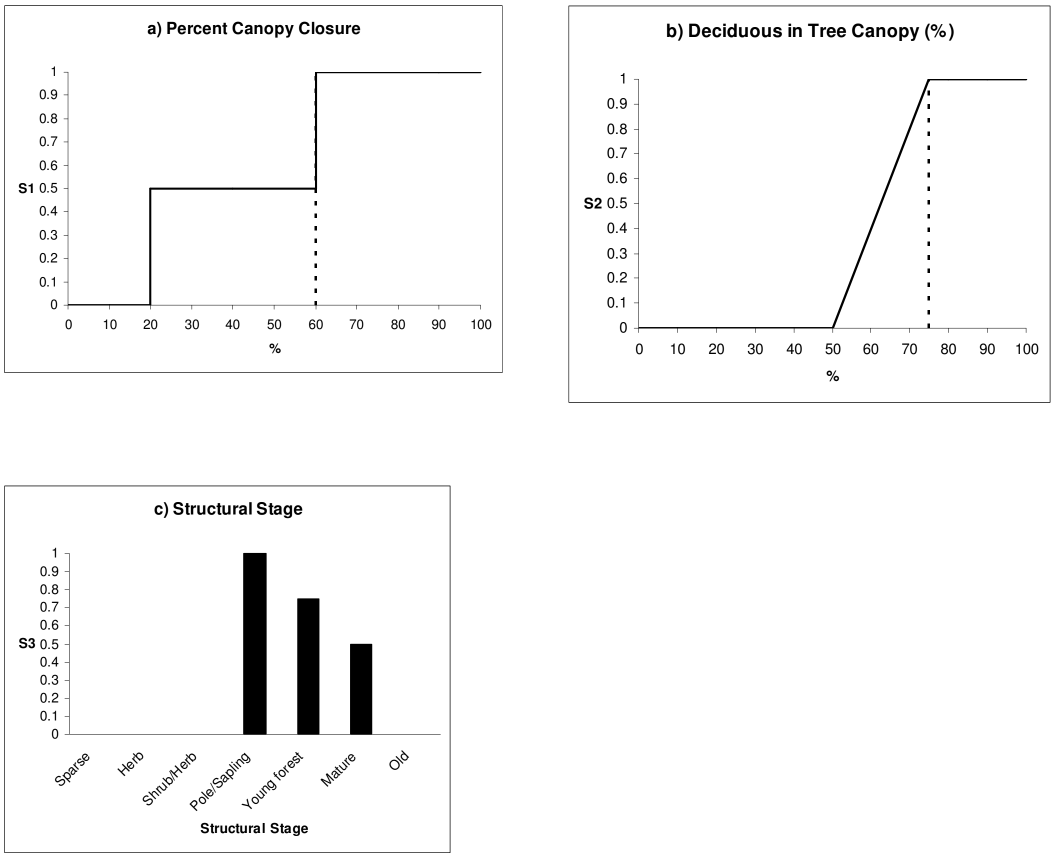

Figure 16. Graphical relationships between habitat variables and HSI components in the Philadelphia vireo model.

Model assumptions

None

Equation

This equation assumes that all variables have equal weighting. Variables are not compensatory (a high value in one component cannot compensate for a low value in another).

$$\mathbf{HSI = S_1 \times S_2 \times S_3}$$

Sources of Other Models

A habitat ratings model for the BWBSmw2 in northeastern BC (Teversham et al. 1998) was reviewed.

Barred Owl (*Strix varia)* Reproductive Habitat Suitability Index Model

Introduction

Habitat Suitability Index (HSI) models express the suitability of habitat to support a selected species as a numerical index based on an assessment of habitat conditions (e.g. stand age, structural attributes, spatial arrangement of habitats) related to key life requisites such as food, cover or reproduction. This HSI reproductive habitat model for the Barred Owl (*Strix varia*) applies to habitats of the Boreal White and Black Spruce (BWBS) biogeoclimatic zone, specifically the Peace Moist Warm variant (mw1) which occurs around the Peace River in northeast British Columbia. Forests in the BWBSmw1 are generally dominated by white spruce or trembling aspen, though they may have a balsam poplar, lodgepole pine and black spruce component (DeLong *et al*. 1990). Tamarack, subalpine fir and paper birch may also be present. This model will be used to predict the spatial distribution of suitable Barred Owl reproductive habitat in the core stratum of the Peace River study area. The core stratum covers an area of approximately 600 km^2 and includes the Peace River from Hudson's Hope to the Alberta border with a corridor of 2000 m on either side (north and south) of the Peace River. This model was developed based on a review of existing habitat suitability models (Allen 1987; MFMWP 1994; Olsen *et al.* 1995; Olsen *et al.* 1999; Higgelke and MacLeod, 2000) and recent literature.

Species Description, Distribution, and General habitat Use

The Barred Owl is a medium-sized, nocturnal owl with dark brown eyes and a distinctive streaking pattern on the body. Horizontal dark brown streaks mark the throat and breast and vertical streaks mark the lower breast and flanks (Johnsgard 1988).

Barred Owls inhabit mature to old mixedwood and coniferous stands (Godfrey 1986, Campbell *et al.* 1990) during the breeding season, and occur from the Atlantic coast across the north-eastern United States and central Canada, westward into British Columbia and the Pacific Northwest (Grant 1966; Taylor and Forsman 1976). Since 1940, the Barred Owl has extended its range southward and westward into British Columbia, becoming established in the central and southeastern portions of the province as well as on the coast (Grant 1966; Campbell *et al.* 1990). It has recently become a permanent resident in Idaho, Washington, Oregon and north-western California (Allen 1987; Hamer *et al.* 1987; Johnsgard 1988). While the Barred Owl is a widely distributed, though rare, resident and sedentary species in eastern and southern British Columbia, it is suspected that in northern areas of the province, many Barred Owls may move southward during the late autumn and winter (Campbell *et al.* 1990).

Barred Owls inhabit mature to old stands with large trees, high structural diversity, and relatively open understories (Dunstan and Sample 1972; Nicholls and Warner 1972; Devereux and Mosher 1984; McGarigal and Fraser 1984; Sutton and Sutton 1985; Bosakowski *et al*. 1987; Benyus *et al*. 1992; Van Ael 1996; Mazur *et al*. 1997; Mazur *et al*. 1998; Takats 1998). Mature to old stands usually have low stem densities providing more subcanopy flying space (Nicholls and Warner 1972, McGarigal and Fraser 1984, Haney 1997) which is important in the habitat selection of many raptors (Fuller 1979). In addition, potential nesting habitat increases with stand maturity as nest sites become available in large diameter trees. Work in the boreal region suggests that mixedwood forests are the preferred habitat type (Smith 1978; Elody and Sloan 1985; Van Ael 1996; Mazur *et al*. 1997; Mazur *et al.* 1998; Takats 1998). Older mixedwoods are thought to supply abundant prey resources, provide suitable nesting opportunities, and offer a range of roost site conditions for protection from inclement weather and predation (MFWMP 1994; James 1996; Mazur *et al*. 1998, Takats 1998).). In Saskatchewan, there was no difference in habitat use between breeding and nonbreeding seasons and preference was for old and mature mixedwood and deciduous stands (Mazur 1997).

Barred Owl reproductive success is dependent on courtship, nesting, shelter and roost sites, and the availability of food (Nicholls and Warner 1972). Courtship, mating and nesting typically occur in large remote forests with mature and old trees (Devereux and Mosher 1984, McGarigal and Fraser 1984). Oeming (1955) concluded that barred owls were likely a common bird in remote areas of undisturbed mature and old growth forests. Mature and old growth forests represent good reproductive habitat because they often contain dead trees or stubs needed for nesting. The nesting requirement for large diameter mature trees may limit population densities (Olsen *et al*. 1999). Barred Owl numbers and range are limited by the amount of nesting habitat available where they can reproduce successfully and fledge their young without interference from competitors and predators (Takats 1998). They require large tracts of mature to old forest to satisfy their life requisities (Elody 1983; Devereux and Mosher 1984; Elody and Sloan 1985; Bosakowski *et al.* 1987). Barred Owls are also sensitive to anthropogenic disturbances, particularly during the nesting season (Takats Priestley 2005).

Raptors are excellent indicators of the health of the environment (Burnham and Cade 1995), and the Barred Owl has been selected as a management indicator species in some National Forests of the United States (McGarigal and Fraser 1984). It is an easily monitored carnivore that is generally present across most of its range year-round (Higgelke and MacLeod 2000), and its specific habitat requirements for closed canopy mature and overmature forest make it a potential bioindicator (McGarigal and Fraser 1984; Derleth *et al*. 1989; James 1993).

Barred owls are considered a sensitive species in Alberta, meaning they are associated with habitats (mature forests) that are or may be deteriorating, and may require special attention or protection to prevent them from becoming at risk (Alberta Sustainable Resource Development 2001, 2005). According to Takats (pers. comm. 1999 in Higgelke and MacLeod 2000), the Barred Owl is listed as sensitive due to its naturally rare status, its tendency for clumped breeding distribution, and its association with habitat elements that warrant special attention in forest management planning. Barred Owls are less common in the aspen parkland of Alberta possibly because undisturbed stands are scarce and there are few trees or snags large enough to provide nesting sites (Boxall and Stepney 1982).

Campbell *et al*. (1990) reported that Barred Owls are usually found near water, including lake shores, swamps, creek valleys, and river bottomlands. Reproductive habitats of Barred Owls vary from dry upland sites to riparian areas (Johnsgard 1988). Early ecological studies concluded that barred owls preferred to nest near water (Bent 1938, Appelgate 1975, Soucy 1976). In particular, water bodies or wetlands surrounded by woodlands have been identified as important foraging grounds (Dunstan and Sample 1972; Nicholls and Warner 1972; Soucy 1976; Francis and Lumbis 1979; Bosakowski *et al*. 1987; DeGraaf and Rudis 1992). However, water may be less significant than stand structure and maturity of vegetation in lowland areas (Devereux and Mosher 1984) which often escape fire and logging. Mature and old riparian forests tend to have lower density understories, higher density canopies, and tree decay classes characteristic of Barred Owl habitat. These sites also contain large trees due to species differences and high productivity associated with moisture and nutrients. Water is abundant throughout the boreal forest, therefore proximity to water is likely not a significant factor in reproductive habitat selection of Barred Owls in this region (Olsen *et al*. 1999).

Food

Barred Owls are opportunistic predators of a variety of prey, including small mammals (mice, voles, hares, shrews, chipmunks, bats, squirrels), birds (passerines, woodpeckers, jays, robins, grouse), amphibians, reptiles, crustaceans, fish, and insects (Wilson 1938; Bent 1961; Leder and

Waters 1980; Devereux and Mosher 1984; Bosakowski *et al.* 1987; DeGraaf and Rudis 1992; Semenchuk 1992; Olsen *et al*. 1995; James 1996; Takats 1998). It is considered a feeding generalist known to consume any animal that it is able to catch (MFWMP 1994; Mazur pers. comm. 1999 in Higgelke and MacLeod 2000). This owl is primarily nocturnal but will hunt during the day while supporting broods (Johnsgard 1988). Research suggests that microtine voles (*Microtus* spp.) are the most common prey item (Cahn and Kemp 1930; Wilson 1938; Marks *et al*. 1984; Bosakowski *et a*l. 1987; Elderkin 1987). However, this may be a reflection of availability in Barred Owl habitat as opposed to a food preference (Mazur pers. comm. *In* Higgelke and MacLeod 2000).

Barred Owls are ground hawkers (DeGraaf *et al*. 1985), watching prey from a perch 5 to 6 m above the ground (Fuller *et al*. 1974; Takats 1996; Takats 1998). In the Foothills Model Forest of west-central Alberta, Barred Owls were opportunistic generalist predators and foraged in mixedwood forests composed of trembling aspen, balsam popular and white spruce (Takats 1998). Foraging sites had 23-90% canopy cover; hunting structures were generally in live trees with a mean diameter and height of 27 cm and 18 m respectively (Takats 1998). Prey is more vulnerable in areas of low understorey density (Nicholls and Warner 1972; Elody 1983; Devereaux and Mosher 1984). Takats (1998) found that shrub and herb cover under hunting perches were significantly lower than the surrounding stand. Van Ael (1996) suggests that dry leaf litter in deciduous and mixedwood forest is thought to facilitate prey detection by the sound of rustling leaves.

Roosting and Cover

Roost sites offer year-round protection from inclement weather and predation. The Great Horned Owl is a significant predator of the Barred Owl and Barred Owls are thought to avoid clearings and areas of minimal canopy closure to avoid predation (Bosakowski *et al.* 1987; Takats 1998). In west-central Alberta, Takats (1998) found Barred Owls roosting in mature and old mixedwood, aspen, balsam poplar or white spruce stands with very little lodgepole pine. Roosts were found in trembling aspen, balsam poplar and white spruce trees, with diameter at breast height (dbh at 1.3 m) ranging from 17-70 cm (mean of 36 cm).

Roost stands had canopy closure between 50% and 80% (though those with >30% cover may be used), tree heights ≥ 20 m (mean of 24 m) and a mean of 45 trees ≥ 35 cm dbh per hectare; roost stand characteristics were similar to nest stands (Takats 1998). Roosting and nesting sites require horizontal and vertical cover for shelter and concealment. Mature spruce and fir forests generally provide the tree height and canopy closure as well as the branching required to provide optimal cover (Olsen *et al.* 1999).

Reproductive and Nesting

Courtship and nesting begins in March and lasts through to May in west-central Alberta (Takats 1998). Nesting pairs are highly territorial and will defend a territory from intruders (Mazur 1997). Nesting home range is smaller and usually within the winter home range (Mazur 1997). A clutch size of 2 or 3 (rarely 4) pure white eggs is common for Barred Owls (Bent 1961). Incubation begins after the first egg is laid, which results in the staggered hatching of young (Johnsgard 1988). The incubation period can range from 28-32 days and re-nesting is common if eggs or broods are lost (Johnsgard 1988). The male will feed the female while she is incubating (Takats 1998). Young are born with eyes closed (Bent 1961) and leave the nest after 4 to 5 weeks and can fly by 6 weeks (Johnsgard 1988). An average nesting success of 2.02 young per breeding pair (N = 55) has been reported (Apfelbaum and Seelbach 1983).

The typical Barred Owl nest is in a cavity in a large living or dead tree or in the top of a broken snag (Mazur and James 2000, Takats Priestley 2004). The Barred owl nests most often in natural tree cavities resulting from broken off tops and holes from fallen limbs (Degraaf and Shigo 1985; Johnsgard 1988; Mazur et al. 1998; Takats Priestley 2004). Trees with a suitable degree of decay (damaged, diseased or dead) are most likely to provide nesting cavities (MFWMP 1994), either natural or created by primary cavity nesters. Barred Owls may nest in the abandoned stick nests of a squirrel, hawk or raven (Bent 1961; Peck and James 1983; Godfrey 1986; Ehrlich *et al*. 1987; Benyus 1989).

The stand characteristic thought most important to Barred Owl habitat selection is the presence of suitable nesting trees (Olsen *et al*. 1995, 1999). The availability of nesting sites is thought to limit the population size of the Barred Owl (Elderkin 1987; MFWMP 1994; Takats 1998).

Several authors have identified large *Populus* spp. or spruce (*Picea* spp.) trees as nest sites, with diameters (dbh) in excess of 40 cm (Houston 1961; Jones 1966; Devereux and Mosher 1984; James 1996; Mazur *et al*. 1998). Takats (1998) found most suitable nest sites in the mixedwood stands of west-central Alberta occurred in poplar trees of greater than 60cm dbh with a fairly closed tree canopy. Average tree diameter in stands used by breeding Barred Owls on the Appalachian Plateau was ≥ 30 cm dbh (Haney 1997).

Barred Owls in western Oregon and Washington nested in cavities of decaying trees at a minimum height of 9 m (Brown 1985). Other research has reported nest cavities at heights ranging from 4 to 20m (Dunstan and Sample 1972; Johnsgard 1988).

In west-central Alberta, mean dbh, number of deciduous trees ≥ 35 cm dbh, percent deciduous trees, percent white spruce (*Picea glauca*) and subalpine fir (*Abies lasiocarpa*), and mean canopy cover ranged from 22-35 cm, 20-70 trees/ha, 20-50%, 50-80% and 66-80% respectively for the nest stands. The distance from human disturbance and openings ranged from 70-300 m and 15-200 m, respectively (Takats 1998). In north-central Alberta, nests were found in balsam poplar (*Populus balsamiferi*) and trembling aspen (*Populus tremuloides*). Nest tree dbh ranged from 34-77 cm, nest tree height ranged from 7-29 m and cavity height ranged from 6-27 m. Canopy cover around the nest tree ranged from 39-86% and canopy height ranged from 20-29 m (B. Olsen, pers. comm. *in* Olsen *et al.* 1999).

In Saskatchewan, nests were found in old mixedwood stands, old coniferous stands and mature deciduous stands (Mazur *et al.* 1997). Nests trees included white spruce, trembling aspen, balsam poplar, and white birch (*Betula papyrifera*). Nest trees were most often live trees (67%) and cavities were either in tops of broken off trees or in cavities created by limbs breaking off. Nest tree height and dbh averaged 19 m (range 8-29 m) and 47 cm (range 32-74 cm) respectively and were found to directly influence nest site selection. Distance to an all weather road ranged from 25-2000 m (average 430 m).

In BC, Campbell *et al.* (1990) report only 8 Barred Owl nests found at that point in time; 4 in the hollowed-out tops of the dead portions of Douglas-firs; the others in natural cavities in living and dead black cottonwoods. Nest heights ranged from 6 to 30m.

Habitat Area, Composition, and Interspersion

The Barred Owl maintains exclusive use over its home range which is stable among years and generations (Bent 1938, Nicholls and Fuller 1987). It requires several nest sites within its home range as it may move to a new nest each year (Higgelke and MacLeod 2000).

