Species Account and Preliminary Habitat Ratings for Pacific Water Shrew (*Sorex bendirii*) using SHIM data

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Introduction

The following report includes a species account and preliminary habitat suitability ratings table for *Sorex bendirii* (Pacific water shrew) using SHIM habitat data.

Previously, I developed a habitat suitability/capability model for Pacific water shrew for use with TEM data (Craig 2003) following RISC standards. Unfortunately, TEM mapping in the Lower Mainland is sparse and is expensive to complete, so the model could not be widely applied. To generate habitat suitability maps for additional areas of the Lower Mainland, SHIM (Sensitive Habitat Inventory Mapping) data are being investigated for their suitability for this task.

The SHIM method was developed as a standard for measuring the attributes of freshwater watercourses and their associated riparian habitats (Mason and Knight 2001). The emphasis of SHIM is on the suitability of the site as fish habitat. Data are collected by volunteers (typically stewardship groups) along waterways. Stream data are summarized along stream segments, and occasionally detailed cross-sectional data are collected across the entire riparian zone. Data such as the presence of barriers to fish passage, areas of concern (such as the presence of degraded habitat), presence of wildlife trees or wildlife sightings are also noted.

Based on the data available from SHIM, I created a Bayesian Belief Network (BBN) which classifies habitat suitability as High, Medium, Low or Nil. I focused the BBN on data collected along stream segments (TblStreams in the CMN database). Although cross-section data are more detailed, the data have only been collected along a few streams; stream segment data are much more abundant. Emphasis was placed on selecting variables that would not vary widely between seasons (*ie*. using Bankfull width instead of wetted width).

The model was applied to the SHIM dataset available from the Community Mapping Network (CMN), which includes data collected from 1999 to 2003 in areas around the province. Additional sites have been mapped with SHIM, but have not been contributed to the CMN database. Due to the content of the SHIM dataset, only habitat suitability can be modeled using the data.

Acknowledgements

The Ministry of Water Land and Air Protection provided funding for the development of this model.

The Community Mapping Network provided access to SHIM data.

Susan Jesson, British Columbia Conservation Foundation, provided valuable assistance during the development of the model.

Species account for a preliminary species-habitat model for *Sorex bendirii*

Name

Scientific Name: *Sorex bendirii*

Common name: Pacific water shrew, Bendire's shrew, or Marsh shrew

Species code: M-SOBE

Status

Sorex bendirii is Red-listed in British Columbia, and designated as Threatened by COSEWIC (2000), based on information in the COSEWIC status report by Galindo-Leal and Runciman (1994). In Canada, the species is confined to low elevations in the lower Fraser Valley of British Columbia. It occurs in low numbers throughout its range. It is a habitat specialist, mainly inhabiting forested riparian areas, and it has low vagility. Its distribution coincides with a large urban area undergoing rapid urban growth. Habitat in some historical sites may be lost or highly fragmented. Globally, *S. bendirii* is listed as Apparently Secure (G4). In the United States, it is listed as Apparently Secure (N4), with a sublisting of Secure (S5) in Washington, Apparently Secure (S4) in Oregon, and Vulnerable (S3/S4) in California.

Distribution

The range of the Pacific Water Shrew in British Columbia is constrained to the extreme southwest corner, from Point Grey in the west, to the Chilliwack Valley in the east, and as far north as the Seymour River (Figure 2). Recent sightings in the Skagit Valley suggest that the species may occur further east, although this remains to be confirmed. The population in British Columbia is the extreme northern limit of its geographic range, which extends southward along the coast to northern California.

Elevational range

The range of the shrew in B.C. is constrained to low elevations (<650 metres; Nagorsen 1996).

Project area

The project area is constrained to the known current range of the Pacific water shrew.

Ecology and habitat requirements

Pacific water shrews are usually associated with riparian areas. In a review of studies, primarily from the United States, Galindo-Leal and Runciman (1994) reported that the majority of water shrews were captured within 25 m of streams. Stinson *et al.* (1997) also reported a strong negative correlation between Pacific water shrew captures and distance to water; all Pacific water shrew were captured <160m from water. In moist forests, Pacific water shrews can be found up to 1 km from water (Pattie 1973), but it is not clear whether these are dispersing individuals.

Capture sites in B.C. appear to be primarily associated with coniferous (western red cedar – western hemlock) or deciduous forest. Most capture sites are very close to water, which could be a reflection of sampling effort. Shrews have also been captured in more open habitat, with dense marsh vegetation. In Oregon, Pacific water shrews primarily associate with small streams in riparian alder habitat, and skunk cabbage marshes (Maser *et al*. 1981). Downed wood appears to be an important habitat component for this species, as has been reported for other shrew species and small mammals. The one known nest of a Pacific water shrew was built under bark of a log (Maser *et al*. 1981), and Pacific water shrews are often successfully captured under logs (Ingles

1965). Large logs that overhang the ground provide ideal travel corridors (Hayes and Cross 1987), and increase the continuity of cover (Terry 1981). Decayed logs also serve as nesting and foraging habitat for shrews; as logs decay they provide habitat for different communities of invertebrates (Maser and Trappe 1984, Harmon *et al*. 1986). Terrestrial shrews also forage in the open and then use logs to cache or consume prey in safety (McLeod 1966, Yoshino and Abe 1984); it is likely that logs are used similarly by Pacific water shrews.

Pacific water shrews have been captured in a variety of seral stages except clear-cuts; the presence of moist habitat appears to be more important than forest age. The data suggest that Pacific water shrews are associated with the riparian microenvironment.

No studies have been conducted on the demography of Pacific water shrew, which is necessary to establish the best habitat for the species (*i.e*. higher survival rates, growth rates, reproductive rates associated with healthy populations, Van Horne 1983).

Reproduction

No studies have been conducted in B.C., but data from the U.S. suggest that the breeding season extends from January to late August, and most young born between March and May (Pattie 1969, Verts and Carraway 1998). The litter size has been reported as 3-4 (Pattie 1969) to 5-7 (Verts and Carraway 1998), with an unknown number of litters.

One *S. bendirii* nest has been discovered under loose bark of a Douglas-fir tree, made from shredded bark (Maser *et al*. 1981). *S. bendirii* live approximately 18 months. Males do not breed their first summer. The Common Water shrew has been reported to use muskrat lodges as its home (Jackson 1961), but no such records exist for *S. bendirii*.

Home Range/Movement

No data are available on home ranges or movement patterns of *S. bendirii*.

Home ranges are likely long, narrow bands that follow the water's edge, similar to those described for the European Water Shrew (*Neomys fodiens*; Churchfield 1990). Harris (1984) suggested that *S. bendirii* have home ranges of 1.09 ha in size. Assuming that home ranges would be approximately 25 m (*S. bendirii* are normally captured <25m from water), the home range would stretch 400 m along the waterbody.

It is unknown whether *S. bendirii* are territorial. Studies of the Common Water Shrew (*Sorex palustris*) in captivity (Conaway 1952), and individuals in wild populations in Utah (Sorenson 1962), indicated that this species of water shrew was not territorial, but it is unknown whether they have overlapping home ranges. Thomas (1979) estimated that a viable Common Water Shrew population would require at least 1600 m of suitable linear habitat. This would be an underestimate unless shrews did have overlapping home ranges. The applicability of these estimates to *S. bendirii* are unknown.