Home range estimates vary regionally. Recorded breeding territories range from 149 to 363 hectares and year-round territories may range from 655 to 1,700 hectares (Nicholls and Warner 1972; Fuller 1979; Elody 1983; Elody and Sloan 1985; Nicholls and Fuller 1987; Hamer 1988; Mazur *et al.* 1998). Research from the eastern United States concludes that 9,300 ha of extensive deciduous forest could support 3 pairs of Barred Owls (Craighead and Craighead 1956). In New

England, population densities of Barred Owls were significantly greater (0.0015 pairs/ha)(Smith 1978). A northern Michigan study located 33 pairs of Barred Owls in 9,308 ha of prime habitat revealing a population density of 0.0036 pairs/ha (Elody 1983).

Takats (1998) determined a conservative estimate of Barred Owl density in west-central Alberta to be 0.05 owls/km^2. Radio telemetry data indicated a home range size for a female ranged from 150 ha to 185 ha in the summer and 170 ha in the, while a male summer home range was 155 to 240 ha (Takats 1998). Home ranges were 131-528 ha in north-central Alberta (B. Olsen, pers. comm. *in* Olsen *et al*. 1999). A mean breeding and non-breeding season home range of 149 ha (range: 38-364 ha) and 1234 ha (range: 573-2678 ha) were determined in southern Saskatchewan and non-breeding home ranges overlapped the breeding season home ranges entirely for most owls (80%)(Mazur 1997).

It has been suggested that at least 500 ha of suitable habitat are required for a pair of Barred Owls to establish a territory (MFWMP 1994). Habitat suitability models prepared by Olsen *et al.* (1999) and Higgelke and MacLeod (2000) require at least 150 ha of suitable reproductive habitat are required to support one breeding pair.

Several authors have suggested that Barred Owls prefer remote mature or old forest and avoid large (> 5 ha) clearings (Oeming 1955; Bosakowski *et al.* 1987; Takats 1998), though small clearings (e.g. road right-of-ways) may not be detrimental (Devereux and Mosher 1984; Mazur *et al.* 1998). Barred Owls tend to remain within 300 m of cover while foraging to avoid predation (Bosakowski *et al*. 1987; Takats 1998). Olsen *et al*. (1999) suggested that optimal habitat was no more than 200m from an opening.

Extensive areas of harvested and regenerating forests less than 80 years old may not have adequate cover and nesting requirements to support a population of Barred Owls (Devereux and Mosher 1984). Retaining patches of old-growth forest within harvested areas could increase habitat suitability, if these areas were strategically placed (Forsman *et al*. 1984).

Human habitation has been negatively correlated with Barred Owls, even when the forest canopy was uninterrupted in low density urban areas (Smith 1978; Sutton and Sutton 1985; Bosakowski *et al.* 1987; Takats 1995). Barred owls avoid woodlands adjacent to major paved roads with moderate to heavy traffic (Bosaskowski *et al.*. 1987). Olsen *et al.* (1999) have recommended that optimal reproductive habitat be at least 100m from human disturbance.

HSI MODEL

Model Applicability

Species: Barred Owl (Strix varia).

Habitat Evaluated: Reproductive habitat.

Geographic area: The model is applicable to the Peace River area of northeastern British Columbia.

Seasonal Applicability: Breeding season.

Cover types: This model applies to all habitats within the Boreal White and Black Spruce Peace Moist Warm biogeoclimatic variant (BWBSmw1) (DeLong *et al*. 1990). As suitability is determined from structural characteristics within stands, the model should also be broadly applicable to other habitat areas dominated by vegetation similar to that found in this region.

Minimum Habitat Area: Minimum habitat area is defined as the minimum amount of contiguous habitat required before an area can be occupied by a species (Allen 1987). A minimum habitat area is not necessary for this model because distance variables ensure that optimal reproductive habitat must be at least 100 m from human disturbance and 200 m from an opening (as per Olsen *et al*. 1999). Further, model outputs will be assessed within an assumed reproductive home range size of 150 ha (Olsen *et al*. 1999; Higgelke and MacLeod 2000).

Model Output: The model will produce habitat suitability values of 0 to 1 for each habitat polygon. These numeric values will be translated to habitat suitability value classes (Nil, Low, Moderate, High) to facilitate interpretation. In addition, Habitat Units (HU) will be calculated for each polygon based on HSI value and stand area. Habitat Units are calculated by multiply the HSI score for the polygon by the number of hectares. As per Mazur (1997), Takats (1998), Olsen *et al*. (1999), and Higgelke and MacLeod (2000), the home range size of breeding Barred Owls is assumed to be 150 ha. According to Mazur (1997) and Olsen *et al*. (1999), at least 40 hectares of the breeding home range should be optimal reproductive habitat (40 ha of HSI=1) or some combination of less suitable habitats equivalent to 40 ha of optimal reproductive habitat.

Model Applicability: This model is designed to run on inventory layers which provide stand level attribute data on tree species composition, mean tree diameters at breast height, stand age (structural stage), and canopy closure. Where inventory layers do not provide this data resolution, predictive relationships between inventory attributes and model attributes will be established. For the Peace River core stratum study area, Terrestrial Ecosystem Mapping (TEM) will be the ecological inventory base layer.

Verification Level: This HSI model provides information useful for impact assessment and habitat management. It is a hypothesis of species-habitat relationships and does not reflect causal relationships. It has been developed based on existing literature review and other published models for the species. Model output has not been evaluated against measures of Barred Owl habitat use or population density.

Model Description

This model assumes that reproductive habitat, which includes nesting, roosting, post-fledging, and foraging habitat is the most limiting characteristic of year-round Barred Owl distribution. A critical component of Barred Owl reproductive habitat appears to be the availability of suitable trees for nest cavities. If a sufficient number of trees of suitable size, species and condition are present to ensure there will be suitable nest sites, in combination with suitable canopy closure, it is assumed that reproductive requirements of Barred Owls are met.

A. Nest Tree

Nesting potential for Barred Owls is based on stand maturity and the number of suitable nesting trees ≥ 35cm dbh per hectare (Olsen *et al*. 1995, 1999). Mature and old stands typically have large trees that are susceptible to damage as a consequence of climatic extremes or insect or fungal infestations (Spurr and Barnes 1980). This results in a greater distribution and abundance of dying and dead trees that have a high probability of containing suitable nest sites in the form of cavities and broken off tops compared with young stands (Spurr and Barnes 1980). Barred Owls nested most often in large balsam poplar trees, trembling aspen and white spruce, which are likely to be of appropriate size and condition for nesting (Olsen *et al*. 1999; Higgelke and MacLeod 2000). Stands composed of at least 50% of nesting tree species will be considered optimal. Stands with no nesting tree species present will be considered unsuitable. Old stands (> 140 years in the BWBSmw1) of appropriate species composition are thought to provide optimal conditions for nest trees, while mature stands (80 to 140 years) less so. Young stands and early seral (<80 years) habitats are unsuitable (Higgelke and MacLeod 2000). A precise count of the number of suitable nest trees trees ≥ 35cm dbh per hectare that exist in a stand is desirable, but generally unavailable due to limitations of inventory and resources. Stand age or structural stage approximations will be used as surrogates for density of suitably sized nesting trees.

B. Nesting/Roosting Cover

Roosting and post-fledging habitat appears to be similar to nesting habitats in stand age, structural diversity and tree size (height). Spruce and fir appear to provide suitable cover for nesting and roosting opportunities in stands of sufficient height and canopy cover (Olsen *et al.* 1999; Higgelke and MacLeod 2000). The percent of spruce and fir in the tree canopy ensures sufficient numbers of conifer branches for shelter and concealment during nesting, roosting and post-fledging. A minimum of 5% spruce-fir is required in the canopy for a stand to have value, with optimal vertical coverage by conifer branches occurring at 25% or more (Olsen *et al.* 1999). Tree canopy closure ensures shelter will occur in the overhead horizontal plane, and must be ≥30% to have value, and ≥50% to be optimal (Olsen *et al*. 1999). Only mature (80-140 years in BWBSmw1) and old stands (≥140 years in BWBSmw1) are considered to have the tree height and canopy closure required. Although they may be used, younger stands are not considered suitable.

The availability of prey is an important component of Barred Owl habitat. Forested stands of sufficient age, composition and structural diversity to provide nesting and roosting characteristics are presumed to likely provide suitable prey habitats. There may be other habitat types which exclusively provide foraging opportunities. Olsen *et al*. (1999) allowed for foraging potential in stands at least 30 years of age (through tree height and tree canopy cover variables). However, this model assumes that nesting opportunities are the more restrictive requirements of reproductive habitat and focuses on the availability of optimal nesting habitats with appropriate cover, assuming that this will maintain the reproductive potential of an average breeding home range.

C. Spatial Component

It is assumed that Barred Owls are adversely affected by human disturbance, defined as roads and trails with motorized access, railroads, camps, industrial activity and active well sites, and human settlements. Habitats greater than 100m from human disturbance are considered optimal. Openings 5 ha or greater are assumed suitable for Great-horned Owls and thus not suitable for barred owls (Takats 1998). Barred Owls presumably avoid these large clearings or other open areas as well as the mature forest edge within the first 200 metres (Olsen *et al*. 1999).

This model will produce HSI values that are assumed proportional to a forest stand's ability to provide suitable reproductive habitat for Barred Owls. A stand with an HSI value of 0 is assumed to represent unsuitable habitat. An HSI value of 1 is assumed to indicate high reproductive habitat quality and presumed high densities of breeding pairs.

Habitat Variables and HSI Components

High quality reproductive habitat for the Barred Owl requires large diameter trees in adequate decay condition in structurally diverse, mixedwood forests to provide suitable nest cavities and roosting opportunities. Such forests are expected to be of sufficient age, composition, height and canopy closure to provide for foraging opportunities (Table 54).

Table 54. Relationship of habitat variables to life requisites for the Barred Owl HSI model.

HSI Component	Life Requisite	Habitat Variable	Habitat Variable Definition
S_1	Nesting	Nest Tree Species in Canopy (%)	Sum of the percent composition of all Trembling Aspen + Balsam Poplar + White Spruce
S_2	Nesting	Density of Large Trees	Stems per hectare of large live and dead trees ≥ 35 cm dbh.

S_3	Cover	Stand Age	Mature and old stands are considered to have optimal tree height and canopy closure required to provide roosting opportunities and cover.
S_4	Cover	Spruce + Fir Composition (%)	Sum of the percent composition of all spruce and fir species in the tree canopy.
S_5	Spatial Component	Distance From Human Disturbance (m)	Human disturbance is defined as roads and trails with motor vehicle access, railways, industrial sites, active well sites, and settlement areas.
S_6	Spatial Component	Distance From Opening (m)	Openings are defined as all areas with < 10% tree canopy closure, a tree canopy height ≤ 5 m and at least 5 ha in size. This includes regenerating clearcuts and agricultural fields.

Graphical HSI Component Relationships

S_1 Stands with ≥ 50% suitable tree species in the canopy (leading stand species) are considered best for nesting (S_1 = 1) (Higgelke and MacLeod 2000). Suitability decreases linearly to 0 at 10% suitable tree species to reflect the need for alternate nest trees in the canopy. (Figure 17a).

S_2 Nesting occurs mainly in stands with ≥ 25 trees of the appropriate size, which provide more choice in nest site locations. Stands with ≤ 10 deciduous trees ≥ 35 cm dbh receive a zero value for component S_2, which increases linearly to 1 at ≥ 25 large deciduous trees (Olsen *et al.* 1999). (Figure 17b).

S_3 Stands that are mature (80-140 years in BWBSmw1; well-developed understories; mature trees in canopy) and old (>140 years in BWBSmw1; structurally diverse) are considered best for providing sufficient tree height and canopy closure associated with nesting and roosting. Stands less than 80 years are considered unsuitable. (Figure 17c).

S_4 Optimal vertical coverage by conifer branches occurs at 25% or more spruce and fir in the tree canopy. There must be at least 5% spruce + fir in the canopy for the stand to have value (Olsen et al. 1999). Since optimal cover conditions exist if some hardwoods are present, suitability drops off as the % of spruce + fir passes 80% and decreases linearly to a value of S =0.3for 100% spruce+fir to reflect that nesting in spruce has been recorded (Mazur *et al.* 1997; Higgelke and MacLeod 2000) (Figure 17d).

S_5 Habitat within 50 m from human disturbance is assumed to be unsuitable for Barred Owls. Suitability increases linearly from 50-100 m at which point greater than 100m from human disturbance, habitat is considered optimal for nesting (Olsen *et al*. 1999; Higgelke and MacLeod 2000). (Figure 17e).

S_6 Habitat greater than 200m from the edge of a non-treed opening is considered optimal. A value of 0 is given to any natural open area (an area with ≤ 10% tree canopy closure, a tree canopy height ≤ 5 m and ≥ 5 ha in size). Suitability increases from 0 to 1 over the range 0-200 metres from the forest edge (Olsen *et al*. 1999; Higgelke and MacLeod 2000). (Figure 17f).

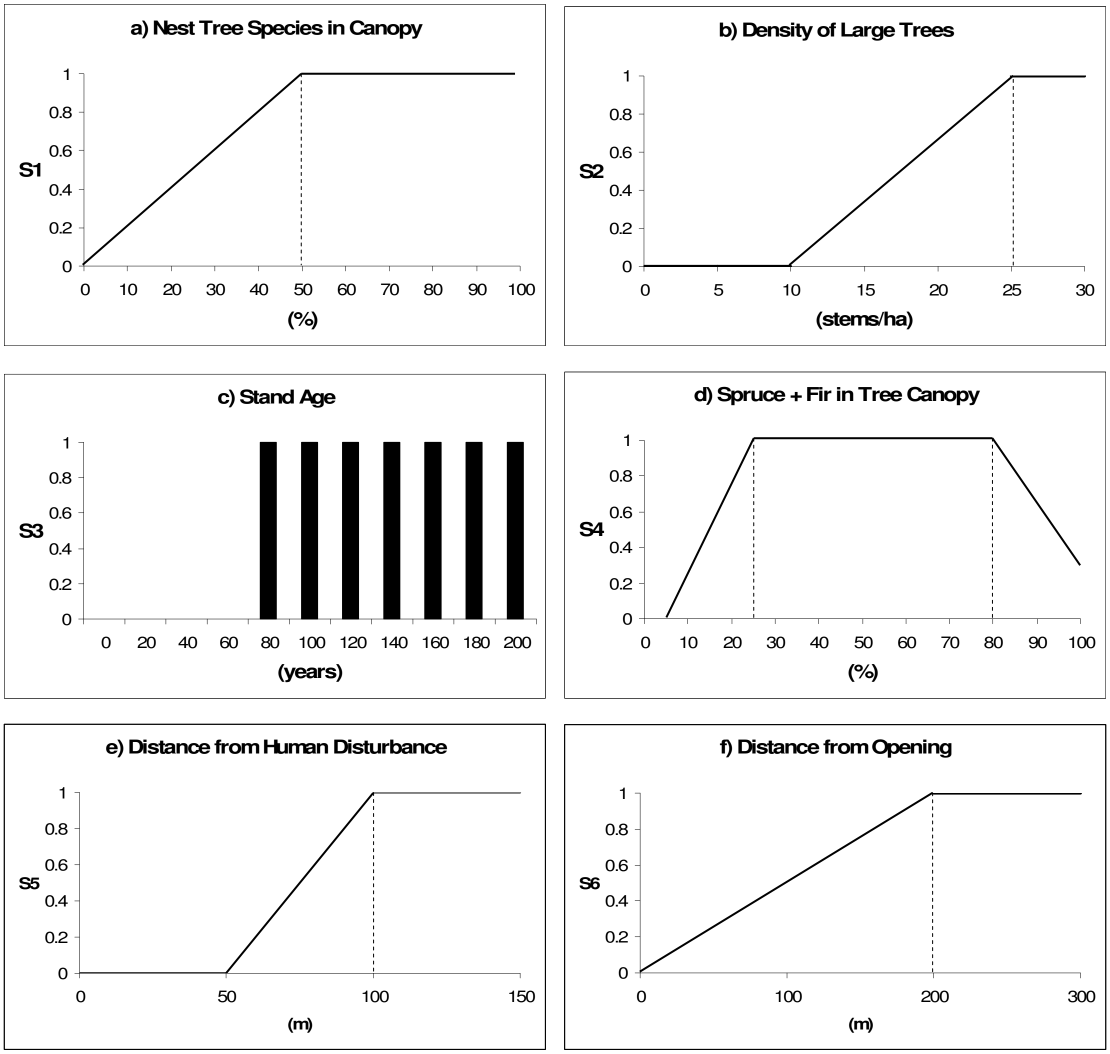

Figure 17. Graphical relationships between habitat variables and HSI components in the Barred Owl model.

Model Assumptions

1. The availability of reproductive habitat limits the year-round boreal owl distribution.
2. The availability and distribution of water is not limiting to Barred Owl habitat use.
3. Foraging habitat will be provided for if suitable nesting and roosting habitat is available.
4. Nesting habitat quality increases as forest stands develop structurally to have larger trees, dying or dead trees, and trees with broken branches or tops for nest cavities.
5. Trembling aspen and balsam poplar are likely to contain suitable nest sites for boreal owls because they are more often subject to heart rot and likely to contain cavities as they mature. Spruce is anticipated to provide suitable nesting cavity opportunities and is of equal value to deciduous species. Because the majority of nests found in the Canadian boreal forest were in natural cavities or broken off snags, stick nests were not considered in this model (Olsen *et al*. 1999).
6. Trees of both suitable size and species are required to provide nesting opportunities.

7. No distinction is made between living and dead trees; it is assumed that both have equal potential for nest sites (Allen 1987; Olsen *et al*. 1999)
8. Roosting habitat is similar to nesting habitat. Percent spruce and fir in the tree canopy and canopy closure are the most significant factors that determine roosting habitat.
9. Only mature or old forests have sufficient tree height and canopy closure to provide roosting opportunities.
10. Stands of both suitable composition and age are required to provide roosting opportunities.
11. Barred owls avoid areas of human disturbance and avoid openings where predation is probable. This spatial component of avoidance is of equal importance to that of the presence of suitable nesting opportunities and associated cover (Olsen *et al*. 1999).

Equations

Variables contributing to nesting and cover suitability are considered equal and weakly compensatory, and this equation takes the geometric mean of those variables (S_1 ,S_2, S_3, S_4) in representing reproductive habitat suitability. Variables representing spatial avoidance (S_5, S_6) directly modify the reproductive habitat suitability.

$$\mathbf{HSI = (S_1 \times S_2 \times S_3 \times S_4)^{1/2} \times S_5 \times S_6}$$

To ensure there is enough nesting habitat, 40 habitat units (HU) of nesting habitat within 150 ha is required before an area is considered suitable (Olsen et al. 1999). Forty habitat units came from Mazur's (1997) smallest home range of 38.1 ha rounded up to 40 ha. This small home range was assumed to be optimum breeding habitat and represented the amount of optimum habitat necessary to successfully raise chicks (Olsen et al. 1999). Takats (1998), B. Olsen (pers. comm. in Olsen *et al.* 1999) and Mazur (1997) had average summer home ranges of approximately 150 ha, which we assumed represented a mixture of both suitable and unsuitable habitat. One hundred and fifty hectares translates to a circle with a radius of 700 m. It is assumed that at least 40 habitat units of optimum reproductive habitat are needed within 700 m of a nest before the area is suitable for nesting.

Sources of Other Models

This model is based on updated literature review for the Barred Owl, literature review from existing models, and modifications of models prepared for the US Fish and Wildlife Service (Allen 1987); the Manitoba Forestry/Wildlife Management Project (MFMWP 1994); the Foothills Model Forest in west-central Alberta (Olsen *et al*. 1995, 1999), and the Millar Western Biodiversity Assessment Project in Alberta (Higgelke and MacLeod 2000).

Boreal Owl (*Aegolius funereus*) Reproductive Habitat Suitability Index Model

Introduction

Habitat Suitability Index (HSI) models express the suitability of habitat to support a selected species as a numerical index based on an assessment of habitat conditions (e.g. stand age, structural attributes, spatial arrangement of habitats) related to key life requisites such as food, cover or reproduction. This HSI reproductive habitat model for the Boreal Owl (*Aegolius funereus*) applies to habitats of the Boreal White and Black Spruce (BWBS) biogeoclimatic zone, specifically the Peace Moist Warm variant (mw1) which occurs around the Peace River in northeast British Columbia. Forests in the BWBSmw1 are generally dominated by white spruce or trembling aspen, though they may have a balsam poplar, lodgepole pine and black spruce component (DeLong *et al*. 1990). Tamarack, subalpine fir and paper birch may also be present. This model will be used to predict the spatial distribution of suitable Boreal Owl reproductive habitat in the core stratum of the Peace River study area. The core stratum covers an area of approximately 600 km^2 and includes the Peace River from Hudson's Hope to the Alberta border with a corridor of 2000 m on either side (north and south) of the Peace River. This model was developed based on a review of existing habitat suitability models (Heinrich *et al*. 1995, 1999; Doyon 2003) and recent literature.

Species Description, Distribution, and General habitat Use

The Boreal Owl is a small brown owl with a large round head and a distinct brown and white facial disc (Johnsgard 1988). This nocturnal owl is a year-round resident of boreal and subalpine forests and feeds on a variety of small mammals and birds.

The Boreal Owl, referred to as Tengmalm's Owl outside of North America, occurs worldwide in boreal forests (Hayward *et al*. 1993). In Northern Europe (Scandinavia, Poland, Germany and Russia), Tengmalm's Owls are found in pine and spruce forests, while in Central Europe they occur in montane forests of the Alps, Carpathian and Jura mountain ranges (Wardhaugh 1983). In North America, the northern limit of the Boreal Owl extends along the arctic tree line from Alaska to the coast of Labrador (Johnsgard 1988). In Alberta, Boreal Owls have been observed across the northern portion of the province and along the Rocky Mountains and Foothills (Heinrich *et al.* 1999). In British Columbia, the Boreal Owl is widespread throughout forested portions of the interior of the province, though it is considered a rare resident (Campbell *et al.* 1990).

Boreal Owls depend on areas that provide nesting, roosting and feeding habitat (Korpimaki 1988; Hayward *et al.* 1993). They nest and roost in mature to old deciduous, mixedwood and coniferous forest and feed in both forested habitats as well as a range of opening types (Meehan and Ritchie 1982; Doyon 2003). In north-eastern Minnesota, boreal owls were found in sawtimber-sized aspen-dominated habitats during nesting (Lane *et al.* 1997a). In Europe, Tengmalm's Owls used coniferous stands, intermixed with agricultural land (Korpimaki 1988). Spruce (*Picea* spp.), fir (*Abies* spp.), mountain pine (*Pinus sylvestris* and *Pinus uncinata*) and beech (*Fagus* spp.) were most commonly used by Tengmalm's Owls (Korpimaki 1981, 1988; Solheim 1983b; Joneniaux and Durand 1987; Dejaifve *et al*. 1990). In Colorado, Boreal Owls avoided large, unbroken stands of lodgepole pine and were found most often above 2,800 m in spruce-fir forests (Palmer 1986).

Boreal Owls are typically associated with structurally diverse, generally old growth stands. These stands have large trees with decreased growth rates and a heightened susceptibility to damage caused by climatic extremes, insect or fungal infestations resulting in an abundance of dying trees (Spurr and Barnes 1980) which provides natural or woodpecker cavities for nesting. Boreal Owls are considered a sensitive species in Alberta because they are associated with habitats that could potentially deteriorate (Wildlife Management Division 1996).

In the northern interior of BC, preferred habitats appear to be stands of white spruce and trembling aspen, similar to those reported by Meehan and Ritchie (1982) in interior Alaska (Campbell *et al.* 1990). Meehan and Ritchie (1982) reported nesting in closed stands (60% to 100% canopy cover) of deciduous and mixed forests; this may be related to availability of suitable cavities (Handel *et al*. 1998).

Boreal Owls are preyed upon by marten and possibly red squirrels at the nest (Handel *et al*. 1998). Raptors such as the Great Horned Owl and Northern Goshawk are likely predators of young and adult Boreal Owls (Hayward and Hayward 1993).

Food

Boreal Owls are primarily "sit-and-wait" nocturnal hunters except near the Arctic where they experience 24-hour daylight (Hayward 1994; Handel *et a*l. 1998). Low (4 m) perches in branches of trees are used and prey is usually attacked within 5 m of their perch (Hayward et al. 1993). Studies have shown that moving prey is taken significantly more often than stationary prey, indicating the importance of auditory cues to locate prey (Palmer 1986). Boreal owls were observed capturing voles under moderate cover by plunging through the shrub layer (*Vaccinium* spp., less than 10 cm tall) (Palmer 1986).

The main prey species of the Boreal Owl in North America are red-backed voles (*Clethrionomys gapperi*), heather voles (*Phenacomys intermedius*), northern bog lemming (*Synaptomys borealis*), other voles (*Microtus* spp.), deer mice (*Peromyscus maniculatus*), western jumping mice (*Zapus princeps*), shrews (*Sorex* spp.), northern pocket gophers (*Thomomys talpoides*), flying squirrels (*Glaucomys* spp.), and chipmunks (*Eutamias* spp.) (Catling 1972; Bondrup-Nielson 1978; Hayward *et al*. 1993). Voles made up greater than 90% of the Boreal Owl's diet in Sweden (Hornfeldt *et al*. 1990). Small passerine birds are taken in relatively small proportions (Korpimaki 1981, 1992, Carlsson 1990). Young snow shoe hares may be important during the peak of the hare cycle (Handel *et al*. 1998).

The abundance of prey may influence distribution and habitat use of Boreal Owls (Korpimaki 1986; Lofgren *et al.* 1986; Carlsson and Hornfeldt 1989; Boutin *et al*. 1996). In Kluane, Yukon, Boreal Owl densities were linked with *Microtus* spp. (Boutin *et al*. 1996). The owls favoured the older stands due to the lack of a crust layer on the snow which facilitated plunge diving. During early spring, Boreal Owls feed in openings and clear-cuts due to earlier snow melt and then move into mature spruce-fir forest (summer, fall and winter) when vegetation becomes too thick in the clearings (Palmer 1986).

Roosting

Roost sites are highly variable (Catling 1972). Boreal Owls roosted mainly in coniferous (spruce, fir and pine) trees in Idaho (Hayward and Garton 1984). In Ontario and Alberta, 14% of roost sites (N = 28) were in aspen and the rest were in conifers, with 46% being in balsam (subalpine) fir (*Abies lasiocarpa*) (Bondrup-Nielson 1978). Balsam fir was preferred for roosting because few needles and branches were close to the trunk where the owls tended to roost but needles and branches were abundant on the outer portion of the trees thus providing good cover. Boreal Owls roost close to the tree trunks to take advantage of their cryptic coloration (Hayward and Garton 1984). Roosting heights have been found to be 5-7 m in trees with an average diameter at breast height (dbh at 1.3 m) of 25-28 cm (Hayward *et al.* 1993). In Colorado, Boreal Owls typically roosted in trees with an average height of 14 m, and used Englemann spruce (*Picea engelmannii*) significantly more often than subalpine fir or lodgepole pine (*Pinus contorta*) (Palmer 1986). Cavities were not used for roosting (Palmer 1986). In Idaho, spruce-fir stands and occasionally pine seem the preferred roosting habitat because these trees provided thermal and hiding cover (Hayward and Garton 1984). In northeastern Minnesota, roost sites and foraging areas were typically in thick, homogeneous conifer stands in lowland areas (Lane *et al*. 1997b). Black spruce (*Picea mariana*) was used as the roost tree 82% of the time; balsam fir 9% and northern white cedar (*Thuja* sp.) 4% (Lane et al. 1997b). Canopy closures of roost sites ranged from 58-63% in Idaho (Hayward et al. 1993).

Reproduction and Nesting

The mating system of the Boreal Owl can be monogamous, polygynous or polyandrous (Solheim 1983a; Carlsson 1990; Korpimaki 1992). However, polygyny and polyandry, observed in years with abundant prey in Europe, have not been documented in North America (Handel *et al.* 1998). Males are poly-territorial (defend more than one nest) and will feed the females prior to egg laying and feed the young exclusively during the early nestling period (Korpimaki 1992).

Egg laying dates range from the middle of March to the end of May in North America (Hayward 1993). Clutch size averages 2-4 eggs (Hayward *et al*. 1993). Eggs are laid in the bottom of the cavity without any nesting material (Wardhaugh 1983). Average nest dimensions for 19 nests in Idaho were 31 cm deep by 19 cm horizontally and openings averaged 9.5 cm by 10.2 cm (Hayward *et al*. 1993). These nest sites were located in trees with dbh ranging from 33-112 cm and greater than 11 m in height (Hayward *et al.* 1993). In central Ontario and northern Alberta, 12 nest cavities (6 confirmed and 6 that were suspected of being used by Boreal Owls) were found 11-17 m above the ground and were 5-35 cm deep with a cavity diameter of 20-25 cm. The cavity openings ranged from 6 cm by 6 cm to 14 cm by 7 cm (Bondrup-Nielson 1978).

Boreal Owls in North America nest in natural tree cavities, cavities excavated in large live or dead trees by large woodpeckers such as Northern Flickers (*Colaptes auratus*) and Pileated Woodpeckers (*Dryocopus pileatus*), and man-made cavities (nest boxes) (Meehan and Ritchie 1982; Johnsgard 1988; Hayward *et al*. 1993; Handel *et al*. 1998; Doyon 2003). Cavities are rarely used for more than one breeding seasons are have been identified as a limiting factor for Boreal Owl populations in Canada (Doyon 2003). Nests are often found in live trees or snags of trembling aspen (*Populus tremuloides*), balsam poplar (*Populus balsamifera*), spruce spp., lodgepole pine, ponderosa pine (*Pinus ponderosa*) , and Douglas-fir (*Pseudotsuga menziesii*) (Bent 1961; Palmer and Ryder 1984; Palmer 1986; Hayward *et al*. 1993).

Nesting sites are highly variable regionally. Boreal Owls in central Ontario occurred in mixed coniferous and deciduous forests rather than pure coniferous forests with nests mainly in aspen (Bondrup-Nielson 1978). In Montana, Idaho and Washington, boreal owls used mature conifer forests consisting of Englemann spruce, subalpine fir and western hemlock (*Tsuga heterophylla*) at elevations above 1500 m (Hayward *et al.* 1987a; Holt and Hillis 1987; O'Connell 1987). Nest trees used by Boreal Owls in Idaho were in relatively open areas with average tree densities of 398 trees/ha with a dbh of 2.5-23.0 cm and 212 trees/ha for trees larger than 23 cm dbh (Hayward *et al.* 1993).

Habitat Area, Composition, and Interspersion

Breeding male Boreal Owls tend to remain on the same territory even when food abundance is limited, while females will move between successive breeding attempts (Lofgren et al. 1986, Korpimaki 1988). Information on home range and population densities is limited. In central Ontario and northern Alberta, estimated boreal owl densities were 0.001 singing male boreal owls/ha for both regions (Bondrup-Nielson 1978). In Kluane, estimated boreal owl density was 0.005 pairs/ha (Boutin *et al*. 1996).

Home range sizes of Boreal Owls are highly variable. Lane *et al*. (1997b) found the home range for nesting male Boreal Owls to be 1,202 ha (n = 4, range = 742-1,444 ha). Palmer (1986) estimated home ranges of two male Boreal Owls in Colorado to be 296 ha during the breeding season and 1,132 ha in the post-breeding season. Male singing territory size during the courtship season was between 0.2-11 ha and expanded to 100-500 ha for hunting in Ontario and Alberta (Bondrup-Nielson 1978). Hunting areas are generally larger than courtship areas (Hayward *et al*. 1987a). In Idaho, winter home ranges averaged 1,451 ha in winter and 1,182 ha in summer (Hayward *et al*. 1993). Home ranges of owls may overlap up to 50% during nesting (Hayward *et al*. 1993) and up to 98% during the post-nesting period (Palmer 1986). Active nests within 500m of one another are common in productive agricultural areas in Scandinavia (Hayward and Hayward 1993).

Relationships between the abundance and spatial distribution of various life requisite habitats, such as nesting, foraging and roosting, and Boreal Owl population response are poorly understood. Though seasonal shifts in home range size have been reported, the spatial composition of home ranges has not been clearly documented. Doyon (2003) has suggested that open foraging habitats greater than 200m from suitable forested cover have limited value. Most literature suggested the year-round use of a mosaic of predominantly coniferous forested habitats mixed with deciduous and open habitat types.

HSI MODEL

Model Applicability

Species: Boreal Owl (*Aegolius funereus*).

Habitat Evaluated: Reproductive habitat.

Geographic area: The model is applicable to the Peace River area of northeastern British Columbia.

Seasonal Applicability: Breeding season.

Cover types: This model applies to all habitats within the Boreal White and Black Spruce Peace Moist Warm biogeoclimatic variant (BWBSmw1) (DeLong *et al*. 1990). As suitability is determined from structural characteristics within stands, the model should also be broadly applicable to other habitat areas dominated by vegetation similar to that found in this region.

Minimum Habitat Area: Minimum habitat area is defined as the minimum amount of contiguous habitat required before an area will be occupied by a species (Allen 1987). It is unknown whether Boreal Owls require a large contiguous forest or whether small patches of suitable habitat in a managed landscape are suitable, so no minimum habitat area is defined for this model (Heinrich *et al*. 1999).

Model Output: This is an aspatial model. The model will produce values of 0 to 1 for each habitat polygon. These numeric values will be translated to habitat suitability value classes (Nil, Low, Moderate, High) to facilitate interpretation. Habitat Units (HU) may be calculated for the Peace River core stratum based on HSI value and stand area. Habitat units are calculated by multiply the HSI score for the area by the number of hectares.

Model Applicability: This model is designed to run on inventory layers which provide stand level attribute data on tree species composition, mean live plus dead stem diameter at breast height, and stand age (structural stage). Where inventory layers do not provide this data resolution, predictive relationships between inventory attributes and model attributes will be established. For the Peace River core stratum study area, Terrestrial Ecosystem Mapping (TEM) will be the ecological inventory base layer.

Verification Level: This HSI model provides information useful for impact assessment and habitat management. It is a hypothesis of species-habitat relationships and does not reflect causal relationships. It has been developed based on existing literature review and other published models for the species. Model output has not been evaluated against measures of Boreal Owl habitat use or population density.

Model Description

A. Nesting

A critical component of Boreal Owl reproductive habitat appears to be the availability of suitable trees for nest cavities. If a sufficient number of trees of suitable size, species and condition are present to ensure there will be suitable nest sites, it is assumed that reproductive requirements of Boreal Owls are met. Boreal Owls require large (>30cm dbh) live and dead trees of suitable condition (decay class) for the presence of nesting cavities (Doyon 2003). In the Peace River core stratum, trembling aspen, balsam poplar, and white spruce are the likely trees species to have the appropriate size and condition. Where present, subalpine fir may also be a good candidate, but it is not anticipated to occur in any significant densities in the study area. Stands composed of at least 50% of nesting tree species will be considered optimal. Stands with no nesting tree species present will be considered unsuitable. A precise count of the number of suitable nest trees ≥ 30cm dbh per hectare that exist in a stand is desirable, but generally unavailable due to limitations of inventory and resources. Stand age or structural stage approximations will be used as surrogates for density of suitably sized nesting trees.

B. Roosting

Roosting habitat, both during the reproductive season as well as winter, appears to be related to the presence of suitable roosting trees in stands which provide thermal and hiding cover. Large live conifers predominate, with some limited use of deciduous stems. Spruce and fir appear to provide suitable roosting opportunities in stands of sufficient height and canopy cover. These stand characteristics are likely similar to those in which suitable nesting opportunities will be found, though not exclusively overlapping. To adequately represent the observed conifer association of Boreal Owls, specifically for roosting, stands with a substantial (≥50%) conifer component will be considered of optimal value (Heinrich *et al*. 1999). To reflect the apparent association with spruce and fir, conifer composition will be weighted. However, all stands have value as Boreal Owls have been located in pure deciduous stands and known to roost in aspen (Bondrup-Nielson 1978). Only mature (80-140 years in BWBSmw1) and old stands (≥140 years in BWBSmw1) are considered to have the height and canopy closure required for roosting. Although they may be used, younger stands are not considered suitable.