The dispersal abilities of *S. bendirii* are unknown. Maser *et al*. (1981) suggested that young disperse during winter into wet forested habitat. The capture of *S. bendirii* >100 m away from water suggests that this species is able to disperse across forested habitat without standing water. European water shrews can move up to 160 m/day (Shillito 1960).

Habitat use and life requisites

All of the life requisites for Pacific water shrew must be met within a small area. The habitat model developed is a year-round model.

No diet studies of *S. bendiri*i have been conducted in B.C., but studies in the U.S. indicate that *S. bendirii* forage both on land and in water.

The bite force of *S. bendirii* is relatively low, meaning that it likely has a relatively soft diet (Carraway and Verts 1994). This information agrees with the data from Pattie (1969) who indicated that captive *S. bendirii* would not eat beetles and crayfish when offered, but ate softer-bodied food items such as earthworms, sowbugs, termites, centipedes, and spiders. Pacific water shrews also consume aquatic arthropods (Pattie 1969). Whitaker and Maser (1976) reported that aquatic invertebrates comprised 25 percent of stomach contents of *S. bendirii*. Stomach contents included insect larvae, slugs, snails, ground beetles, harvestmen and earthworms. Pattie (1969) reported that *S. bendirii* in captivity would cache items, a behaviour that has been reported for other species of *Sorex* (McLeod 1966). All prey are consumed on land (Pattie 1969).

S. bendirii are usually captured close to water. Moist western redcedar forests, skunk cabbage marshes, and riparian forest appear to be the preferred habitat for the species.

Models

Variables used for SHIM habitat suitability modeling included:

- From the stream segment dataset (TblStreams; CMN database):
  - Primary stream class (choices were: channelized, culvert, ditch, modified, natural, other);
  - Stream gradient (measured in degrees);
  - Bankfull width (measured in m);
  - Bankfull depth (measured in m);
  - Riparian class of the dominant vegetation on the left bank (choices were: row crops, broadleaf forest, bryophytes, coniferous forest, planted tree farm, disturbed wetland, dug out pond, exposed soil, flood plain, herbs and grasses, high impervious, medium impervious, low impervious, mixed forest, natural wetland, rock, and shrubs);
  - Riparian class of the dominant vegetation on the right bank (same as for left above);
  - Qualifier for riparian class on the left bank (choices were: agriculture, natural, urban residential, recreation, disturbed, and unknown);
  - Qualifier for riparian class on the right bank (same as for left above);
  - Structural stage of the dominant riparian vegetation on the left bank (choices were: low shrubs <2m, tall shrubs >2m, sapling >10m, young forest, mature forest, old forest);
  - Structural stage of the dominant riparian vegetation on the right bank (same as for left above);
  - Density of shrubs in the left bank riparian zone (choices were: <5%, 5-33%, 34-66%, 67-100%);
  - Density of shrubs in the right bank riparian zone (same as for left above).

- The Bayesian Belief Network (BBN; Figure 1) consists of 3 submodels:
  - Stream characteristics submodel (Figure 2), which uses the primary stream class, bankfull width, bankfull depth, and gradient to classify the suitability of the watercourse. See Appendix 1a for the suitability ratings for this submodel.

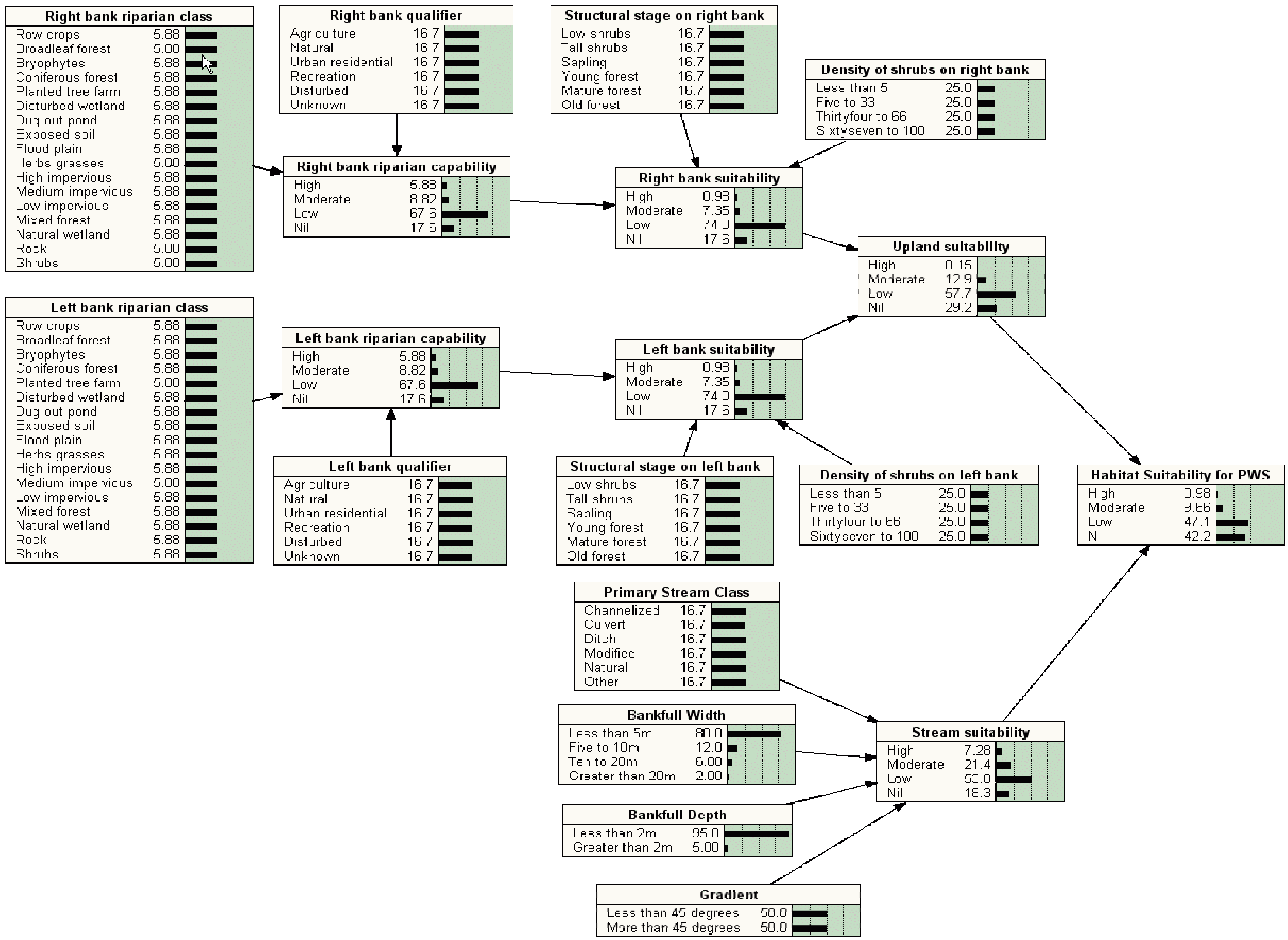

Figure 1. Full Bayesian Belief Network for rating the suitability of habitat for Pacific water shrew based on SHIM data.