The availability of prey is an important component of Boreal Owl habitat. Small mammals such as voles and mice make up the majority of their diet and occur in substantial supply in older conifer and mixedwood forests with relatively open understories, predominantly spruce and fir, as well as in adjacent non-forested openings. This model assumes that Boreal Owl food requirements will be met in the same habitats that provide suitable nesting and roosting habitat

The knowledge base for Boreal Owl ecology is limited, and descriptions of nesting, roosting and foraging habitat requirements are varied. Based on these limitations, nesting and roosting requirements are assumed to be the best understood. Therefore, forested stands of sufficient age, composition and structural diversity to provide nesting characteristics are presumed to likely provide suitable prey habitats, and be sufficient in height and canopy cover to provide roosting opportunities. There may be other habitat types which exclusively provide foraging opportunities. This model does not have the spatial capacity to consider the adjacency and availability of those habitats.

This model will produce HSI values that are assumed proportional to a forest stand’s ability to provide suitable reproductive habitat for Boreal Owls. A stand with an HSI value of 0 is assumed to represent unsuitable habitat. An HSI value of 1 is assumed to indicate high reproductive habitat quality and presumed high densities of breeding pairs.

Habitat Variables and HSI Components

High quality reproductive habitat for the Boreal Owl requires large diameter trees in adequate decay condition in structurally diverse, conifer-leading forests to provide suitable nest cavities and roosting opportunities. Such forests are expected to be of sufficient age, composition, height and canopy closure to provide for foraging opportunities (Table 55).

Table 55. Relationship of habitat variables to life requisites for the Boreal Owl HSI model.

HSI Component	Life Requisite	Habitat Variable	Habitat Variable Definition
S_1	Nesting	Nest Tree Species in Canopy	Combined %Trembling Aspen + %Balsam Poplar + %White Spruce
S_2	Nesting	Density of large live and dead trees	Stems per hectare of large live trees and snags ≥ 30 cm dbh.
S_3	Roosting	Weighted Conifer in Tree Canopy	Combined % Spruce (Black + White) + % Fir + 0.25 x % Pine in the tree canopy.
S_4	Roosting	Stand Age	Mature and old stands are considered to have optimal height and canopy closure.

Graphical HSI Component Relationships

S_1 Stands with ≥ 50% suitable tree species in the canopy are considered best for nesting (S_1 = 1). Suitability decreases linearly to 0 suitability when no suitable tree species are present. There are insufficient data to set clear thresholds for stand composition. It is assumed that as little as one suitable nesting tree or snag will be used if available. (Figure 18a).

S_2 Suitability increases linearly from 0 suitability at 0 large trees/ha to a suitability of 1 at 30 large trees/ha based on thresholds set in other Boreal Owl models (Heinrich *et al*. 1999; Doyon 2003) (Figure 18b).

S_3 Stands with ≥ 50% weighted conifer are the best for roosting (S_3 = 1). Suitability decreases linearly to 0.1 suitability when less than 10% of suitable conifers are present in the tree canopy. There are insufficient data to set clear thresholds for stand composition. Boreal Owls have been located in pure deciduous stands and known to roost in aspen. (Figure 18c).

S_4 Stands that are mature (80-140 years in BWBSmw1; well-developed understories; mature trees in canopy) and old (>140 years in BWBSmw1; structurally diverse) are considered best for providing sufficient tree height and canopy closure associated with nesting and roosting. Stands less than 80 years are considered unsuitable. (Figure 18d).

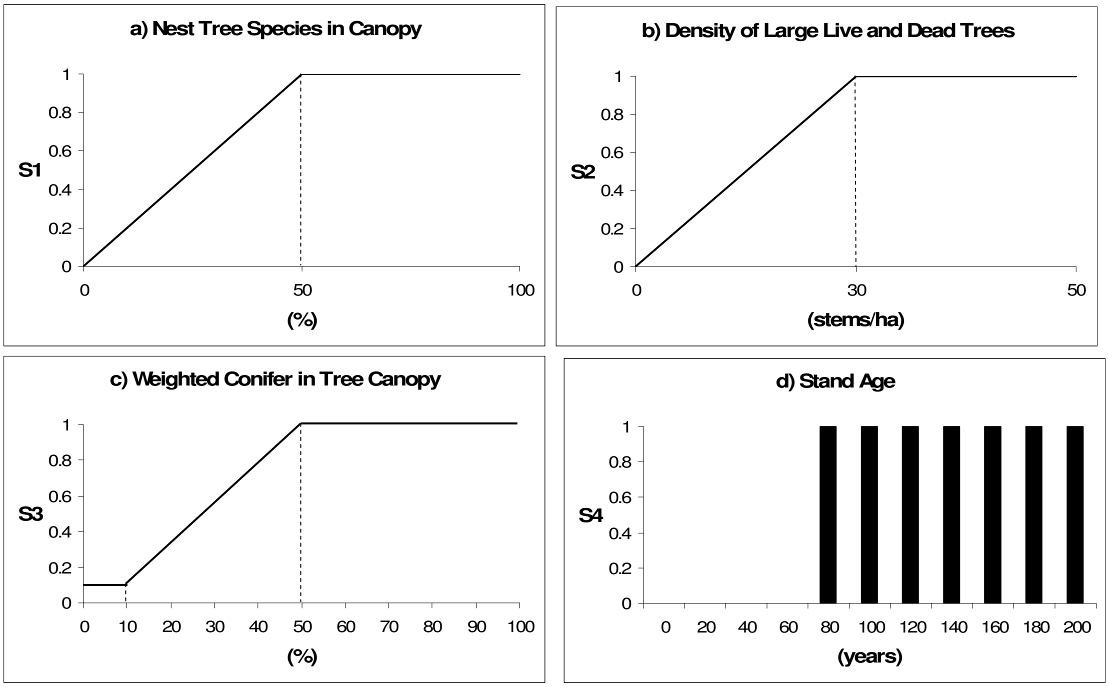

Figure 18. Graphical relationships between habitat variables and HSI components in the Boreal Owl model.

Model Assumption

1. The availability of reproductive habitat limits the year-round boreal owl distribution.

2. Foraging habitat will be provided for if suitable nesting and roosting habitat is available.

3. Nesting habitat quality increases as forest stands develop structurally to have larger diameter trees and more dying or dead trees.

4. Trembling aspen and balsam poplar are likely to contain suitable nest sites for boreal owls because they are more often subject to heart rot and therefore excavated by woodpeckers. Spruce is anticipated to provide suitable nesting cavity opportunities and is of equal value to deciduous species. Subalpine fir may provide opportunities, but is less frequently used and is not anticipated to occur in the study area.

5. Trees of both suitable size and species are required to provide nesting opportunities.

6. Boreal Owls are conifer-associated, and roosting is more tightly associated with spruce and fir forests.

7. Only mature or old forests have sufficient tree height and canopy closure to provide roosting opportunities.

8. Stands of both suitable composition and age are required to provide roosting opportunities.

9. Stands that provide either suitable nesting or roosting opportunities during the reproductive season will have value, but those that provide nesting habitat are of greater reproductive value. Suitable roosting habitat may provide some nesting opportunity, and the reverse may be true.

Equation

This equation takes the weighted arithmetic mean of nesting and roosting habitat in representing reproductive habitat suitability as a combination of nesting and roosting suitability. Nesting and roosting habitat opportunities are considered to be compensatory, though nesting habitat is considered to contribute twice the value of roosting habitat to reproductive habitat suitability. The equation assumes that attributes of nesting habitat are equally important (non-compensatory), and attributes of roosting habitat are equally important (non-compensatory).

$$\mathbf{HSI} = [(S_1 \times S_2) + 0.5(S_3 \times S_4)] / 2$$

where $SI_{nesting} = (S_1 \times S_2)$,

and $SI_{roosting} = (S_3 \times S_4)$.

Sources of Other Models

This model is based on literature review for the Boreal Owl, a HSI model format for owls (Allen 1987) and modifications of models prepared for the Foothills Model Forest in Alberta (Heinrich et al. 1995, 1999) and the Western Newfoundland Model Forest (Doyon 2003).

Appendix II.Data sheets used for each component of the wildlife inventory of the Peace River study area in Spring 2005. Some data forms were modified from existing RISC data forms

Pond-breeding amphibians and painted turtle: Adult

Project: EA1786 **Survey: Peace River Wildlife Surveys** **Study Area: Peace River, BC**

Search Area: ______________________ **Surveyors:** ______________________

Date :___-___-___ (dd-mmm-yy) ***Search Type:*** *Time Constrained* ☐ *hrs* ____ ***OR*** *Systematic* ☐ *Area* ____

Survey Data	Time	Ceiling	CC	Wind	Precip	Temperature Wet	Temperature Dry	Temperature Humidity	Temperature Water	Temperature Soil	Soil Moist
Start											
End											

Obs No	Time	Spp	Sex	AC	TL	SVL	W (g)	Mark	Loc	Cov Obj	W	L	H	DC	Sub	Dist	Easting	Northing
		A-																
		A-																
		A-																
		A-																
		A-																
		A-																
		A-																
		A-																
		A-																
		A-																
		A-																
		A-																

Notes:____

Pond-breeding amphibians and painted turtle: Larvae

Project: EA1786 **Survey: Peace River Wildlife Surveys** **Study Area: Peace River, BC**

RA Surveys Only: **Transect Label** ________ Stratum ________ Trans Length _____ **UTM: Start E:**_________**N:**________ **End E:** _________**N:**_________

Date:____-____-____ Entire Study Area (Site/Pond) Sampled? Yes ☐ No ☐ AA Survey? Yes ☐ No ☒
dd-mmm-yy

Survey Data	Time	Ceiling	CC	Wind	Precip	Temperature Wet	Temperature Dry	Humidity	Water	Soil	Soil Moist
Start											
End											

Surveyors:

Swp #	Obs #	Mac Hab	Plants			Bot Sub	Sweep Size Lgth	Sweep Size Wdth	Water Depth Min	Water Depth Max	Water Temp	Time	Spp	# / Swp	Size TL	Size SVL	Dev Stg	Sex	Prev Mark / Mark ID		Comments/ Voucher Label
													A-								
													A-								
													A-								
													A-								
													A-								
													A-								
													A-								
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													A-								
													A-								
													A-								
													A-								

Fish Present: Y ☐ **N** ☐ **Fish Spp:**_______________________________________

Terrestrial Arthropods: Butterflies

Project:		**Survey:**
Study Area:	**Location Name:**	
Location Description:		
Habitat Block:	**Date:**	**Surveyors:**

	Time	CC	Wind	Air T	Precip	Recent Rain		Surface Leaf Moisture	Comments
						24	48		
Start									
End									

No. Observers:_____ Total Search Time: _____ mins Person Distance-Sampled_______ km

Geographic Location and Ecological Data. Complete only once for each habitat block (if repeated visits are made)

UTM			Elevation (m)	Slope (%)	Aspect (deg)	Mesoslope	BEU	Ecosection	BGC Subzone	Structural Stage
Zone	Easting	Northing								

Dominant Indicator Vegetation Species (usually minimum 3 / layer)

Tree Layer	% Cover	Shrub Layer	% Cover	Forb Layer	% Cover	Moss / Lichen Layer	% Cover

OBSERVATIONS

Obs No.	Taxon (Species Name)	Count	Adult			Capt Mech (Sight, Net, Other)	Comments	ID Verifier and Date
			M	F	UC			

Raptors and Owls: Encounter Transects

Project: EA1786 **Survey: Peace River Wildlife Surveys** **Study Area: Peace River, BC**

Transect Label _________ Stratum _________ Trans Commen____

Trans: Length _____ **Bearing** ______ **Date :**___-___-___ UTM: Start **E:**________**N:**_______ End **E:**________**N:**_______

dd-mmm-yy

Survey Data	Time	CC	Wind	Precip	Temp
Start					
End					

Surveyors ____

Obs #	Spp	Trans Dist	Detec t Dir	Activit y	Des	Sex	Age Class	Nest Label / Fm		BEU	Detection UTM Zone / East / North			Comments
	B-													
	B-													
	B-													
	B-													
	B-													
	B-													
	B-													
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	B-													
	B-													

Raptors and Owls Call Playback Part A

Project: EA1786 **Survey**: **Peace River Wildlife Surveys** **Study Area: Peace River, BC**

Transect Label _________ Stratum _________ Trans Commen____

Trans: Length _____ **Bearing** ______ **Date :____-____-____** UTM: Start **E:**_______**N:**_______End **E:**_______**N:**______ Interstation Dist ________
dd-mmm-yy

Obs Date: Start ______/______/________ End ______/______/________ Call Type(s) _________________________

Surveyors____

Call Sta	Sta UTM Zone/East/North			Ecosystem Form Type / #		Stratum	Time Start	Time End	Wind	Precip	CC	Temp	Comments

[Record the observations associated with the Call Stations listed above on copies of the **Raptor Call Playback *-Part B*** form.]

Raptors and Owls Call Playback Part B

Project: **EA1786** **Survey**: **Peace River Wildlife Surveys** **Study Area:** **Peace River, BC**

Transect Label _________ **Obs Date:** Start ____-____-____ End ____-____-____
dd-mmm-yy dd-mmm-yy

Call Sta	Obs #	Spp	Detect Dir	Dist to Detect	V/C	Activity	Des	Sex	Age Class	Nest Label	Nest / Fm	Comments
		B-										
		B-										
		B-										
		B-										
		B-										
		B-										
		B-										
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		B-										
		B-										

[Observations recorded in this section must correspond to Call Stations listed on copies of the **Raptor Call Playback *-Part A*** form.]

Snake Hand Collecting

Project: EA1786 **Survey: Peace River Wildlife Surveys** **Study Area: Peace River, BC**

TCS Y ☐ N ☐ Person-min. Search Time _____ **Date :___-___-___** (dd-mmm-yy) **Capt Sess Label** (if applicable) ____________

Search Unit Label _________ Stratum ________ UTM **E:**_________**N:**________

OR

Quadrat Label _________ Stratum ________ UTM **E:**_________**N:**________ Quad Dim ________

Survey Data	Time	CC	Wind	Precip	Temp: Air / Ground	
Start						
End						

Surveyors ____

Obs#	Grp#	Spp	Capture UTM Zone/East/North			Prev Mark / Mark ID		Sex	AgeCl	Reprod Cond	SVL	Weight	Comments [Radio Freq, Voucher Label]
		R-											
		R-											
		R-											
		R-											
		R-											
		R-											
		R-											
		R-											
		R-											
		R-											
		R-											
		R-											
		R-											

NOTES:____

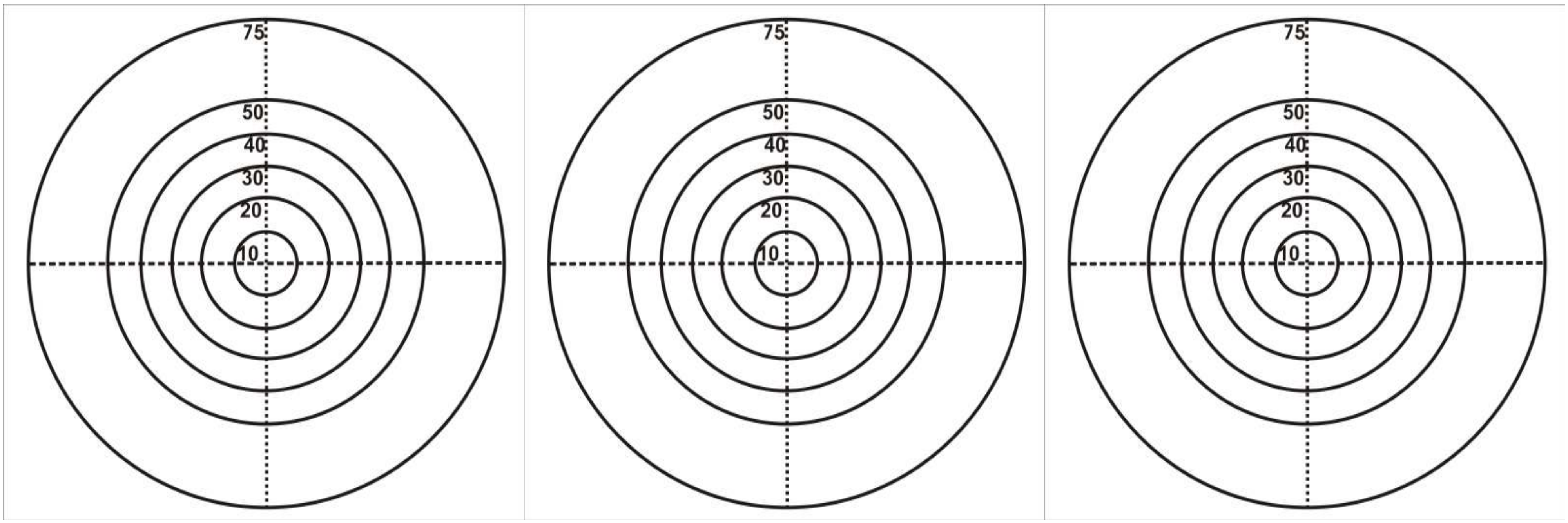
Songbird Pointcount

Project: EA1786 **Survey: Peace River Wildlife Surveys** **Study Area: Peace River, BC**

Pt Cnt Sta Label __________ Stratum __________ UTM **E:**________**N:**_______ Ecosystem Form Type / # ___/________ [Trans Label ______]

Date :____-____-____ **Time: Start ________ End ________ Ceiling _____ CC _____ Wind _____ Precip ______ Temp ______**
dd-mmm-yy

Surveyors____



Time Interval: 0 - 3 minutes **Time Interval: 3 - 5 minutes** **Time Interval: > 5minutes**

Project: **EA1786** **Survey**: **Peace River Wildlife Surveys** **Study Area:** **Peace River, BC**

Pt Cnt Sta Label __________ Stratum __________ UTM **E:**________**N:**_______ Ecosystem Form Type / # ___/________ [Trans Label _____]

Date :____-____-____ Time: Start ________ End ________ Ceiling _____ CC _____ Wind _____ Precip ______ Temp ______
dd-mmm-yy

Surveyors____

Record Observations in Time Intervals of 0-3; 3-5; and > 5 minutes (specify)

Time Interv	Obs #	Spp	Dist to Bird	V/C/S	Sex	Age Class	Activity	Fly-overs	Nest Label / Fm		Comments
0-3		B-									
		B-									
		B-									
		B-									
		B-									
		B-									
		B-									
		B-									
		B-									
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		B-									
		B-									
		B-									
		B-									
		B-									

[Use additional form if additional lines are needed for observations associated with the station labeled at the top of this form.]