- Upland characteristics submodel (Figure 3), which uses the dominant riparian class with the land use qualifier (left and right banks), the structural stage of the dominant vegetation (left and right), the density of shrubs present (left and right) to classify the suitability of the upland habitat.

For this submodel, there were 3 steps:

a. the overall habitat capability of the dominant riparian class was ranked, which provides a maximum suitability of the class (ratings in Appendix 1b);
b. the habitat suitability of the right and left bank was rated separately (ratings in Appendix 1c); and
c. an overall habitat suitability rating was applied based on the combination of right and left bank suitability (ratings in Appendix 1d).

- An overall habitat suitability submodel (Figure 4) which combines stream suitability and upland suitability to provide an overall suitability classification for the habitat. See Appendix 1e for the overall habitat ratings.

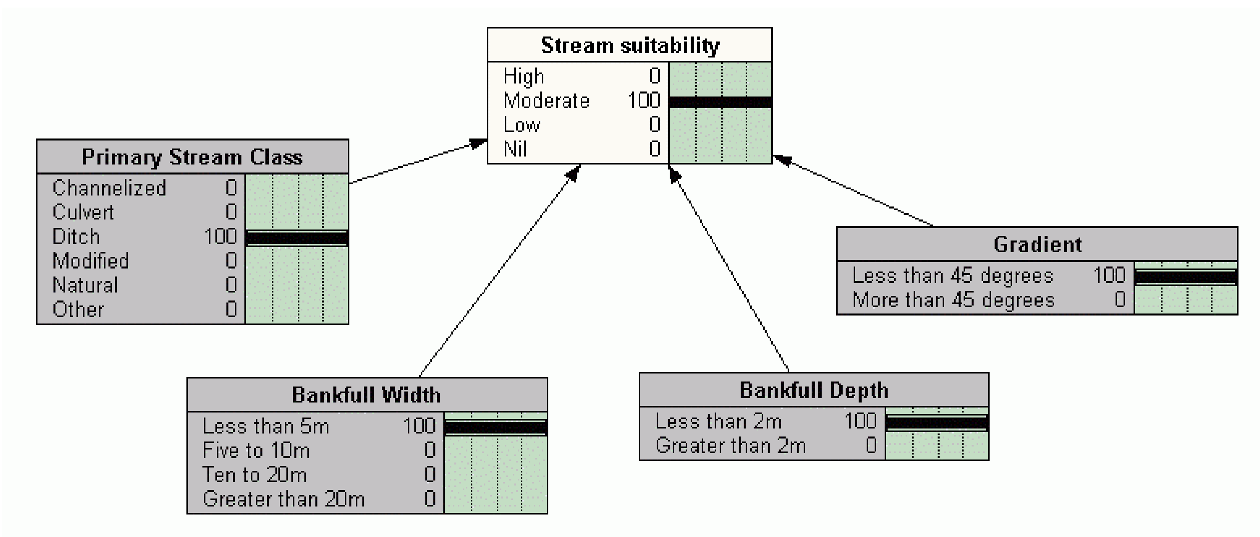

Figure 2. Stream suitability submodel. For detailed ratings information, see Appendix 1a.

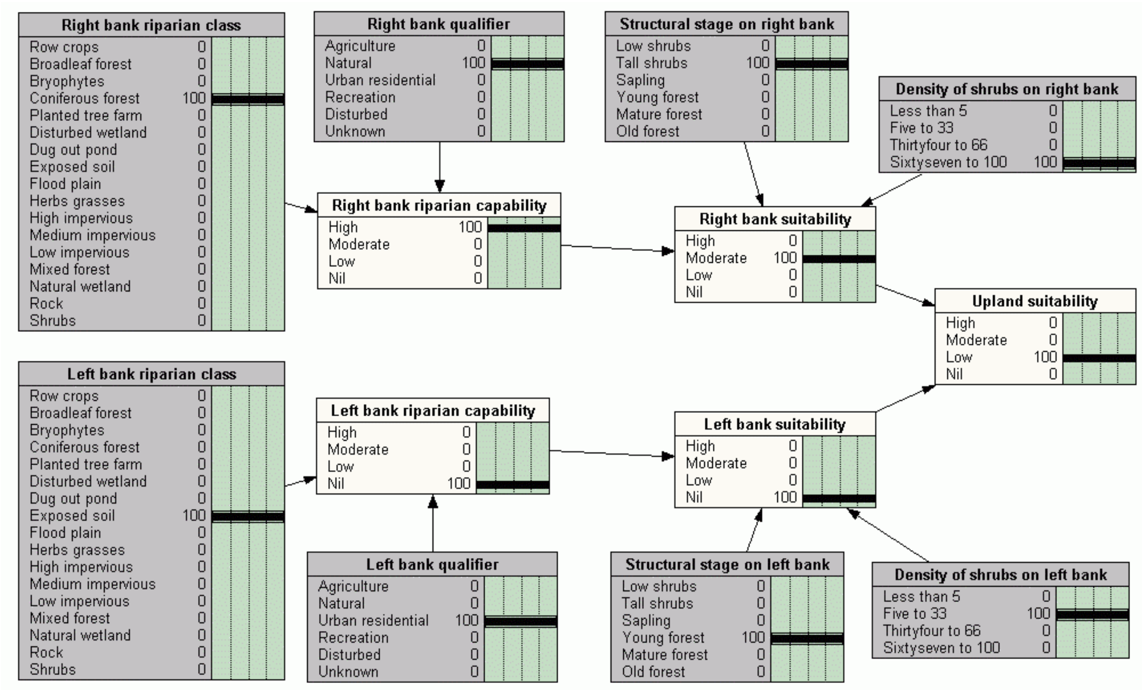

Figure 3. Upland suitability submodel. Right and left bank capability is calculated first. Suitability of habitat on the left and right banks is calculated separately, then combined to generate an overall suitability index for the site. For a detailed description of ratings, see Appendix 1b-1d.

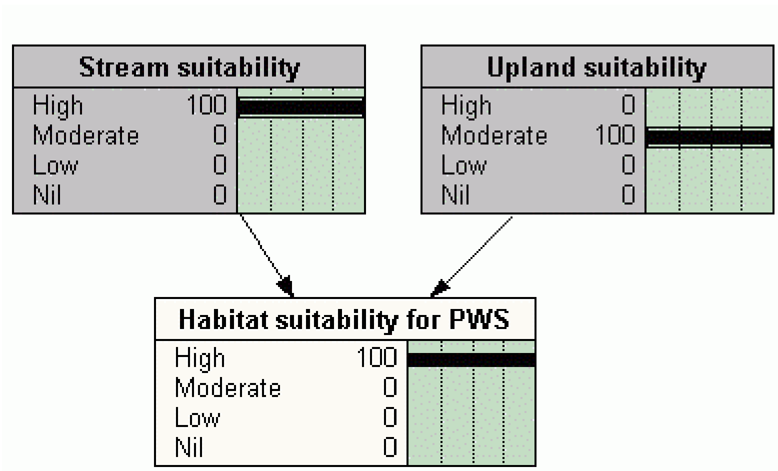

Figure 4. The overall habitat suitability submodel. Combines the ratings for stream and upland habitat to generate an overall suitability index. For a detailed description of ratings, see Appendix 1e.

Model Output

The output from the model is the probability that the stream segment suitability is High, Moderate, Low or Nil (see examples of model output in Appendix 2a-c). Where data for all of the variables in the model is present, the model is set up so that the output is 100% certainty. However, in many instances, data for at least one of the variables included in the model were not collected; in those cases the habitat suitability probability is split between two or more outcomes. For overall rating purposes, stream segment suitability was ranked according to the suitability class that had the highest probability, and assigned a confidence class (either >75%, >50%, or

>25%). Where habitat suitability probabilities were tied between two suitability classes, the habitat was assigned to the highest class. For example, if a data case had a probability of 55% that it was Moderate suitability, and 45% that it was Low suitability, it was assigned a Moderate suitability rating, with a confidence class of >50%. Lower confidence ratings (>25% or >50%) occurred when data were missing.

The model output was used in combination with GIS data to create a habitat suitability map (see Appendix 4 for an example). Overall habitat suitability classes were assigned a colour, and intensity of shading used to indicate confidence of the rating.

Data Gaps

Important data gaps that were identified for the TEM model still remain and apply to this SHIM habitat suitability model, including:

- The definition of the highest quality habitat (benchmark) for *Sorex bendirii*;
- Basic information on habitat associations. Lack of these data limits the ability to assign high, moderate, or low rankings with confidence;
- Most of the streams in the lower mainland have not been mapped; therefore, SHIM habitat suitability modeling is not possible.

For the SHIM data, gaps are specific; occasionally data were not collected for all of the variables used in the model.

- Elevation is included as a data variable in the cross-section dataset, but few crews collected cross-section data; elevation is not included as a variable in the Stream segment dataset;
- Hydraulic (the dominant hydraulic of the stream segment) in the Stream segment dataset was a potentially useful variable; however, in most cases data were not collected; therefore, Gradient was used instead as an indicator of stream condition;
- Riparian bandwidth was originally perceived as being useful and was included in the model originally; however, the measurement reflects the width of the first discernable vegetation band, not necessarily the size of the riparian buffer so it was deleted from the model. The cross-section dataset includes more detailed information about the size of the buffer, but few crews collected cross-section data;
- Data quality is variable depending on the crews collecting the data;
- Data variables collected are variable depending on the crews collecting the data;
- Interpretation of how data are to be collected is variable depending on the crew collecting the data (S. Jesson, *pers. comm*.);
- For some data cases, no data were available for any of the variables used in the model. These cases were deleted and not investigated further.

Ratings

The restricted data available on *S. bendirii* support the use of a 4-class rating scheme. Preliminary habitat suitability ratings for SHIM data are presented in Appendix 1, where habitat is ranked as High suitability (class 1), Moderate suitability (class 2), Low suitability (class 3) and Nil suitability (class 4).

<u>SHIM data Benchmark</u>

Surveys for *S. bendirii* have been insufficient to identify the current distribution of the species in B.C. No population demography studies have been conducted on the species to identify the best habitat. Therefore, the identification of benchmark habitat is tentative, based on the data available.

The current definition of High quality habitat for SHIM data includes:

- Natural mature or old forest habitat that may be coniferous, deciduous, broadleaf, or mixed; or a natural wetland;
- Stream segments <10 m bankfull width;
- Stream segments <2 m bankfull depth;
- Stream segments with <45 degree gradient

Ratings Assumptions for <u>habitat capability</u>:

The nature of SHIM data do not support the development of a robust habitat capability model. Where TEM data are available (including all environmental assessments), the habitat capability model created in 2003 (Craig 2003) should take precedence over this model created for SHIM data.

NOTE that all environmental assessments should use habitat capability ratings instead of habitat suitability ratings.

Ratings Assumptions for <u>habitat suitability</u>:

1. Where the Primary stream class is Culvert, the maximum suitability class is: Nil (class 4);
2. Where the stream is >20 m bankfull width, the maximum suitability class is: Nil (class 4);
3. Where the gradient of the stream is >45 degrees, the maximum suitability class is: Low (class 3);
4. Where the dominant vegetation in the riparian zone is Bryophytes, the maximum suitability class is: Nil (class 4);
5. Where the dominant vegetation in the riparian zone is Exposed Soil, the maximum suitability class is: Nil (class 4);
6. Where the dominant habitat in the riparian zone is High Impervious, the maximum suitability is: Nil (class 4);
7. The size of the riparian buffer is unknown; ratings are based on the assumption that the buffer is adequate, and so represent <u>maximum</u> suitability. Actual suitability of the habitat will vary according to buffer size;
8. The habitat is <650 m elevation;
9. There was information available for at least one of the variables considered in the model. Cases for which no data were available were deleted and were not considered further;
10. There were some riparian classes included in the dataset that were anomalies (not suitable categories according to the metadata). These anomalous cases were reclassified as:
    a. Lawns and lands – reclassified as Herb/grasses with an Urban Residential qualifier;
    b. Non-intens agriculture – reclassified as Row Crops with an Agriculture qualifier;
    c. Impervious manmade – reclassified as High Impervious;
    d. Residential forest – reclassified as Mixed Forest with an Urban Residential qualifier;
    e. Logged areas – reclassified as Mixed Forest (which was rated the same as coniferous or broadleaf forest) with a Disturbed qualifier;

f. Hayfield – reclassified as Row Crops with an Agriculture qualifier;
g. Gravel/soil roads – reclassified as Low Impervious;
h. Agriculture – reclassified as Row Crops with an Agriculture qualifier;
i. Agriculture intensive – reclassified as Row Crop with an Agriculture qualifier
j. Cleared (Flume Creek) – reclassified as Coniferous (based on other plots done along creek) with a Disturbed qualifier;
k. Deciduous forest – reclassified as Broadleaf forest;
l. Impervious (without specifying low, medium, or high) – reclassified as High Impervious;
m. Pavement – reclassified as High Impervious;
n. Residential – reclassified as Unknown class (left blank) with an Urban Residential qualifier;
o. Christmas tree farms – reclassified as Planted Tree Farm with an Agriculture qualifier

11. Data for bankfull width and bankfull depth often were not recorded, but a 0 was placed in the data field. Data for these cases were treated as missing. Prior probabilities in the model for stream bankfull width and bankfull depth were modified from random to reflect the types of streams with data (ie. most streams investigated were small). Prior probabilities were set as:
    a. For bankfull width, the probability of the stream being
        i. <5 m was 80%
        ii. 5-10 m was 12%
        iii. 10-20 m was 6%
        iv. >20 m was 2%
    b. For bankfull depth, the probability of the stream being
        i. <2 m was 95%
        ii. >2 m was 5%

Model Testing

The model was tested with data collected around known Pacific water shrew locations (Appendix 1 in Craig and Vennesland 2004), and by CMN personnel (K. Roger *pers comm*.). In addition, the area around one previous shrew capture (Hoy Creek by Zuleta and Galindo-Leal 1994) had SHIM data collected along it as well.