Waterfowl: Breeding Pair / Brood / Non-breeding Surveys *Part A*

Project: EA1786 **Survey: Peace River Wildlife Surveys** **Study Area: Peace River, BC**

Date :____-____-____ Ground ☐ Boat ☐ Aerial ☐ Flt Alt ______ Air Spd ______ Grd Spd ______
dd-mmm-yy

(Note: weather information is for 1 station or 1 transect)

Obs Day	Time	CC	Wind / SC	Temp	Precip	Tide
Start						
End						

Surveyors ________________________ **Pilot** ________________________ **Navigator** ________________________

Observation Station Label _________ Stratum ________ BEU______ UTM ____/________/_________

Wetland Survey: ☐ Complete _______ % or ☐ Sampling: Station Area _________

OR

Transect Label_______ **Stratum**_______ **BEU**_______ **Trans Comment**____________________________

Trans: Length_______ **Width**_______ **Bearing**_______ UTM: Start **E:**_______**N:**______ End **E:**_______**N:**______

Transect Segments - use as needed (e.g. for numerous sequential transects along a shoreline)

Sgmt #	Time		Sgmt UTM: Start / End						Sgmt Lgth	Dist from Shore	Comments
	Start	End	Zone	East	North	Zone	East	North			

[Record the observations associated with the station, transect or transect segments listed above on copies of Part B of this form.]

Waterfowl: Breeding Pair / Brood / Non-breeding Surveys *Part B*

Project: EA1786 **Survey: Peace River Wildlife Surveys** **Study Area: Peace River, BC**

Observation Station Label __________ *OR* Transect Label __________

Date :____-____-____ Surveyors______________________________

dd-mmm-yy

Sgmt	Obs	Spp	# Pairs	# Lone			M	Mix Flk			Isol	Imm Grp			Comments
#	#			M	F	UC	Grp	M	F	UC	Pair	M	F	UC	
		B-													
		B-													
		B-													
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		B-													

Appendix III. Complete species list of butterflies found in the study area. Common and scientific names are provided. Names are based primarily on the North American Butterfly Association[a] and the Canadian Biodiversity Information System[b]

Common Name	Scientific Name	Source
Hesperidae: Skippers		
Northern Cloudywing	*Thorybes pylades*	LGL & Kondla et al. 1994
Dreamy Duskywing	*Erynnis icelus*	Kondla et al. 1994
Persius Duskywing	*Erynnis persius*	LGL & Kondla et al. 1994
Arctic Skipper	*Carterocephalus palaemon*	LGL & Kondla et al. 1994
Garita skipperling	*Oarisma garita*	LGL & Kondla et al. 1994
Common Branded Skipper	*Hesperia comma*	LGL
Assiniboia Skipper	*Hesperia assiniboia*	Kondla et al. 1994
Long Dash Skipper	*Polites mystic*	Kondla et al. 1994
Papilionidae: Swallowtails		
Baird's Swallowtail	*Papilio machaon*	LGL & Kondla et al. 1994
Anise Swallowtail	*Papilio zelicaon*	Kondla et al. 1994
Canadian Tiger Swallowtail	*Papilio canadensis*	LGL & Kondla et al. 1994
Western Tiger Swallowtail	*Papilio rutulus*	LGL
Pieridae: Whites and Sulphurs		
Western Checkered White	*Pieris occidentalis*	Kondla et al. 1994
Mustard White	*Pieris napi*	LGL
Cabbage White	*Pieris rapae*	LGL & Kondla et al. 1994
Large Marble	*Euchloe ausonides*	Kondla et al. 1994
Northern Marble	*Euchloe creusa*	Kondla et al. 1994
Clouded Sulphur	*Colias philodice*	LGL & Kondla et al. 1994
Christina's Sulphur	*Colias christina*	LGL & Kondla et al. 1994
Canadian Sulphur	*Colias canadensis*	Kondla et al. 1994
Giant Sulphur	*Colias gigantea*	LGL & Kondla et al. 1994
Pink-edged Sulphur	*Colias interior*	LGL & Kondla et al. 1994
Bronze Copper	*Lycaena hyllus*	LGL
Purplish Copper	*Lycaena helloides*	Kondla et al. 1994
Dorcas Copper	*Lycaena dorcas*	LGL & Kondla et al. 1994
Mariposa Copper	*Lycaena mariposa*	Kondla et al. 1994
Coral Hairstreak	*Satyrium titus*	LGL & Kondla et al. 1994
Striped Hairstreak	*Satyrium liparops*	Kondla et al. 1994
Hoary Elfin	*Callophrys polios*	Kondla et al. 1994
Eastern Pine Elfin	*Callophrys niphon*	Kondla et al. 1994
Western Pine Elfin	*Callophrys eryphon*	Kondla et al. 1994
Western Tailed-blue	*Everes amyntula*	LGL & Kondla et al. 1994
Boreal Spring Azure	*Celastrina ladon lucia*	LGL & Kondla et al. 1994
Silvery Blue	*Glaucopsyche lygdamus*	LGL & Kondla et al. 1994
Northern Blue	*Lycaeides idas*	LGL & Kondla et al. 1994
Greenish Blue	*Plebejus saepiolus*	LGL & Kondla et al. 1994
Rustic Blue	*Agriades glandon*	Kondla et al. 1994
Nymphalidae: Brushfoots		
Great Spangled Fritillary	*Speyeria cybele*	LGL & Kondla et al. 1994
Aphrodite Fritillary	*Speyeris aphrodite*	LGL & Kondla et al. 1994

Northwestern Fritillary	*Speyeria atlantis hesperis*	LGL & Kondla et al. 1994
Atlantis Fritillary	*Speyeria atlantis hollandi*	LGL & Kondla et al. 1994
Mormon Fritillary	*Speyeria mormonia*	LGL & Kondla et al. 1994
Bog Fritillary	*Boloria eunomia*	Kondla et al. 1994
Silver-bordered Fritillary	*Boloria selene*	Kondla et al. 1994
Meadow Fritillary	*Boloria bellona*	LGL & Kondla et al. 1994
Frigga Fritillary	*Boloria frigga*	Kondla et al. 1994
Freija Fritillary	*Boloria freija*	Kondla et al. 1994
Arctic Fritillary	*Boloria chariclea*	LGL & Kondla et al. 1994
Northern Checkerspot	*Chlosyne palla*	Kondla et al. 1994
Pearl Crescent	*Phyciodes tharos*	LGL
Northern Crescent	*Phyciodes selenis*	Kondla et al. 1994
Tawny Crescent	*Phyciodes batesii*	Kondla et al. 1994
Field Crescent	*Phyciodes campestris*	LGL & Kondla et al. 1994
Satyr Angelwing	*Polygonia satyrus*	LGL & Kondla et al. 1994
Green Comma	*Polygonia faunus*	LGL & Kondla et al. 1994
Gray Comma	*Polygonia progne*	Kondla et al. 1994
Compton Tortoiseshell	*Nymphalis vaualbum*	Kondla et al. 1994
Mourning Cloak	*Nymphalis antiopa*	LGL & Kondla et al. 1994
Milbert's Tortoiseshell	*Nymphalis milberti*	LGL & Kondla et al. 1994
Painted Lady	*Vanessa cardui*	LGL & Kondla et al. 1994
Red Admiral	*Vanessa atalanta*	Kondla et al. 1994
White Admiral	*Limenitis arthemis arthemis*	LGL & Kondla et al. 1994
Common Ringlet	*Coenonympha tullia*	LGL
Common Wood-nymph	*Cercyonis pegala*	LGL & Kondla et al. 1994
Small Wood-nymph	*Cercyonis oetus*	LGL & Kondla et al. 1994
Red-disked Alpine	*Erebia discoidalis*	Kondla et al. 1994
Common Alpine	*Erebia epipsodea*	LGL & Kondla et al. 1994
Uhler's Arctic	*Oeneis uhleri*	Kondla et al. 1994
Alberta Arctic	*Oeneis alberta*	Kondla et al. 1994

[a] http://www.naba.org/
[b] http://www.cbif.gc.ca/spp_pages/butterflies/index_e.php

Appendix IV. UTM coordinates for each songbird pointcount station sampled in each stratum during spring 2005 surveys of the Peace River.

SBPC Label	Stratum	UTM_East	UTM_North	SBPC Label	Stratum	UTM_East	UTM_North
001	CORE	575935	621043	SS051	CORE	572275	6213660
BF001	CORE	683444	6223646	SS052	CORE	576172	6218963
BF001W	CORE			SS053	CORE	578068	6239837
BF002	CORE	683613	6223695	SS054	CORE	581761	6219661
BFP	CORE	683700	6224964	SS055	CORE	588439	6225384
Lynx001	CORE	572786	6215519	SS056	CORE	590686	6226732
Maurice002	CORE	566843	6207185	SS057	CORE	572104	6213557
Maurice011	CORE	568271	6208801	SS058	CORE	577871	6219556
NS011	CORE	596423	6231164	SS059	CORE	594741	6229635
NS012	CORE	586330	6223429	SS060	CORE	588078	6224954
NS013	CORE	586541	6223591	SS061	CORE	590978	6226881
NS014	CORE	586707	6223782	SS062	CORE	660977	6219836
NS015	CORE	596856	6223991	SS063	CORE	668531	6220400
NS016	CORE	587039	6224179	SS064	CORE	660782	6219971
NS017	CORE	594556	6229388	SS065	CORE	587923	6224782
NS018	CORE	630018	6229532	SS066	CORE	590099	6226490
NS019	CORE	636523	6230448	SS067	CORE	642619	6223158
NS020	CORE	630225	6229506	SS068	CORE	668729	6220518
NS021	CORE	636409	6230484	SS080	CORE	606282	6233564
NS022	CORE	586012	6223214	SS081	CORE	641822	6224602
NS023	CORE	647609	6223008	SS082	CORE	675910	6219644
NS023A	CORE	585812	6223002	SS084	CORE	680854	6221634
NS024	CORE	585433	6222828	SS085	CORE	680751	6221500
NS025	CORE	585602	6223103	SS086	CORE	676124	6219643
NS026	CORE	585700	6223083	BP001	PERIPHERY	626795	6244967
NS027	CORE	585876	6223160	BP002	PERIPHERY	626928	6244796
NS031	CORE	607127	6236452	BP003	PERIPHERY	627050	6244636
NS033	CORE	598681	6234351	BP004	PERIPHERY	627129	6244457
NS036	CORE	647363	6223129	BP005	PERIPHERY	627268	6244323
NS037A	CORE	638523	6230449	BP006	PERIPHERY	627483	6244099
NS042	CORE	651085	6222867	BP007	PERIPHERY	627643	6243969
NS042A	CORE	576317	6219059	BP008	PERIPHERY	627773	6243815
NS043	CORE	652053	6222275	BP009	PERIPHERY	627799	6243619
NS046	CORE	652293	6222192	BP010	PERIPHERY	627132	6243604
NS053	CORE	682983	6225687	BP011	PERIPHERY	626936	6243593
NS054	CORE	683702	6225313	BP012	PERIPHERY	627119	6243793
NS055	CORE	683602	6225004	BP013	PERIPHERY	627227	6243959
NS056	CORE	684001	6224879	BP014	PERIPHERY	627535	6244294
NS057	CORE	681797	6224288	BP015	PERIPHERY	627701	6244412
NS058	CORE	681294	6224165	BP016	PERIPHERY	627784	6244596
NS078	CORE	662855	6220596	BP017	PERIPHERY	627902	6244758
NS079	CORE	662752	6220784	BP018	PERIPHERY	628026	6244916
SBPC22	CORE	586019	6223210	NS005	PERIPHERY	574776	6233729
SS001	CORE	652674	6221354	NS006	PERIPHERY	579632	6231001
SS002	CORE	653331	6221101	NS028	PERIPHERY	623075	6239985

SS003	CORE	653589	6221139	NS029	PERIPHERY	606890	6235558
SS004	CORE	653855	6221121	NS030	PERIPHERY	607677	6236701
SS005	CORE	654059	6221126	NS032	PERIPHERY	597062	6234888
SS006	CORE	654287	6221061	NS034	PERIPHERY	610300	6260394
SS007	CORE	653139	6221220	NS034A	PERIPHERY	629292	6230465
SS008	CORE	652901	6221243	NS035	PERIPHERY	629057	6230736
SS009	CORE	652450	6221438	NS035A	PERIPHERY	610513	6260263
SS010	CORE	652189	6221438	NS037	PERIPHERY	609865	6259518
SS011	CORE	654537	6220358	NS038	PERIPHERY	609672	6259665
SS012	CORE	654798	6220956	NS044	PERIPHERY	606849	6256253
SS012A	CORE	566936	6206995	NS045	PERIPHERY	606721	6255609
SS013	CORE	654798	6220956	NS050	PERIPHERY	686023	6227850
SS015	CORE	600554	6232740	NS051	PERIPHERY	683243	6227532
SS016	CORE	600741	6233174	NS052	PERIPHERY	683284	6226661
SS017	CORE	606501	6233664	NS059	PERIPHERY	606652	6255457
SS018	CORE	600354	6232599	NS060	PERIPHERY	595630	6235700
SS019	CORE	600882	6233204	NS061	PERIPHERY	592762	6240000
SS020	CORE	634137	6229340	NS062	PERIPHERY	604658	6255091
SS021	CORE			NS063	PERIPHERY	591790	6243794
SS022	CORE	635776	6229957	NS064	PERIPHERY	589265	6247444
SS023	CORE	635963	6230052	NS065	PERIPHERY	604867	6255226
SS024	CORE	615759	6233320	NS070	PERIPHERY	604165	6255176
SS025	CORE	613025	6235709	NS075	PERIPHERY	604134	6255373
SS026	CORE	612836	6235860	NS080	PERIPHERY	633404	6243183
SS027	CORE	613856	6235049	NS081	PERIPHERY	633670	6242912
SS028	CORE	615590	6233508	NS082	PERIPHERY	638806	6239892
SS029	CORE	623928	6233030	NS083	PERIPHERY	603636	6254729
SS030	CORE			NS084	PERIPHERY	663226	6231384
SS032	CORE	626104	6232941	NS086	PERIPHERY	664553	6230725
SS033	CORE	626809	6232558	NS087	PERIPHERY	662297	6226875
SS034	CORE	642006	6224487	NS088	PERIPHERY	603401	6254585
SS035	CORE	624088	6233186	NS095	PERIPHERY	602192	6251096
SS036	CORE	625940	6233011	NS096	PERIPHERY	602367	6250975
SS037	CORE	626586	6232716	NS097	PERIPHERY	601471	6248603
SS038	CORE	622968	6232929	NS098	PERIPHERY	601550	6248425
SS039	CORE	622751	6232709	NS099	PERIPHERY	601538	6248205
SS040	CORE	569769	6210930	NS100	PERIPHERY	601372	6248422
SS041	CORE	572627	6213912	SS070	PERIPHERY	617219	6221744
SS042	CORE	576317	6219059	SS071	PERIPHERY	603582	6216360
SS042A	CORE	572873	6214049	SS072	PERIPHERY	603390	6218310
SS043	CORE	578981	6219562	SS073	PERIPHERY	604695	6224760
SS044	CORE	582089	6219723	SS074	PERIPHERY	608868	6228235
SS045	CORE	582410	6219852	SS075	PERIPHERY	597980	6220990
SS046	CORE	569612	6210760	SS076	PERIPHERY	609058	6218827
SS047	CORE	572873	6214049	SS077	PERIPHERY	614540	6223763
SS048	CORE	576449	6219081	SS078	PERIPHERY	611700	6226158
SS049	CORE	578718	6219543	SS079	PERIPHERY	610832	6224655
SS050	CORE	569393	6210477	NS040	PERIPHERY	606835	6256126

Appendix V. Bird species documented at songbird pointcount locations in the Peace River during spring 2005 surveys.