The output for test data (Appendix 3) indicated that most of the test records around known Pacific water shrew location would be classified as High suitability. Exceptions:

- Martin Gebauer's record on Sumas Mountain, which was in disturbed habitat. Although the stream rated High suitability, the surrounding habitat was rated Low, resulting in an overall Low rating;
- Glenn Ryder's sighting in Langley (1) was rated as probably Moderate based on the wide watercourse (wetland), and lack of information on the dominant upland riparian habitat;
- Leavens capture in Chilliwack, which was ranked as Low. The stream habitat was rated as High suitability, but the surrounding habitat which was young forest in an urban residential setting was rated as Low;

- Denis Knopp's capture in Harrison was ranked as Low suitability. While the stream was rated as High suitability, the surrounding habitat , which was young forest with low shrub cover, rated as Low. Knopp also mentioned that there were some older trees in the forest. If the forest was rated as Mature instead of Young, the site would have been rated Moderate;
- Similar to Denis' record above, Glenn Ryder's sighting in Aldergrove (2) was rated as Low based on the surrounding young forest with low shrub cover. The stream suitability was rated High.

The Test SHIM data were also largely ranked as High suitability:

- Although not discussed in the metadata accompanying the test SHIM data, the four segments along the Salmon River were all classified as High suitability, based on the presence of a small stream with surrounding habitat of mature mixed forest with heavy shrub cover, or young broadleaf forest with heavy shrub cover;
- Five of the seven plots on the Trinity Western campus were rated as High suitability based on the presence of a small stream with a surround of mature broadleaf forest with heavy shrub cover/heavy tall shrub cover. Two other segments were rated as probably Low; the majority of these data were missing;
- The 4Pipe site in Burnaby was rated as High based on the small stream and surrounding mature forest with abundant shrub cover;
- The Clayburn Tributary/Sumas Mountain segments were all classified as High suitability based on the small stream with surrounding dominant riparian habitat (variably classified as Young, Mature, Low Shrubs and Tall Shrubs) with abundant shrub cover;
- The DND wetland was variably rated as Low or Moderate. The two sites rated Low had low shrub cover and one site was classified as Modified/Disturbed. The three sites rated as moderate had relatively abundant shrub cover.
- The Chilliwack River was rated as Nil habitat, based on the presence of an extremely large waterway (>20 m wide). The upland habitat suitability was rated as Moderate, so if there were any small/ephemeral/intermittent streams in the area they would likely be suitable for Pacific water shrew.

Hoy Creek in Coquitlam was the location of a PWS capture by Zuleta and Galindo-Leal in 1994. Based on their data (Zuleta and Galindo-Leal 1994), the capture location would be rated as High suitability (Appendix 3). This result is based on the summary data in Craig and Vennesland (2004). Based on the SHIM data collected in the area however, the streams would be classified as Low suitability. Three of the SHIM stream segments were completed along ditches that connect to South Hoy Creek. In those cases the upland habitat was rated as probably Low, and the stream as Moderate. The other 2 records were along natural habitat; the stream was rated as High suitability, but the surrounding habitat was rated Low based on the dominant riparian class (shrubs or young forest), with low overall shrub cover. Zuleta and Galindo-Leal (1994) reported the capture along an ephemeral stream, therefore it is likely that the area of capture (with the apparently superior habitat) was not included in the SHIM data collected.

The TEM data classified the habitat surrounding the Chilliwack River as High capability for Pacific water shrew. TEM is focused on the terrestrial habitat; based on the SHIM model the terrestrial habitat was suitable for Pacific water shrew as well. Any small streams/tributaries around the river would be suitable for Pacific water shrew.

Based on the test data, the current habitat suitability model created for use with SHIM data appears adequate. One area where the model might be deficient is in classification of wetland data. Stream width is used to rate habitat suitability, with streams <10 m wide receiving a High rating, streams 10-20 m a Moderate rating and streams >20 m a Nil rating. The width of wetlands does not fit in well with this variable, and could result in some areas being erroneously classified as Nil. Where wetland data exist (especially if the water width is >20 m), stream data should not be entered in the model (enter Natural as Primary stream class but treat all other stream data are missing). This will result in a stream classification of 44% probability of High and 52% Low. If the surrounding upland habitat is rated as Moderate or High (if the wetland is surrounded by mature or old forest, or heavy shrub habitat), the overall habitat will be rated as most probably Moderate.

As additional data are collected the model should be refined further.

Preliminary Ratings Table

See Appendix 1 for habitat suitability ratings.

Personal Communication

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Appendix 1. Preliminary habitat suitability ratings table for *Sorex bendirii* using SHIM data.

Appendix 1a. Stream suitability ratings (1 = High, 2 = Moderate, 3 = Low, 4 = Nil)

Bankfull Width	Bankfull depth	Gradient	Primary stream class	Habitat suitability M-SOBE
<5 m	<2 m	<45 degrees	Channelized	2
<5 m	<2 m	<45 degrees	Culvert	4
<5 m	<2 m	<45 degrees	Ditch	2
<5 m	<2 m	<45 degrees	Modified	2
<5 m	<2 m	<45 degrees	Natural	1
<5 m	<2 m	<45 degrees	Other	3
<5 m	<2 m	>45 degrees	Channelized	3
<5 m	<2 m	>45 degrees	Culvert	4
<5 m	<2 m	>45 degrees	Ditch	3
<5 m	<2 m	>45 degrees	Modified	3
<5 m	<2 m	>45 degrees	Natural	3
<5 m	<2 m	>45 degrees	Other	3
<5 m	>2 m	<45 degrees	Channelized	3
<5 m	>2 m	<45 degrees	Culvert	4
<5 m	>2 m	<45 degrees	Ditch	3
<5 m	>2 m	<45 degrees	Modified	3
<5 m	>2 m	<45 degrees	Natural	3
<5 m	>2 m	<45 degrees	Other	3
<5 m	>2 m	>45 degrees	Channelized	3
<5 m	>2 m	>45 degrees	Culvert	4
<5 m	>2 m	>45 degrees	Ditch	3
<5 m	>2 m	>45 degrees	Modified	3
<5 m	>2 m	>45 degrees	Natural	3
<5 m	>2 m	>45 degrees	Other	3
5 to 10 m	<2 m	<45 degrees	Channelized	3
5 to 10 m	<2 m	<45 degrees	Culvert	4
5 to 10 m	<2 m	<45 degrees	Ditch	2
5 to 10 m	<2 m	<45 degrees	Modified	2
5 to 10 m	<2 m	<45 degrees	Natural	1
5 to 10 m	<2 m	<45 degrees	Other	3
5 to 10 m	<2 m	>45 degrees	Channelized	3
5 to 10 m	<2 m	>45 degrees	Culvert	4
5 to 10 m	<2 m	>45 degrees	Ditch	3
5 to 10 m	<2 m	>45 degrees	Modified	3
5 to 10 m	<2 m	>45 degrees	Natural	3
5 to 10 m	<2 m	>45 degrees	Other	3
5 to 10 m	>2 m	<45 degrees	Channelized	3
5 to 10 m	>2 m	<45 degrees	Culvert	4
5 to 10 m	>2 m	<45 degrees	Ditch	3
5 to 10 m	>2 m	<45 degrees	Modified	3
5 to 10 m	>2 m	<45 degrees	Natural	3