		Stratum		
Bird Code	**Common Name**	**Core**	**Periphery**	**Total**
B-ALFL	Alder Flycatcher	15	24	39
B-AMCO	American Coot		18	18
B-AMCR	American Crow	29	15	44
B-AMKE	American Kestrel	3		3
B-AMRE	American Redstart	93	34	127
B-AMRO	American Robin	112	96	208
B-BAEA	Bald Eagle	10		10
B-BAOR	Baltimore Oriole	9	11	20
B-BAOW	Barred Owl	1		1
B-BAWW	Black-and-White Warbler	16	7	23
B-BBMA	Black-billed Magpie	20	6	26
B-BCCH	Black-capped Chickadee	45	72	117
B-BEKI	Belted Kingfisher	4	1	5
B-BHCO	Brown-headed Cowbird	22	31	53
B-BHVI	Blue-headed Vireo	13	5	18
B-BKSW	Bank Swallow	4	10	14
B-BLJA	Blue Jay	4	6	10
B-BLTE	Black Tern		2	2
B-BNSW	Barn Swallow		1	1
B-BOCH	Boreal Chickadee	19	3	22
B-BOGU	Bonaparte's Gull	2		2
B-BTNW	Black-throated Green Warbler	39	26	65
B-BUFF	Bufflehead	1	2	3
B-CAGO	Canada Goose	7		7
B-CAWA	Canada Warbler	59	8	67
B-CCSP	Clay-colored Sparrow	9	22	31
B-CEWA	Cedar Waxwing	27	18	45
B-CHSP	Chipping Sparrow	36	48	84
B-CLSW	Cliff Swallow	7		7
B-CMWA	Cape May Warbler		4	4
B-COGO	Common Goldeneye	2		2
B-COME	Common Merganser	2		2
B-CORA	Common Raven	33	23	56
B-COWA	Connecticut Warbler	1	31	32
B-COYE	Common Yellowthroat	16	19	35
B-DEJU	Dark-eyed Junco	53	29	82
B-DOWO	Downy Woodpecker	3	3	6
B-EAPH	Eastern Pheobe		5	5
B-EUST	European Starling	4	6	10
B-EVGR	Evening Grosbeak	1		1
B-FOSP	Fox Sparrow	5	4	9
B-FRGU	Franklin's Gull	1		1
B-GCKI	Golden-crowned Kinglet	13	9	22
B-GHOW	Great-horned Owl		1	1
B-GOLD	Goldeneye species	1		1
B-GRJA	Gray Jay	27	25	52

Bird Code	Common Name	Stratum Core	Stratum Periphery	Total
B-GWTE	Green-winged Teal		1	1
B-HAFL	Hammond's Flycatcher		2	2
B-HAWO	Hairy Woodpecker	8	9	17
B-HETH	Hermit Thrush	29	70	99
B-HOWR	House Wren	9	8	17
B-LCSP	LeConte's Sparrow	4	2	6
B-LEFL	Least Flycatcher	136	107	243
B-LISP	Lincoln's Sparrow	14	61	75
B-MALL	Mallard	2		2
B-MAWR	Marsh Wren		11	11
B-MERL	Merlin	7		7
B-MGNW	Magnolia Warbler	46	2	48
B-MODO	Mourning Dove	6		6
B-MOWA	Mourning Warbler	13		13
B-NOFL	Northern Flicker	7	11	18
B-NOGO	Northern Goshawk	1	1	2
B-NOWA	Northern Waterthrush	7	12	19
B-NPOW	Northern Pygmy-owl	1		1
B-NRWS	Northern Rough-winged Swallow		1	1
B-OCWA	Orange-crowned Warbler	33	18	51
B-OSFL	Olive-sided Flycatcher	2	4	6
B-OSPR	Osprey	1		1
B-OVEN	Ovenbird	87	60	147
B-PBGR	Pied-billed Grebe		3	3
B-PHVI	Philadelphia Vireo	1		1
B-PISI	Pine Siskin	10	9	19
B-PIWO	Pileated Woodpecker	6		6
B-PSFL	Pacific-slope Flycatcher	21	1	22
B-PUFI	Purple Finch	3	7	10
B-RBGR	Rose-breasted Grosbeak	40	26	66
B-RBGU	Ring-billed Gull	3		3
B-RBNU	Red-breasted Nuthatch	6	4	10
B-RCKI	Ruby-crowned Kinglet	21	10	31
B-REVI	Red-eyed Vireo	268	124	392
B-RTHA	Red-tailed Hawk	2	3	5
B-RTHU	Ruby-throated Hummingbird	1		1
B-RUBL	Rusty Blackbird		1	1
B-RUDU	Ruddy Duck		1	1
B-RUGR	Ruffed Grouse	8	1	9
B-RWBL	Red-winged Blackbird	25	90	115
B-SAVS	Savannah Sparrow	11	12	23
B-SORA	Sora		10	10
B-SOSA	Solitary Sandpiper		3	3
B-SOSP	Song Sparrow	45	7	52
B-SPSA	Spotted Sandpiper	20		20
B-SSHA	Sharp-shinned Hawk	6		6
B-SWSP	Swamp Sparrow		11	11
B-SWTH	Swainson's Thrush	180	158	338
B-TEWA	Tennessee Warbler	18	48	66

Bird Code	Common Name	Stratum Core	Periphery	Total
B-TRES	Tree Swallow	1	2	3
B-TRUS	Trumpeter Swan		5	5
B-TTWO	Three-toed Woodpecker	5	1	6
B-UPSA	Upland Sandpiper		3	3
B-VATH	Varied Thrush	2		2
B-VESP	Vesper Sparrow	1	6	7
B-WAVI	Warbling Vireo	47	48	95
B-WBNU	White-breasted Nuthatch		1	1
B-WCSP	White-crowned Sparrow	1		1
B-WETA	Western Tanager	72	38	110
B-WEWP	Western Wood-pewee	8	15	23
B-WISN	Wilson's Snipe	7	22	29
B-WIWA	Wilson's Warbler	1		1
B-WIWR	Winter Wren	2	2	4
B-WTSP	White-throated Sparrow	116	123	239
B-WWCR	White-winged Crossbill	2	3	5
B-YBSA	Yellow-bellied Sapsucker	58	62	120
B-YEWA	Yellow Warbler	152	115	267
B-YRWA	Yellow-rumped Warbler	187	62	249
Total Observations		2538	2042	4580
Total Species		95	88	114

Appendix VI. Total sites and encounter frequencies for the 81 songbird species detected within 75 m of the pointcount center for all sites, only the core, and only the periphery stratum. Blanks indicate that a species was not detected in a particular stratum.

		Strata			Frequency of Occurrence		
Bird Code	Common Name	Core	Periphery	Total	Core	Periphery	All sites
B-ALFL	Alder Flycatcher	5	10	15	4.2%	14.5%	8.0%
B-AMCR	American Crow	6		6	5.1%	0.0%	3.2%
B-AMRE	American Redstart	42	15	57	35.6%	21.7%	30.5%
B-AMRO	American Robin	46	41	87	39.0%	59.4%	46.5%
B-BAOR	Baltimore Oriole	3	7	10	2.5%	10.1%	5.3%
B-BAWW	Black-and-White Warbler	14	5	19	11.9%	7.2%	10.2%
B-BBMA	Black-billed Magpie	5		5	4.2%	0.0%	2.7%
B-BCCH	Black-capped Chickadee	23	30	53	19.5%	43.5%	28.3%
B-BHCO	Brown-headed Cowbird	13	19	32	11.0%	27.5%	17.1%
B-BHVI	Blue-headed Vireo	11	4	15	9.3%	5.8%	8.0%
B-BKSW	Bank Swallow	4	1	5	3.4%	1.4%	2.7%
B-BLJA	Blue Jay	3	3	6	2.5%	4.3%	3.2%
B-BOCH	Boreal Chickadee	13	2	15	11.0%	2.9%	8.0%
B-BTNW	Black-throated Green Warbler	17	11	28	14.4%	15.9%	15.0%
B-BAWW	Black-and-white Warbler	1	2	3	0.8%	2.9%	1.6%
B-CAWA	Canada Warbler	20	5	25	16.9%	7.2%	13.4%
B-CCSP	Clay-colored Sparrow	6	8	14	5.1%	11.6%	7.5%
B-CEWA	Cedar Waxwing	10	12	22	8.5%	17.4%	11.8%
B-CHSP	Chipping Sparrow	26	29	55	22.0%	42.0%	29.4%
B-CLSW	Cliff Swallow	4		4	3.4%	0.0%	2.1%
B-CMWA	Cape May Warbler		3	3	0.0%	4.3%	1.6%
B-CORA	Common Raven	1	2	3	0.8%	2.9%	1.6%
B-COWA	Connecticut Warbler	1	6	7	0.8%	8.7%	3.7%
B-COYE	Common Yellowthroat	7	8	15	5.9%	11.6%	8.0%
B-DEJU	Dark-eyed Junco	40	21	61	33.9%	30.4%	32.6%
B-DOWO	Downy Woodpecker	3	3	6	2.5%	4.3%	3.2%
B-EAPH	Eastern Phoebe		1	1	0.0%	1.4%	0.5%
B-EUST	European Starling	3	1	4	2.5%	1.4%	2.1%
B-EVGR	Evening Grosbeak	1		1	0.8%	0.0%	0.5%
B-FOSP	Fox Sparrow	1		1	0.8%	0.0%	0.5%
B-GCKI	Golden-crowned Kinglet	12	4	16	10.2%	5.8%	8.6%
B-GRJA	Gray Jay	10	14	24	8.5%	20.3%	12.8%
B-HAFL	Hammond's Flycatcher		2	2	0.0%	2.9%	1.1%
B-HAWO	Hairy Woodpecker	7	7	14	5.9%	10.1%	7.5%
B-HETH	Hermit Thrush	7	16	23	5.9%	23.2%	12.3%
B-HOWR	House Wren	3	5	8	2.5%	7.2%	4.3%
B-LCSP	Le Conte's Sparrow	1	1	2	0.8%	1.4%	1.1%
B-LEFL	Least Flycatcher	40	34	74	33.9%	49.3%	39.6%
B-LISP	Lincoln's Sparrow	6	16	22	5.1%	23.2%	11.8%
B-MGNW	Magnolia Warbler	26	2	28	22.0%	2.9%	15.0%
B-MODO	Mourning Dove	4		4	3.4%	0.0%	2.1%
B-MOWA	Mourning Warbler	7		7	5.9%	0.0%	3.7%
B-NOFL	Northern Flicker	5	6	11	4.2%	8.7%	5.9%
B-NOWA	Northern Waterthrush	5	3	8	4.2%	4.3%	4.3%
B-NRWS	Northern Rough-winged Swallow		1	1	0.0%	1.4%	0.5%

		Strata			Frequency of Occurrence		
Bird Code	**Common Name**	**Core**	**Periphery**	**Total**	**Core**	**Periphery**	**All sites**
B-OCWA	Orange-crowned Warbler	19	12	31	16.1%	17.4%	16.6%
B-OSFL	Olive-sided Flycatcher	1		1	0.8%	0.0%	0.5%
B-OVEN	Ovenbird	36	22	58	30.5%	31.9%	31.0%
B-PHVI	Philadelphia Vireo	1		1	0.8%	0.0%	0.5%
B-PISI	Pine Siskin	10	7	17	8.5%	10.1%	9.1%
B-PIWO	Pileated Woodpecker	5		5	4.2%	0.0%	2.7%
B-PSFL	Pacific-slope Flycatcher	16	1	17	13.6%	1.4%	9.1%
B-PUFI	Purple Finch	3	4	7	2.5%	5.8%	3.7%
B-RBGR	Rose-breasted Grosbeak	13	17	30	11.0%	24.6%	16.0%
B-RBNU	Red-breasted Nuthatch	4	3	7	3.4%	4.3%	3.7%
B-RCKI	Ruby-crowned Kinglet	14	9	23	11.9%	13.0%	12.3%
B-REVI	Red-eyed Vireo	82	28	110	69.5%	40.6%	58.8%
B-RTHU	Ruby-throated Hummingbird	1		1	0.8%	0.0%	0.5%
B-RUBL	Rusty Blackbird		1	1	0.0%	1.4%	0.5%
B-RWBL	Red-winged Blackbird	6	9	15	5.1%	13.0%	8.0%
B-SAVS	Savannah Sparrow	4	4	8	3.4%	5.8%	4.3%
B-SOSP	Song Sparrow	15	4	19	12.7%	5.8%	10.2%
B-SWSP	Swamp Sparrow		4	4	0.0%	5.8%	2.1%
B-SWTH	Swainson's Thrush	57	30	4	48.3%	43.5%	2.1%
B-TEWA	Tennessee Warbler	12	26	4	10.2%	37.7%	2.1%
B-TRES	Tree Swallow	1	2	3	0.8%	2.9%	1.6%
B-TTWO	Three-toed Woodpecker	5	1	6	4.2%	1.4%	3.2%
B-VATH	Varied Thrush	2		2	1.7%	0.0%	1.1%
B-VESP	Vesper Sparrow		1	1	0.0%	1.4%	0.5%
B-WAVI	Warbling Vireo	25	26	51	21.2%	37.7%	27.3%
B-WBNU	White-breasted Nuthatch		1	1	0.0%	1.4%	0.5%
B-WCSP	White-crowned Sparrow	1		1	0.8%	0.0%	0.5%
B-WETA	Western Tanager	35	18	53	29.7%	26.1%	28.3%
B-WEWP	Western Wood-pewee	3	7	10	2.5%	10.1%	5.3%
B-WIWA	Wilson's Warbler	1		1	0.8%	0.0%	0.5%
B-WIWR	Winter Wren	2		2	1.7%	0.0%	1.1%
B-WTSP	White-throated Sparrow	28	28	56	23.7%	40.6%	29.9%
B-WWCR	White-winged Crossbill	2	3	5	1.7%	4.3%	2.7%
B-YBSA	Yellow-bellied Sapsucker	34	25	59	28.8%	36.2%	31.6%
B-YEWA	Yellow Warbler	57	31	88	48.3%	44.9%	47.1%
B-YRWA	Yellow-rumped Warbler	71	31	102	60.2%	44.9%	54.5%

Appendix VII. Species detection by habitat types and number of pointcount locations within each habitat type for the core [C] and periphery [P] study strata sampled in spring 2005. Bold and shaded cells indicate Red- or Blue-listed songbird species.

	Habitat Code																
	2		3		4		5		9		10		Habitat Types		Total Sites		
Species Code	C	P	C	P	C	P	C	P	C	P	C	P	Core	Periphery	Core	Periphery	Total
B-ALFL		1	1		1	2		6	2	1	1		4	4	5	10	15
B-AMCR	1						1		2		2		4		6		6
B-AMMA					1		3		1				3		5		5
B-AMRE	12	4			4	3	12	7	11	1	3		5	4	42	15	57
B-AMRO	11	10	1		11	7	10	20	9	2	4	2	6	5	46	41	87
B-BAOR	1	2				1	1	3	1	1			3	4	3	7	10
B-BAWW	4	1			2	2	2	2	5		1		5	3	14	5	19
B-BCCH	5	4			8	6	6	18	2	2	2		5	4	23	30	53
B-BHCO	4	8			1	4	2	6	5	1	1		5	4	13	19	32
B-BHVI		1			6		2	2	2		1	1	4	3	11	4	15
B-BKSW	1	1					3						2	1	4	1	5
B-BLJA					2	2	1	1					2	2	3	3	6
B-BOCH	2				8	1	3	1					3	2	13	2	15
B-BTNW	**1**	**1**			**7**	**3**	**9**	**6**				**1**	**3**	**4**	**17**	**11**	**28**
B-BWWA	1							2					1	1	1	2	3
B-CAWA	**3**				**7**		**3**	**4**	**7**			**1**	**4**	**2**	**20**	**5**	**25**
B-CCSP	1	4						1	3	3	2		3	3	6	8	14
B-CEWA	3	1			1	2	1	7	4	2	1		5	4	10	12	22
B-CHSP	3	5			7	6	6	16	9	1	1	1	5	5	26	29	55
B-CLSW			1				1		1		1		4		4		4
B-CMWA						**2**						**1**		**2**		**3**	**3**
B-CORA			1					2					1	1	1	2	3
B-COWA		**2**						**4**	**1**				**1**	**2**	**1**	**6**	**7**
B-COYE		1	1		1	1		5	3	1	2		4	4	7	8	15
B-DEJU	7	1	1		14	5	10	14	4		4	1	6	4	40	21	61
B-DOWO	1	1			1			2	1				3	2	3	3	6
B-EAPH										1				1		1	1

	Habitat Code																
	2		3		4		5		9		10		Habitat Types		Total Sites		
Species Code	**C**	**P**	**C**	**P**	**C**	**P**	**C**	**P**	**C**	**P**	**C**	**P**	**Core**	**Periphery**	**Core**	**Periphery**	**Total**
B-EUST			1				1		1	1			3	1	3	1	4
B-EVGR											1		1		1		1
B-FOSP									1				1		1		1
B-GCKI					10	2		2			2		2	2	12	4	16
B-GRJA					3	2	6	12			1		3	2	10	14	24
B-HAFL						1		1						2		2	2
B-HAWO	1	2			2	1	3	3	1	1			4	4	7	7	14
B-HETH	2	3			1	1	2	11		1	2		4	4	7	16	23
B-HOWR	2	1				1			1	3			2	3	3	5	8
B-LCSP			**1**							**1**			**1**	**1**	**1**	**1**	**2**
B-LEFL	19	15	1		2	2	8	15	9	2	1		6	4	40	34	74
B-LISP	1	2			1	3		9	4	2			3	4	6	16	22
B-MGNW	6	1			7	1	8		2		3		5	2	26	2	28
B-MODO	3				1								2		4		4
B-MOWA	2				1		3		1				4		7		7
B-NOFL	2	1			2		1	4		1			3	3	5	6	11
B-NOWA	1				2			3	2				3	1	5	3	8
B-NRWS								1						1		1	1
B-OCWA	3	1			3	3	6	7	7	1			4	4	19	12	31
B-OSFL											1		1		1		1
B-OVEN	5	7			8	3	13	11	8		2	1	5	4	36	22	58
B-PHVI							**1**						**1**		**1**		**1**
B-PISI	3	3			4	3	2	1	1				4	3	10	7	17
B-PIWO					1		3		1				3		5		5
B-PSFL	2	1			4		5		4		1		5	1	16	1	17
B-PUFI	1	1			1	1	1	2					3	3	3	4	7
B-RBGR	4	6				2	2	8	7	1			3	4	13	17	30
B-RBNU					2	2	2	1					2	2	4	3	7
B-RCKI					6	4	5	5	1		2		4	2	14	9	23
B-REVI	20	6	1		18	6	20	14	14	1	9	1	6	5	82	28	110

	Habitat Code																
	2		3		4		5		9		10		Habitat Types		Total Sites		
Species Code	**C**	**P**	**C**	**P**	**C**	**P**	**C**	**P**	**C**	**P**	**C**	**P**	**Core**	**Periphery**	**Core**	**Periphery**	**Total**
B-RTHU									1				1		1		1
B-RUBL								1						1		1	1
B-RWBL		2					1	6	5	1			2	3	6	9	15
B-SAVS		2	1						3	2			2	2	4	4	8
B-SOSP	1	1	2		2	1	1		6	2	3		6	3	15	4	19
B-SWSP						1		3						2		4	4
B-TRES						1	1	1					1	2	1	2	3
B-TTWO					5	1							1	1	5	1	6
B-VATH					2								1		2		2
B-VESP		1												1		1	1
B-WAVI	6	6			4	2	1	15	11	2	3	1	5	5	25	26	51
B-WBNU						1								1		1	1
B-WCSP									1				1		1		1
B-WETA	5	2			12	3	11	11	4	1	3	1	5	5	35	18	53
B-WEWP	2	3				1		2	1	1			2	4	3	7	10
B-WIWA									1				1		1		1
B-WIWR					1						1		2		2		2
B-WTSP	10	8	1		5	2	6	16	5	1	1	1	6	5	28	28	56
B-WWCR					2	1		2					1	2	2	3	5
B-YBSA	6	6			7	3	7	15	11		3	1	5	4	34	25	59
B-YEWA	18	13	1		5	3	13	12	17	3	3		6	4	57	31	88
B-YRWA	14	1			24	9	21	19	6	1	6	1	5	5	71	31	102
Count of Species	42	42	14		48	45	46	51	49	31	33	14			71	64	79

Appendix VIII. Relative abundance for each species documented in the core and periphery strata during spring 2005 surveys of the Peace River project area. Shading indicates higher relative abundance for that species and habitat type.

	Habitat Code									
	2		3		4		5		9	
Common Name	C[1]	P[1]	C	P[2]	C	P	C	P	C	P
Alder Flycatcher	0.000	0.071	0.750		0.010	0.065	0.000	0.067	0.038	0.150
American Crow	0.012	0.000	0.000		0.000	0.000	0.010	0.000	0.063	0.000
American Redstart	0.366	0.157	0.000		0.042	0.174	0.309	0.104	0.329	0.050
American Robin	0.329	0.286	0.125		0.208	0.326	0.165	0.299	0.266	0.250
Baltimore Oriole	0.037	0.029	0.000		0.000	0.022	0.010	0.037	0.038	0.100
Black-and-White Warbler	0.049	0.014	0.000		0.021	0.043	0.031	0.015	0.063	0.000
Black-billed Magpie	0.000	0.000	0.000		0.021	0.000	0.082	0.000	0.025	0.000
Black-capped Chickadee	0.110	0.143	0.000		0.135	0.283	0.124	0.351	0.063	0.100
Brown-headed Cowbird	0.073	0.229	0.000		0.021	0.087	0.041	0.075	0.114	0.050
Blue-headed Vireo	0.000	0.014	0.000		0.073	0.000	0.031	0.015	0.025	0.000
Bank Swallow	0.012	0.143	0.000		0.000	0.000	0.031	0.000	0.000	0.000
Blue Jay	0.000	0.000	0.000		0.031	0.109	0.010	0.007	0.000	0.000
Barn Swallow	0.000	0.000	0.000		0.000	0.000	0.000	0.000	0.000	0.000
Boreal Chickadee	0.024	0.000	0.000		0.135	0.043	0.041	0.007	0.000	0.000
Black-throated Green Warbler	0.012	0.014	0.000		0.135	0.174	0.144	0.067	0.000	0.000
Black-and-White Warbler	0.012	0.000	0.000		0.000	0.000	0.000	0.015	0.000	0.000
Canada Warbler	0.098	0.000	0.000		0.125	0.000	0.093	0.052	0.101	0.000
Clay-colored Sparrow	0.012	0.171	0.000		0.000	0.000	0.000	0.015	0.038	0.400
Cedar Waxwing	0.146	0.014	0.000		0.010	0.043	0.021	0.075	0.127	0.100
Chipping Sparrow	0.037	0.100	0.000		0.083	0.217	0.082	0.201	0.165	0.050
Cliff Swallow	0.000	0.000	0.250		0.000	0.000	0.010	0.000	0.025	0.000
Cape May Warbler	0.000	0.000	0.000		0.000	0.043	0.000	0.000	0.000	0.000
Common Raven	0.000	0.000	0.125		0.000	0.000	0.000	0.015	0.000	0.000
Connecticut Warbler	0.000	0.057	0.000		0.000	0.000	0.000	0.060	0.013	0.000
Common Yellowthroat	0.000	0.014	0.750		0.010	0.022	0.000	0.097	0.051	0.200
Dark-eyed Junco	0.098	0.029	0.125		0.167	0.196	0.155	0.127	0.076	0.000
Downy Woodpecker	0.012	0.014	0.000		0.010	0.000	0.000	0.015	0.013	0.000
Eastern Phoebe	0.000	0.000	0.000		0.000	0.000	0.000	0.000	0.000	0.150
European Starling	0.000	0.000	0.250		0.000	0.000	0.010	0.000	0.013	0.250
Evening Grosbeak	0.000	0.000	0.000		0.000	0.000	0.000	0.000	0.000	0.000
Fox Sparrow	0.000	0.000	0.000		0.000	0.000	0.000	0.000	0.025	0.000
Golden-crowned Kinglet	0.000	0.000	0.000		0.104	0.109	0.000	0.030	0.000	0.000
Gray Jay	0.000	0.000	0.000		0.073	0.065	0.175	0.157	0.000	0.000
Hammond's Flycatcher	0.000	0.000	0.000		0.000	0.022	0.000	0.007	0.000	0.000
Hairy Woodpecker	0.012	0.029	0.000		0.021	0.022	0.031	0.030	0.013	0.050
Hermit Thrush	0.037	0.143	0.000		0.021	0.065	0.021	0.149	0.000	0.050
House Wren	0.061	0.029	0.000		0.000	0.022	0.000	0.000	0.013	0.200
Le Conte's Sparrow	0.000	0.000	0.500		0.000	0.000	0.000	0.000	0.000	0.100
Least Flycatcher	0.780	0.829	0.125		0.073	0.065	0.247	0.306	0.418	0.200
Lincoln's Sparrow	0.012	0.157	0.000		0.010	0.130	0.000	0.187	0.089	0.600
Marsh Wren	0.000	0.000	0.000		0.000	0.000	0.000	0.000	0.000	0.000
Magnolia Warbler	0.159	0.014	0.000		0.104	0.022	0.155	0.000	0.038	0.000
Mourning Dove	0.049	0.000	0.000		0.010	0.000	0.000	0.000	0.000	0.000

	Habitat Code 2		3		4		5		9	
Common Name	**C[1]**	**P[1]**	**C**	**P[2]**	**C**	**P**	**C**	**P**	**C**	**P**
Mourning Warbler	0.049	0.000	0.000		0.010	0.000	0.062	0.000	0.025	0.000
Northern Flicker	0.024	0.014	0.000		0.021	0.000	0.010	0.037	0.000	0.050
Northern Waterthrush	0.012	0.000	0.000		0.021	0.000	0.000	0.030	0.038	0.000
Northern Rough-winged Swallow	0.000	0.000	0.000		0.000	0.000	0.000	0.007	0.000	0.000
Orange-crowned Warbler	0.073	0.014	0.000		0.031	0.130	0.124	0.067	0.139	0.050
Olive-sided Flycatcher	0.000	0.000	0.000		0.000	0.000	0.000	0.000	0.000	0.000
Ovenbird	0.110	0.200	0.000		0.146	0.087	0.289	0.179	0.291	0.000
Philadelphia Vireo	0.000	0.000	0.000		0.000	0.000	0.010	0.000	0.000	0.000
Pine Siskin	0.037	0.043	0.000		0.042	0.087	0.021	0.015	0.013	0.000
Pileated Woodpecker	0.000	0.000	0.000		0.010	0.000	0.031	0.000	0.013	0.000
Pacific-slope Flycatcher	0.049	0.014	0.000		0.063	0.000	0.062	0.000	0.051	0.000
Purple Finch	0.012	0.014	0.000		0.010	0.022	0.010	0.037	0.000	0.000
Rose-breasted Grosbeak	0.061	0.100	0.000		0.000	0.065	0.021	0.075	0.127	0.100
Red-breasted Nuthatch	0.000	0.000	0.000		0.021	0.065	0.031	0.007	0.000	0.000
Ruby-crowned Kinglet	0.000	0.000	0.000		0.104	0.087	0.062	0.045	0.013	0.000
Red-eyed Vireo	0.829	0.300	0.375		0.354	0.239	0.598	0.284	0.633	0.150
Ruby-throated Hummingbird	0.000	0.000	0.000		0.000	0.000	0.000	0.000	0.013	0.000
Rusty Blackbird	0.000	0.000	0.000		0.000	0.000	0.000	0.007	0.000	0.000
Red-winged Blackbird	0.000	0.029	0.000		0.000	0.000	0.031	0.425	0.165	1.100
Savannah Sparrow	0.000	0.129	0.625		0.000	0.000	0.000	0.000	0.063	0.100
Song Sparrow	0.012	0.014	1.000		0.021	0.022	0.010	0.000	0.139	0.200
Swamp Sparrow	0.000	0.000	0.000		0.000	0.043	0.000	0.067	0.000	0.000
Swainson's Thrush	0.341	0.243	0.000		0.427	0.326	0.423	0.403	0.241	0.600
Tennessee Warbler	0.037	0.043	0.000		0.042	0.217	0.052	0.231	0.025	0.000
Tree Swallow	0.000	0.000	0.000		0.000	0.022	0.010	0.007	0.000	0.000
Three-toed Woodpecker	0.000	0.000	0.000		0.052	0.022	0.000	0.000	0.000	0.000
Varied Thrush	0.000	0.000	0.000		0.021	0.000	0.000	0.000	0.000	0.000
Vesper Sparrow	0.000	0.029	0.000		0.000	0.000	0.000	0.000	0.000	0.000
Warbling Vireo	0.122	0.114	0.000		0.042	0.043	0.010	0.179	0.278	0.300
White-breasted Nuthatch	0.000	0.000	0.000		0.000	0.022	0.000	0.000	0.000	0.000
White-crowned Sparrow	0.000	0.000	0.000		0.000	0.000	0.000	0.000	0.013	0.000
Western Tanager	0.073	0.029	0.000		0.208	0.217	0.206	0.112	0.139	0.050
Western Wood-pewee	0.061	0.057	0.000		0.000	0.043	0.000	0.037	0.013	0.200
Wilson's Warbler	0.000	0.000	0.000		0.000	0.000	0.000	0.000	0.013	0.000
Winter Wren	0.000	0.000	0.000		0.010	0.000	0.000	0.000	0.000	0.000
White-throated Sparrow	0.293	0.429	0.125		0.063	0.109	0.206	0.246	0.228	0.100
White-winged Crossbill	0.000	0.000	0.000		0.021	0.022	0.000	0.015	0.000	0.000
Yellow-bellied Sapsucker	0.098	0.100	0.000		0.135	0.109	0.144	0.284	0.190	0.000
Yellow Warbler	0.500	0.814	0.250		0.094	0.087	0.247	0.284	0.759	0.400
Yellow-rumped Warbler	0.317	0.014	0.000		0.760	0.413	0.680	0.284	0.165	0.050

[1] C = Core; P = Periphery. [2] Habitat type not represented in periphery stratum.

Appendix IX.Species of vascular plants documented from the Peace River study area in 2005.

Vascular Plants: Scientific Name	
Achillea sibirica	*Impatiens noli-tangere*
Achnatherum nelsonii	*Juncus alpinoarticulatus*
Achnatherum richardsonii	*Juncus articulatus*
Actaea rubra	*Juncus balticus*
Adoxa moschatellina	*Juncus bufonius*
Agrostis exarata	*Juncus confusus*
Agrostis gigantea	*Juncus effusus*
Agrostis scabra	*Juncus nodosus*
Agrostis stolonifera	*Juncus tenuis*
Allium cernuum	*Juncus vaseyi*
Allium schoenoprasum	*Juniperus communis*
Alnus incana subsp. tenuifolia	*Juniperus horizontalis*
Alnus viridis s.l	*Kochia scoparia*
Alopecurus aequalis	*Koeleria macrantha*
Amelanchier alnifolia	*Lactuca pulchella*
Amerorchis rotundifolia	*Lappula squarrosa*
Anaphalis margaritacea	*Larix laricina*
Androsace septentrionalis	*Lathyrus ochroleucus*
Anemone multifida	*Ledum groenlandicum*
Anemone patens	*Lemna minor*
Anemone virginiana var. cylindroidea	*Lemna trisulca*
Antennaria neglecta	*Lepidium densiflorum*
Antennaria parvifolia	*Leymus innovatus*
Antennaria pulcherrima	*Limosella aquatica*
Antennaria umbrinella	*Linaria genistifolia*
Apera interrupta	*Linaria vulgaris*
Apocynum androsaemifolium	*Linnaea borealis*
Aquilegia brevistyla	*Linum lewisii*
Arabis drummondii	*Lithospermum incisum*
Arabis glabra	*Lolium perenne*
Arabis holboellii var. retrofracta	*Lonicera dioica*
Arabis lignifera	*Lonicera involucrata*
Arabis x divaricarpa	*Lonicera tatarica*
Aralia nudicaulis	*Lotus corniculatus*
Arctagrostis latifolia	*Lycopus uniflorus*
Arctostaphylos uva-ursi	*Maianthemum canadense*
Arnica chamissonis subsp. incana	*Maianthemum racemosum*
Arnica chamissonis subsp. incana?	*Maianthemum stellatum*
Arnica chamissonis	*Maianthemum trifolium*
Artemisia biennis	*Matricaria discoidea*
Artemisia campestris	*Matricaria perforata*
Artemisia dracunculus	*Medicago lupulina*
Artemisia frigida	*Medicago sativa*
Artemisia longifolia	*Melilotus alba*
Aster borealis	*Melilotus officinalis*

Vascular Plants: Scientific Name	
Aster ciliolatus	*Mentha arvensis*
Aster conspicuus	*Mertensia paniculata*
Aster ericoides subsp. pansus	*Mitella nuda*
Aster laevis var. geyeri	*Moehringia lateriflora s.n.*
Aster lanceolatus	*Monarda fistulosa*
Aster modestus	*Moneses uniflora*
Aster occidentalis	*Monotropa hypopithys*
Aster sibiricus	*Monotropa uniflora*
Aster subspicatus	*Myriophyllum sibiricum*
Astragalus agrestis	*Myriophyllum verticillatum*
Astragalus alpinus	*Opuntia fragilis*
Astragalus americanus	*Orobanche fasciculata*
Astragalus cicer	*Orthilia secunda*
Astragalus eucosmus	*Orthocarpus luteus*
Astragalus tenellus	*Oryzopsis asperifolia*
Athyrium filix-femina	*Osmorhiza depauperata*
Atriplex nuttallii	*Oxytropis campestris var. cusickii*
Axyris amaranthoides	*Oxytropis deflexa*
Beckmannia syzigachne	*Oxytropis jordalii subsp. davisii*
Betula nana subsp. glandulosa	*Oxytropis maydelliana*
Betula papyrifera	*Oxytropis sericea*
Betula pumila	*Oxytropis splendens*
Bidens cernua	*Parnassia palustris*
Botrychium crenulatum	*Pascopyrum smithii*
Botrychium lunaria	*Penstemon gracilis*
Botrychium virginianum	*Petasites frigidus*
Bromus ciliatus	*Petasites sagittatus*
Bromus inermis	*Phalaris arundinacea*
Calamagrostis canadensis	*Phleum pratense*
Calamagrostis montanensis	*Picea glauca*
Calamagrostis stricta	*Picea mariana*
Callitriche palustris	*Pinus contorta*
Capsella bursa-pastoris	*Piptatherum pungens*
Caragana arborescens	*Plantago major*
Carex aquatilis	*Platanthera aquilonis*
Carex atherodes	*Platanthera obtusata*
Carex athrosquamma	*Platanthera orbiculata*
Carex aurea	*Platanthera stricta*
Carex canescens	*Poa alpina*
Carex capillaris	*Poa compressa*
Carex concinnoides	*Poa palustris*
Carex crawfordii	*Poa pratensis*
Carex deweyana?	*Poa secunda s.l.*
Carex diandra	*Poa sp.*
Carex disperma	*Poa trivialis*
Carex duriuscula	*Polemonium boreale*
Carex eburnea	*Polygonum achoreum*
Carex filifolia	*Polygonum amphibium*
Carex foenea	*Polygonum aviculare*

Vascular Plants: Scientific Name	
Carex garberi	*Polygonum douglasii*
Carex gynocrates	*Polygonum lapathifolium*
Carex heliophila	*Populus balsamifera*
Carex laeviculmis	*Populus tremuloides*
Carex lanuginosa	*Potamogeton foliosus*
Carex lenticularis var. limnaphila	*Potamogeton pusillus = P. berchtoldii*
Carex macloviana	*Potamogeton richardsonii*
Carex magellanica	*Potentilla anserina*
Carex obtusata	*Potentilla argentea*
Carex pachystachya	*Potentilla arguta*
Carex praegracilis	*Potentilla glandulosa*
Carex prairea	*Potentilla gracilis*
Carex retrorsa	*Potentilla hippiana*
Carex richardsonii	*Potentilla norvegica*
Carex rossii	*Potentilla pensylvanica*
Carex scirpoidea subsp. pseudoscirpoidea	*Prosartes trachycarpa*
Carex sect. Montanae	*Prunella vulgaris*
Carex stipata	*Prunus emarginata*
Carex supina	*Prunus virginiana*
Carex tenuiflora	*Puccinellia distans*
Carex torreyi	*Pyrola asarifolia*
Carex tracyi	*Pyrola chlorantha*
Carex umbellata	*Pyrola minor*
Carex utriculata	*Ranunculus aquatilis s.l.*
Carex vaginata	*Ranunculus cymbalaria*
Carex xerantica	*Ranunculus gmelinii*
Castilleja rhexiifolia	*Ranunculus macounii*
Cerastium arvense	*Ranunculus pensylvanicus*
Cerastium beeringianum	*Ranunculus sceleratus*
Cerastium fontanum	*Ranunculus subrigidus*
Ceratophyllum demersum	*Rhinanthus minor*
Chenopodium album	*Ribes hudsonianum*
Chenopodium atrovirens	*Ribes oxyacanthoides*
Chenopodium desiccatum	*Ribes triste*
Chenopodium hybridum	*Rorippa palustris*
Chenopodium salinum	*Rosa acicularis*
Cicuta douglasii	*Rosa gymnocarpa*
Cinna latifolia	*Rubus idaeus*
Circaea alpina	*Rubus pubescens*
Cirsium arvense	*Rumex aquaticus*
Cirsium drummondii	*Rumex maritimus*
Clematis occidentalis	*Rumex salicifolius*
Coeloglossum viride	*Sagittaria cuneata*
Collomia linearis	*Salix amygdaloides*
Comandra umbellata	*Salix barclayi*
Comarum palustre	*Salix bebbiana*
Corallorhiza maculata	*Salix commutata*
Corallorhiza trifida	*Salix discolor*
Cornus canadensis	*Salix drummondiana*