Bankfull Width	Bankfull depth	Gradient	Primary stream class	Habitat suitability M-SOBE
5 to 10 m	>2 m	<45 degrees	Other	3
5 to 10 m	>2 m	>45 degrees	Channelized	3
5 to 10 m	>2 m	>45 degrees	Culvert	4
5 to 10 m	>2 m	>45 degrees	Ditch	3
5 to 10 m	>2 m	>45 degrees	Modified	3
5 to 10 m	>2 m	>45 degrees	Natural	3
5 to 10 m	>2 m	>45 degrees	Other	3
10 to 20 m	<2 m	<45 degrees	Channelized	3
10 to 20 m	<2 m	<45 degrees	Culvert	4
10 to 20 m	<2 m	<45 degrees	Ditch	3
10 to 20 m	<2 m	<45 degrees	Modified	3
10 to 20 m	<2 m	<45 degrees	Natural	2
10 to 20 m	<2 m	<45 degrees	Other	3
10 to 20 m	<2 m	>45 degrees	Channelized	3
10 to 20 m	<2 m	>45 degrees	Culvert	4
10 to 20 m	<2 m	>45 degrees	Ditch	3
10 to 20 m	<2 m	>45 degrees	Modified	3
10 to 20 m	<2 m	>45 degrees	Natural	3
10 to 20 m	<2 m	>45 degrees	Other	3
10 to 20 m	>2 m	<45 degrees	Channelized	3
10 to 20 m	>2 m	<45 degrees	Culvert	4
10 to 20 m	>2 m	<45 degrees	Ditch	3
10 to 20 m	>2 m	<45 degrees	Modified	3
10 to 20 m	>2 m	<45 degrees	Natural	3
10 to 20 m	>2 m	<45 degrees	Other	3
10 to 20 m	>2 m	>45 degrees	Channelized	3
10 to 20 m	>2 m	>45 degrees	Culvert	4
10 to 20 m	>2 m	>45 degrees	Ditch	3
10 to 20 m	>2 m	>45 degrees	Modified	3
10 to 20 m	>2 m	>45 degrees	Natural	3
10 to 20 m	>2 m	>45 degrees	Other	3
>20 m	<2 m	<45 degrees	Channelized	4
>20 m	<2 m	<45 degrees	Culvert	4
>20 m	<2 m	<45 degrees	Ditch	4
>20 m	<2 m	<45 degrees	Modified	4
>20 m	<2 m	<45 degrees	Natural	4
>20 m	<2 m	<45 degrees	Other	4
>20 m	<2 m	>45 degrees	Channelized	4
>20 m	<2 m	>45 degrees	Culvert	4
>20 m	<2 m	>45 degrees	Ditch	4
>20 m	<2 m	>45 degrees	Modified	4
>20 m	<2 m	>45 degrees	Natural	4
>20 m	<2 m	>45 degrees	Other	4
>20 m	>2 m	<45 degrees	Channelized	4
>20 m	>2 m	<45 degrees	Culvert	4
>20 m	>2 m	<45 degrees	Ditch	4
>20 m	>2 m	<45 degrees	Modified	4

Bankfull Width	Bankfull depth	Gradient	Primary stream class	Habitat suitability M-SOBE
>20 m	>2 m	<45 degrees	Natural	4
>20 m	>2 m	<45 degrees	Other	4
>20 m	>2 m	>45 degrees	Channelized	4
>20 m	>2 m	>45 degrees	Culvert	4
>20 m	>2 m	>45 degrees	Ditch	4
>20 m	>2 m	>45 degrees	Modified	4
>20 m	>2 m	>45 degrees	Natural	4
>20 m	>2 m	>45 degrees	Other	4

Appendix 1b. Riparian bank capability (applied separately to left and right banks). Riparian classes were grouped for the model. The ranking reflects the maximum suitability rating that can be applied to the habitat type irrespective of other habitat present. 1 = High, 2 = Moderate, 3 = Low, 4 = Nil.

Riparian class	Qualifier	Riparian bank capability M-SOBE
Row crops	Agriculture	3
Row crops	Natural	3
Row crops	Urban residential	3
Row crops	Recreation	3
Row crops	Disturbed	3
Row crops	Unknown	3
Broadleaf forest	Agriculture	3
Broadleaf forest	Natural	1
Broadleaf forest	Urban residential	3
Broadleaf forest	Recreation	3
Broadleaf forest	Disturbed	2
Broadleaf forest	Unknown	3
Bryophytes	Agriculture	4
Bryophytes	Natural	4
Bryophytes	Urban residential	4
Bryophytes	Recreation	4
Bryophytes	Disturbed	4
Bryophytes	Unknown	4
Coniferous forest	Agriculture	3
Coniferous forest	Natural	1
Coniferous forest	Urban residential	3
Coniferous forest	Recreation	3
Coniferous forest	Disturbed	2
Coniferous forest	Unknown	3
Planted tree farm	Agriculture	3

Riparian class	Qualifier	Riparian bank capability M-SOBE
Planted tree farm	Natural	2
Planted tree farm	Urban residential	3
Planted tree farm	Recreation	3
Planted tree farm	Disturbed	3
Planted tree farm	Unknown	3
Disturbed wetland	Agriculture	3
Disturbed wetland	Natural	2
Disturbed wetland	Urban residential	3
Disturbed wetland	Recreation	3
Disturbed wetland	Disturbed	3
Disturbed wetland	Unknown	3
Dug out pond	Agriculture	3
Dug out pond	Natural	2
Dug out pond	Urban residential	3
Dug out pond	Recreation	3
Dug out pond	Disturbed	3
Dug out pond	Unknown	3
Exposed soil	Agriculture	4
Exposed soil	Natural	4
Exposed soil	Urban residential	4
Exposed soil	Recreation	4
Exposed soil	Disturbed	4
Exposed soil	Unknown	4
Flood plain	Agriculture	2
Flood plain	Natural	1
Flood plain	Urban residential	3
Flood plain	Recreation	3
Flood plain	Disturbed	3
Flood plain	Unknown	3
Herbs grasses	Agriculture	3
Herbs grasses	Natural	3
Herbs grasses	Urban residential	3
Herbs grasses	Recreation	3
Herbs grasses	Disturbed	3
Herbs grasses	Unknown	3
High impervious	Agriculture	4
High impervious	Natural	4
High impervious	Urban residential	4
High impervious	Recreation	4
High impervious	Disturbed	4
High impervious	Unknown	4
Medium impervious	Agriculture	3
Medium impervious	Natural	3
Medium impervious	Urban residential	3

Riparian class	Qualifier	Riparian bank capability M-SOBE
Medium impervious	Recreation	3
Medium impervious	Disturbed	3
Medium impervious	Unknown	3
Low impervious	Agriculture	3
Low impervious	Natural	2
Low impervious	Urban residential	3
Low impervious	Recreation	3
Low impervious	Disturbed	3
Low impervious	Unknown	3
Mixed forest	Agriculture	3
Mixed forest	Natural	1
Mixed forest	Urban residential	3
Mixed forest	Recreation	3
Mixed forest	Disturbed	2
Mixed forest	Unknown	3
Natural wetland	Agriculture	3
Natural wetland	Natural	1
Natural wetland	Urban residential	3
Natural wetland	Recreation	3
Natural wetland	Disturbed	2
Natural wetland	Unknown	3
Rock	Agriculture	3
Rock	Natural	3
Rock	Urban residential	3
Rock	Recreation	3
Rock	Disturbed	3
Rock	Unknown	3
Shrubs	Agriculture	3
Shrubs	Natural	1
Shrubs	Urban residential	3
Shrubs	Recreation	3
Shrubs	Disturbed	3
Shrubs	Unknown	3

Appendix 1c. Upland bank suitability (applied separately to left and right banks). 1 = High, 2 = Moderate, 3 = Low, 4 = Nil.

Riparian bank capability	Structural stage	Density of shrubs	Habitat suitability M-SOBE
High	Low Shrubs	<5	3
High	Low Shrubs	5-33%	3
High	Low Shrubs	34-66%	2
High	Low Shrubs	67-100%	2
High	Tall Shrubs	<5	3
High	Tall Shrubs	5-33%	3
High	Tall Shrubs	34-66%	2
High	Tall Shrubs	67-100%	2
High	Sapling	<5	3
High	Sapling	5-33%	3
High	Sapling	34-66%	2
High	Sapling	67-100%	2
High	Young Forest	<5	3
High	Young Forest	5-33%	3
High	Young Forest	34-66%	2
High	Young Forest	67-100%	2
High	Mature Forest	<5	2
High	Mature Forest	5-33%	2
High	Mature Forest	34-66%	1
High	Mature Forest	67-100%	1
High	Old Forest	<5	2
High	Old Forest	5-33%	2
High	Old Forest	34-66%	1
High	Old Forest	67-100%	1
Moderate	Low Shrubs	<5	3
Moderate	Low Shrubs	5-33%	3
Moderate	Low Shrubs	34-66%	2
Moderate	Low Shrubs	67-100%	2
Moderate	Tall Shrubs	<5	3
Moderate	Tall Shrubs	5-33%	3
Moderate	Tall Shrubs	34-66%	2
Moderate	Tall Shrubs	67-100%	2
Moderate	Sapling	<5	3
Moderate	Sapling	5-33%	3
Moderate	Sapling	34-66%	2
Moderate	Sapling	67-100%	2
Moderate	Young Forest	<5	3
Moderate	Young Forest	5-33%	3
Moderate	Young Forest	34-66%	2
Moderate	Young Forest	67-100%	2
Moderate	Mature Forest	<5	3
Moderate	Mature Forest	5-33%	3

Riparian bank capability	Structural stage	Density of shrubs	Habitat suitability M-SOBE
Moderate	Mature Forest	34-66%	2
Moderate	Mature Forest	67-100%	2
Moderate	Old Forest	<5	3
Moderate	Old Forest	5-33%	3
Moderate	Old Forest	34-66%	2
Moderate	Old Forest	67-100%	2
Low	Low Shrubs	<5	3
Low	Low Shrubs	5-33%	3
Low	Low Shrubs	34-66%	3
Low	Low Shrubs	67-100%	3
Low	Tall Shrubs	<5	3
Low	Tall Shrubs	5-33%	3
Low	Tall Shrubs	34-66%	3
Low	Tall Shrubs	67-100%	3
Low	Sapling	<5	3
Low	Sapling	5-33%	3
Low	Sapling	34-66%	3
Low	Sapling	67-100%	3
Low	Young Forest	<5	3
Low	Young Forest	5-33%	3
Low	Young Forest	34-66%	3
Low	Young Forest	67-100%	3
Low	Mature Forest	<5	3
Low	Mature Forest	5-33%	3
Low	Mature Forest	34-66%	3
Low	Mature Forest	67-100%	3
Low	Old Forest	<5	3
Low	Old Forest	5-33%	3
Low	Old Forest	34-66%	3
Low	Old Forest	67-100%	3
Nil	Low Shrubs	<5	4
Nil	Low Shrubs	5-33%	4
Nil	Low Shrubs	34-66%	4
Nil	Low Shrubs	67-100%	4
Nil	Tall Shrubs	<5	4
Nil	Tall Shrubs	5-33%	4
Nil	Tall Shrubs	34-66%	4
Nil	Tall Shrubs	67-100%	4
Nil	Sapling	<5	4
Nil	Sapling	5-33%	4
Nil	Sapling	34-66%	4
Nil	Sapling	67-100%	4
Nil	Young Forest	<5	4
Nil	Young Forest	5-33%	4
Nil	Young Forest	34-66%	4
Nil	Young Forest	67-100%	4

Riparian bank capability	Structural stage	Density of shrubs	Habitat suitability M-SOBE
Nil	Mature Forest	<5	4
Nil	Mature Forest	5-33%	4
Nil	Mature Forest	34-66%	4
Nil	Mature Forest	67-100%	4
Nil	Old Forest	<5	4
Nil	Old Forest	5-33%	4
Nil	Old Forest	34-66%	4
Nil	Old Forest	67-100%	4

Appendix 1d. Overall upland suitability. Combines ratings for left and right banks to generate an overall upland suitability rating. 1 = High, 2 = Moderate, 3 = Low, 4 = Nil.

Right bank suitability	Left bank suitability	Overall upland suitability rating M-SOBE
High	High	1
High	Moderate	1
High	Low	2
High	Nil	3
Moderate	High	1
Moderate	Moderate	2
Moderate	Low	2
Moderate	Nil	3
Low	High	2
Low	Moderate	2
Low	Low	3
Low	Nil	4
Nil	High	3
Nil	Moderate	3
Nil	Low	4
Nil	Nil	4

Appendix 1e. Overall habitat suitability ratings for M-SOBE. Combines stream and upland suitability to generate an overall suitability rating. 1 = High, 2 = Moderate, 3 = Low, 4 = Nil.

Stream suitability	Upland suitability	Overall suitability rating M-SOBE
High	High	1
High	Moderate	1
High	Low	3
High	Nil	4
Moderate	High	1
Moderate	Moderate	2
Moderate	Low	3
Moderate	Nil	4
Low	High	2
Low	Moderate	2
Low	Low	3
Low	Nil	4
Nil	High	4
Nil	Moderate	4
Nil	Low	4
Nil	Nil	4

Appendix 2. Examples of SHIM data with habitat suitability ratings

Appendix 2a. Example of stream habitat suitability rating. A * indicates missing data.