Vascular Plants: Scientific Name
Cornus stolonifera
Corylus cornuta
Crepis tectorum
Cypripedium passerinum
Danthonia intermedia
Delphinium glaucum
Deschampsia cespitosa
Dracocephalum parviflorum
Dryas drummondii
Dryopteris carthusiana
Elaeagnus commutata
Eleocharis acicularis
Eleocharis tenuis
Elymus canadensis
Elymus hirsutus
Elymus lanceolatus
Elymus repens
Elymus trachycaulus
Epilobium angustifolium
Epilobium ciliatum subsp. glandulosum
Epilobium leptophyllum
Epilobium saximontanum
Equisetum arvense
Equisetum arvense x Equisetum fluviatile
Equisetum fluviatile
Equisetum hyemale
Equisetum scirpoides
Equisetum sylvaticum
Equisetum variegatum
Erigeron caespitosus
Erigeron glabellus
Erigeron philadelphicus
Erigeron speciosus?
Erigeron subtrinervis
Fagopyrum esculentum
Festuca rubra
Festuca saximontana
Fragaria vesca
Fragaria virginiana
Galium boreale
Galium trifidum
Galium triflorum
Gentianella amarella
Geocaulon lividum
Geum aleppicum
Geum triflorum
Glyceria grandis
Glyceria pulchella
Glyceria striata
Salix exigua
Salix lucida
Salix maccalliana
Salix monticola
Salix myrtillifolia
Salix planifolia
Salix serissima
Sanicula marilandica
Schizachne purpurascens
Schizachyrium scoparium
Schoenoplectus tabernaemontani
Scirpus microcarpus
Scutellaria galericulata
Sedum lanceolatum
Selaginella rupestris
Senecio eremophilus
Senecio pauciflorus
Senecio pauperculus
Senecio streptanthifolius
Silene drummondii
Sisyrinchium montanum
Solidago canadensis
Solidago spathulata
Sonchus asper
Sparganium emersum
Spartina gracilis
Spiraea betulifolia
Spiranthes romanzoffiana
Stachys palustris
Stellaria longifolia
Stuckenia filiformis?
Stuckenia pectinata
Symphoricarpos albus
Symphoricarpos occidentalis
Taraxacum officinale
Thalictrum venulosum
Thlaspi arvense
Torreyochloa pallida
Tragopogon pratensis
Trientalis europaea subsp. arctica
Trifolium dubium
Trifolium hybridum
Trifolium pratense
Trimorpha debilis
Trisetum spicatum
Typha latifolia
Urtica dioica
Utricularia macrorhiza
Verbascum thapsus

Vascular Plants: Scientific Name	
Goodyera repens	*Veronica anagallis-aquatica*
Grindelia squarrosa var. quasiperennis	*Veronica peregrina*
Gymnocarpium disjunctum	*Veronica scutellata*
Hedysarum boreale	*Viburnum edule*
Helictotrichon hookeri	*Vicia americana*
Heracleum maximum	*Viola adunca*
Hesperostipa curtiseta	*Viola canadensis*
Heuchera richardsonii	*Viola palustris*
Hieracium umbellatum	*Viola renifolia*
Hierochloë hirta	*Woodsia oregana*
Hippuris vulgaris	*Zizia aptera*
Hordeum jubatum	

Appendix X. TEM attribute – habitat model variable relationships

1. Introduction

Habitat variables are required to establish the Habitat Suitability Index (HSI) models. To establish a relationship between the required habitat variables and available TEM data (Table 1), several assumptions had to be made. Table 56 outlines the rationale for each assumption and relationship.

Table 56. TEM attributes related to habitat model variable by species.

Species	TEM Ecosystem Unit (EU)	TEM Structural Stage	TEM Modifers
BTNW	% Sw in tree canopy	stand age	
CAMA	% Sw in tree canopy	stand age	
CAWA	% tall shrub understorey cover	stand age	slope
	% deciduous in tree canopy		floodplain
COWA	% herbaceous understorey cover	stand age	
	% trembling aspen in tree canopy		
PHVI	% tree canopy closure	stand age	
	% deciduous in tree canopy		
BOOW	% nest tree* species in tree canopy	stand age	
	% weighted conifer species** in tree canopy	density of large trees	
BAOW	% nest tree* species in tree canopy	stand age	
	% spruce (Sw, Sb) and fir in tree canopy	density of large trees	

* trembling aspen, balsam poplar, white spruce
** black and white spruce, balsam fir and lodgepole pine

2. Species Composition

Data available for analyses include the VPro data provided by Keystone and includes percent presence and percent cover. Percent presence is the proportion of sample plots containing a particular plant and percent cover the proportion of the plot covered by the foliage of each species. From this the percent cover and prominence value was calculated for the following categories: tall shrubs, herbaceous layer, deciduous component, and individual tree species (Sw, Pl, At, Ep, Act, Sb and Lt).

Category	Percent Cover	Prominence Value
Tall Shrubs	The Average % Cover for tall shrubs is calculated by adding the percent cover of each tall shrub species. This may be an overestimate since the overall % tall shrub cover in not necessarily additive of the individual species, i.e. this method does not	Prominence values were calculated by multiplying a species mean percent cover by the square root of its percent presence.

Category	Percent Cover	Prominence Value
	account for overlap between species. Possible bias towards overestimating percent shrub cover per site series.	
Herbaceous Layer	The Average % Cover for herbs is calculated by adding the percent cover of each herb species. This may be an overestimate since the overall % herb cover in not necessarily additive of the individual species, i.e. this method does not account for overlap between species. Possible bias towards overestimating percent herb per site series.	Prominence values were calculated by multiplying a species mean percent cover by the square root of its percent presence.
Deciduous in Tree Canopy	Deciduous species include Ep, At and Act. The percent cover was obtained from VPro data for each site series. Percent covers were transformed to percent canopy closure according to assumptions below in section 3b.	Prominence values were calculated by multiplying a species mean percent cover by the square root of its percent presence.
At in Tree Canopy	The percent cover was obtained from VPro data for each site series. Percent cover was transformed to percent canopy closure according to assumptions below in section 3b.	Prominence values were calculated by multiplying a species mean percent cover by the square root of its percent presence.
Sw in Tree Canopy	The percent cover was obtained from VPro data for each site series. Percent cover was transformed to percent canopy closure according to assumptions below in section 3b.	Prominence values were calculated by multiplying a species mean percent cover by the square root of its percent presence.
Sb in Tree Canopy	The percent cover was obtained from VPro data for each site series. Percent cover was transformed to percent canopy closure according to assumptions below in section 3b.	Prominence values were calculated by multiplying a species mean percent cover by the square root of its percent presence.
Bl in Tree Canopy	The percent cover was obtained from VPro data for each site series. Percent cover was transformed to percent canopy closure according to assumptions below in section 3b.	Prominence values were calculated by multiplying a species mean percent cover by the square root of its percent presence.
Pl in Tree Canopy	The percent cover was obtained from VPro data for each site series. Percent cover was transformed to percent canopy closure according to assumptions below in section 3b.	Prominence values were calculated by multiplying a species mean percent cover by the square root of its percent presence.

Model variables for percent tall shrub and percent herbaceous understorey cover were determined as follows:

1. The average % cover in an ecosystem unit was determined.
2. The average % cover was used to determine the values for model variables of percent tall shrub and percent herbaceous understorey cover.

Model variables for percentages of tree species in the tree canopy were determined using the following steps:

1. The estimated percentage of canopy closure for each tree species in an ecosystem unit was determined.
2. The **total** estimated percentage of canopy closure in an ecosystem unit was calculated by summing the estimated percentage of canopy closure for the tree species in that ecosystem unit.
3. The **proportion** of the total canopy cover for each tree species in an ecosystem unit was calculated by dividing the estimated percentage of canopy closure for the tree species by the **total** estimated percentage of canopy cover for that ecosystem unit.
4. The **proportion** of the total canopy cover for each tree species in an ecosystem unit was then used to determine the values of model variables for the percentage of tree species in the tree canopy.

3. Structural

Structural features are important habitat variables that need to be quantified per site unit and was based on structural stage and site index. The following structural components where included: likelihood of large live and/or dead trees, percent canopy closure, likelihood of tall trees and stand age.

<table>
<tr><th>Category</th><th>Rationale</th></tr>
<tr><td>a. Likelihood of Large Live and/or Dead Trees</td><td>Site Index (SI) relates to site productivity (SIBEC RDM Version: March 2005) and therefore to diameter at breast height (dbh) and height (ht.). The table below is the SI value for certain tree species in the BWBSmw1 subzone.
<table>
<tr><th>Code</th><th>Site Series</th><th>At</th><th>Pl</th><th>Sw</th><th>Sb</th></tr>
<tr><td>AM</td><td>01</td><td>18</td><td>18</td><td>17</td><td></td></tr>
<tr><td>LL</td><td>02</td><td></td><td>12</td><td>9</td><td></td></tr>
<tr><td>SW</td><td>03</td><td>17</td><td>18</td><td>17</td><td></td></tr>
<tr><td>BL</td><td>04</td><td></td><td>15</td><td>12</td><td>9</td></tr>
<tr><td>SO</td><td>05</td><td></td><td>18</td><td>18</td><td>15</td></tr>
<tr><td>SC</td><td>06</td><td>17</td><td>18</td><td>18</td><td></td></tr>
<tr><td>SH</td><td>07</td><td></td><td>18</td><td>18</td><td></td></tr>
<tr><td>BT</td><td>08</td><td></td><td>12</td><td>9</td><td>9</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>
A four class rating system was arbitrarily assigned in relation to SI values, given that the maximum SI value is 18 for the BWBSmw1 subzone, this arbitrarily becomes a high rating.</td></tr>
</table>

<table>
<tr><th>Category</th><th>Rationale</th></tr>
<tr><td></td><td>
<table>
<tr><th>Rating</th><th>SI Value</th></tr>
<tr><td>High</td><td>16, 17, 18</td></tr>
<tr><td>Moderate</td><td>13, 14, 15</td></tr>
<tr><td>Low</td><td>10, 11, 12</td></tr>
<tr><td>Nil</td><td>9 or less</td></tr>
</table>

Assumptions related to tree size where SI values are available:

The higher the SI value, the higher the likelihood that trees will be larger (dbh) and taller (ht.).
The higher the SI value, the higher the likelihood that there will be live and dead trees greater than 30 cm dbh.

If no SI value is available for a particular Site Series, then the following assumptions apply:

Alluvial sites are typically nutrient rich and productive ecosystems, resulting in larger, taller trees, therefore a greater likelihood of finding large (>30 cm dbh) live and/or dead trees. The following quote illustrates this point, “the most productive forests occur on rich, well drained alluvial sites, Sw and Act can reach heights of over 50 m…” Ch.16, Ecosystems of BC.
Subhygric sites, nutrient rich sites, are more likely to support larger trees
In the BWBSmw1, Sb and Lt, rarely become large trees either in dbh or ht.

</td></tr>
<tr><td>b. Percent Canopy Closure</td><td>Canopy closure is based on percent mean cover for each species. Canopy closure is a function of structural stage and type of tree (conifer vs. deciduous).

Structural Stage 6 &7:
<table>
<tr><th>Species</th><th>Proportion of Mean Cover</th></tr>
<tr><td>Sw</td><td>90</td></tr>
<tr><td>Pl</td><td>70</td></tr>
<tr><td>At</td><td>80</td></tr>
<tr><td>Ep</td><td>80</td></tr>
<tr><td>Act</td><td>90</td></tr>
<tr><td>Sb</td><td>10</td></tr>
<tr><td>Lt</td><td>20</td></tr>
</table>

Assumptions:

The type of tree, conifer or deciduous, plays a role in determining canopy cover. Deciduous trees have most of the leaves up in the canopy (above 10 m) but the crown is not solid, allowing light to penetrate through. Therefore, canopy cover is typically less than the mean percent cover for that species.
Tree species play a role in canopy closure. White spruce typically has a denser crown than lodgepole pine. Black spruce and larch have poorly developed and/or narrow crowns therefore, provide minimal canopy cover.
Canopy cover includes overlap between species whereas mean percent cover doe not, therefore, canopy cover is typically less than the mean percent cover for that species.

</td></tr>
</table>

<table>
<tr><th>Category</th><th>Rationale</th></tr>
<tr><td></td><td>
Structural Stage 4 & 5:
<table>
<tr><th>Species</th><th>Proportion of Mean Cover</th></tr>
<tr><td>Sw</td><td>70</td></tr>
<tr><td>Pl</td><td>70</td></tr>
<tr><td>At</td><td>80</td></tr>
<tr><td>Ep</td><td>80</td></tr>
<tr><td>Act</td><td>90</td></tr>
<tr><td>Sb</td><td>10</td></tr>
<tr><td>Lt</td><td>20</td></tr>
</table>
Assumptions:
• The shape of a tree plays a role in determining canopy cover. Young spruce trees have more branches near the bottom than at the top, this results in a high percent cover but a lower canopy cover.
</td></tr>
<tr><td>c. Tree Height</td><td>
Site Index (SI) relates to site productivity (SIBEC RDM Version: March 2005) and therefore to diameter at breast height (dbh) and height (ht.). The table below is the SI value for certain tree species in the BWBSmw1 subzone.
<table>
<tr><th>Code</th><th>Site Series</th><th>At</th><th>Pl</th><th>Sw</th><th>Sb</th></tr>
<tr><td>AM</td><td>01</td><td>18</td><td>18</td><td>17</td><td></td></tr>
<tr><td>LL</td><td>02</td><td></td><td>12</td><td>9</td><td></td></tr>
<tr><td>SW</td><td>03</td><td>17</td><td>18</td><td>17</td><td></td></tr>
<tr><td>BL</td><td>04</td><td></td><td>15</td><td>12</td><td>9</td></tr>
<tr><td>SO</td><td>05</td><td></td><td>18</td><td>18</td><td>15</td></tr>
<tr><td>SC</td><td>06</td><td>17</td><td>18</td><td>18</td><td></td></tr>
<tr><td>SH</td><td>07</td><td></td><td>18</td><td>18</td><td></td></tr>
<tr><td>BT</td><td>08</td><td></td><td>12</td><td>9</td><td>9</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td></tr>
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</table>
A four class rating system was arbitrarily assigned in relation to SI values, given that the maximum SI value is 18 for the BWBSmw1 subzone, this arbitrarily becomes a high rating.
<table>
<tr><th>Rating</th><th>SI Value</th></tr>
<tr><td>High</td><td>16, 17, 18</td></tr>
<tr><td>Moderate</td><td>13, 14, 15</td></tr>
<tr><td>Low</td><td>10, 11, 12</td></tr>
<tr><td>Nil</td><td>9 or less</td></tr>
</table>
Assumptions related to tree size where SI values are available:
• The higher the SI value, the higher the likelihood that trees will be larger (dbh) and taller (ht.).
• The higher the SI value, the higher the likelihood that there will be live and dead trees greater than 30 cm dbh.
If no SI value is available for a particular Site Series, then the following assumptions apply:
• Alluvial sites are typically nutrient rich and productive ecosystems,
</td></tr>
</table>

Category	Rationale
	resulting in larger, taller trees, therefore a greater likelihood of finding large (>30 cm dbh) live and/or dead trees. The following quote illustrates this point, “the most productive forests occur on rich, well drained alluvial sites, Sw and Act can reach heights of over 50 m…” Ch.16, Ecosystems of BC. • Subhygric, nutrient rich sites are more likely to support larger trees • In the BWBSmw1, Sb and Lt, rarely become large trees either in dbh or ht.

The model variable for the density of large live and dead trees was determined as follows:

1. Convert the four point categorical score (High, Moderate, Low, Nil) for the likelihood of finding stems > 30 cm dbh to a four point numeric score (1, 0.75, 0.5, 0) for each ecosystem unit/tree species combination.
2. Weight each numeric score by the ecosystem unit/tree species canopy closure proportion (from step 3 above).
3. Total the weighted numeric scores for the ecosystem unit’s tree species.
4. Use the total weighted scores for each ecosystem unit to determine the value of the model variable for the density of large live and dead trees.

4. Age

<table>
<tr><th>Category</th><th>Rationale</th></tr>
<tr><td>Likelihood of Large Live and/or Dead Trees</td><td>The older the seral stage the higher the likelihood of finding large live and/or dead trees.
<table>
<tr><th>Structural Stage</th><th>Seral Stage</th><th>Likelihood of finding live and/or dead trees greater than 30 cm dbh</th></tr>
<tr><td>7</td><td>Old growth</td><td>Very Likely</td></tr>
<tr><td>6</td><td>Mature</td><td>Likely</td></tr>
<tr><td>5</td><td>Young</td><td>Not Very Likely</td></tr>
<tr><td>4</td><td>Pole/Sapling</td><td>Nil, unless fire regeneration stand and in that case, fir vets may be present</td></tr>
</table>
</td></tr>
<tr><td>Canopy Closure</td><td>The age of the stand is related to canopy closure. As the stand ages, canopy closure changes. The canopy in a pole/sapling stand is very open because the tree canopy is not yet well developed. As the stand becomes a young stand, the canopy becomes closed but more or less a function of stand density rather than well developed tree crowns. As the stand ages into maturity, self thinning occurs and the tree crowns enlarge resulting in a well developed tree canopy. By old growth stage, the tree canopy is well developed but patchy, as old trees die, open patches occur sporadically.
<table>
<tr><th>Structural Stage</th><th>Seral Stage</th><th>Canopy Characteristics</th></tr>
<tr><td>7</td><td>Old growth</td><td>Closed canopy with gaps, crowns well developed</td></tr>
<tr><td>6</td><td>Mature</td><td>Closed canopy, crowns well developed</td></tr>
<tr><td>5</td><td>Young</td><td>Closed canopy as a function of stand density, some self thinning evident, crowns not well developed.</td></tr>
<tr><td>4</td><td>Pole/Sapling</td><td>Open canopy as a function of stand</td></tr>
</table>
</td></tr>
</table>

	<table><tr><td></td><td></td><td>density, crowns not well developed.</td></tr></table>
Tree Height	The age of the stand is related to tree height. As the stand ages, tree heights increase. <table><tr><th>Structural Stage</th><th>Seral Stage</th><th>Likelihood of finding tall trees</th></tr><tr><td>7</td><td>Old growth</td><td>Very Likely</td></tr><tr><td>6</td><td>Mature</td><td>Likely</td></tr><tr><td>5</td><td>Young</td><td>Not Very Likely</td></tr><tr><td>4</td><td>Pole/Sapling</td><td>Nil, unless fire regeneration stand and in that case, fir vets may be present</td></tr></table>

Appendix XI. Habitat Suitability Index Model Output Maps