							Probability			
Primary	Gradient num	Gradient class	BF Width	BFWidth class	BFDepth	BFDepth class	High	Moderate	Low	Nil
Natural	5	Less_than_45_degrees	6.1	Five_to_10m	0.2	Less_than_2m	1	0	0	0
Natural	8	Less_than_45_degrees	5.5	Five_to_10m	0.25	Less_than_2m	1	0	0	0
Natural	7	Less_than_45_degrees	5.5	Five_to_10m	0.25	Less_than_2m	1	0	0	0
Natural	7	Less_than_45_degrees	5.6	Five_to_10m	0.4	Less_than_2m	1	0	0	0
Natural	8	Less_than_45_degrees	6.1	Five_to_10m	0.35	Less_than_2m	1	0	0	0
Natural	4	Less_than_45_degrees	6.2	Five_to_10m	0.14	Less_than_2m	1	0	0	0
Natural	37	Less_than_45_degrees	*	*	0.02	Less_than_2m	0.92	0.06	0	0.02
Natural	32	Less_than_45_degrees	0.6	Less_than_5m	0.06	Less_than_2m	1	0	0	0
Natural	30	Less_than_45_degrees	0.8	Less_than_5m	0.06	Less_than_2m	1	0	0	0
Natural	7	Less_than_45_degrees	5.8	Five_to_10m	0.4	Less_than_2m	1	0	0	0
Natural	6	Less_than_45_degrees	6.7	Five_to_10m	0.35	Less_than_2m	1	0	0	0
Natural	8	Less_than_45_degrees	6.5	Five_to_10m	0.35	Less_than_2m	1	0	0	0
Natural	40	Less_than_45_degrees	0.3	Less_than_5m	0.02	Less_than_2m	1	0	0	0
Modified	5	Less_than_45_degrees	0.3	Less_than_5m	0.02	Less_than_2m	0	1	0	0
Natural	4	Less_than_45_degrees	5.9	Five_to_10m	0.3	Less_than_2m	1	0	0	0
Natural	20	Less_than_45_degrees	1.1	Less_than_5m	0.08	Less_than_2m	1	0	0	0
Natural	6	Less_than_45_degrees	5.9	Five_to_10m	0.3	Less_than_2m	1	0	0	0
Natural	12	Less_than_45_degrees	5.8	Five_to_10m	0.35	Less_than_2m	1	0	0	0
Natural	8	Less_than_45_degrees	0.5	Less_than_5m	0.08	Less_than_2m	1	0	0	0
Modified	11	Less_than_45_degrees	0.45	Less_than_5m	0.03	Less_than_2m	0	1	0	0
Natural	15	Less_than_45_degrees	0.45	Less_than_5m	0.03	Less_than_2m	1	0	0	0
Natural	6	Less_than_45_degrees	0.45	Less_than_5m	0.07	Less_than_2m	1	0	0	0
*	0	Less_than_45_degrees	3.1	Less_than_5m	0.4	Less_than_2m	0.17	0.5	0.17	0.17

Appendix 2b. Example of upland habitat suitability classification. A * indicates missing data

L Class	Left Qualifier	L Stage	L Shrubs	R Class	Right Qualifier	R Stage	R Shrubs	Probability High	Probability Mod	Probability Low	Probability Nil
Mixed_forest	Natural	Mature_forest	Thirtyfour_to_66	Broadleaf_forest	Natural	Mature_forest	Sixtyseven_to_100	1	0	0	0
Broadleaf_forest	Natural	Mature_forest	Thirtyfour_to_66	Herbs_grasses	Urban residential	Mature_forest	Sixtyseven_to_100	0	1	0	0
Mixed_forest	Natural	Mature_forest	Five_to_33	Mixed_forest	Natural	Mature_forest	Thirtyfour_to_66	1	0	0	0
Broadleaf_forest	Natural	Young_forest	Sixtyseven_to_100	Broadleaf_forest	Natural	Young_forest	Sixtyseven_to_100	0	1	0	0
Mixed_forest	Natural	Mature_forest	Sixtyseven_to_100	Broadleaf_forest	Natural	Mature_forest	Sixtyseven_to_100	1	0	0	0
Shrubs	Disturbed	Low_shrubs	Sixtyseven_to_100	Shrubs	Disturbed	Low_shrubs	Sixtyseven_to_100	0	0	1	0
Mixed_forest	*	*	*	Mixed_forest	*	*	*	0.01	0.35	0.65	0
Mixed_forest	Natural	Mature_forest	Sixtyseven_to_100	Coniferous_forest	Natural	Mature_forest	Five_to_33	1	0	0	0
Mixed_forest	Natural	Mature_forest	Thirtyfour_to_66	Mixed_forest	Natural	Mature_forest	Thirtyfour_to_66	1	0	0	0
Mixed_forest	Disturbed	Mature_forest	Five_to_33	Mixed_forest	Natural	Mature_forest	Thirtyfour_to_66	0	1	0	0
Mixed_forest	Natural	Young_forest	Thirtyfour_to_66	Mixed_forest	Natural	Mature_forest	Sixtyseven_to_100	1	0	0	0
Mixed_forest	Natural	Young_forest	Sixtyseven_to_100	Mixed_forest	Natural	Mature_forest	Thirtyfour_to_66	1	0	0	0
Mixed_forest	Natural	Mature_forest	Sixtyseven_to_100	Mixed_forest	Natural	Mature_forest	Five_to_33	1	0	0	0
Coniferous_forest	Natural	Mature_forest	Sixtyseven_to_100	Coniferous_forest	Natural	Mature_forest	Thirtyfour_to_66	1	0	0	0
Coniferous_forest	Natural	Mature_forest	Less_than_5	Coniferous_forest	Natural	Mature_forest	Less_than_5	0	1	0	0
Coniferous_forest	Natural	Mature_forest	Five_to_33	Coniferous_forest	Natural	Mature_forest	Five_to_33	0	1	0	0
Shrubs	Disturbed	Low_shrubs	Sixtyseven_to_100	Shrubs	Disturbed	Low_shrubs	Sixtyseven_to_100	0	0	1	0
Shrubs	Disturbed	Low_shrubs	Sixtyseven_to_100	Shrubs	Disturbed	Low_shrubs	Sixtyseven_to_100	0	0	1	0
Shrubs	Natural	Low_shrubs	Sixtyseven_to_100	Shrubs	Natural	Low_shrubs	Sixtyseven_to_100	0	1	0	0
Coniferous_forest	Natural	Mature_forest	Thirtyfour_to_66	Mixed_forest	Natural	Mature_forest	Thirtyfour_to_66	1	0	0	0
Mixed_forest	Natural	Young_forest	Sixtyseven_to_100	Mixed_forest	Natural	Young_forest	Sixtyseven_to_100	0	1	0	0
Mixed_forest	*	Young_forest	Sixtyseven_to_100	Shrubs	*	Tall_shrubs	Sixtyseven_to_100	0	0.44	0.56	0
Mixed_forest	*	Mature_forest	Thirtyfour_to_66	Mixed_forest	*	Mature_forest	Thirtyfour_to_66	0.08	0.47	0.44	0
Shrubs	*	Tall_shrubs	Sixtyseven_to_100	Mixed_forest	*	Mature_forest	Thirtyfour_to_66	0.03	0.42	0.56	0
Broadleaf_forest	*	Young_forest	Thirtyfour_to_66	Mixed_forest	*	Mature_forest	Five_to_33	0	0.44	0.56	0

Appendix 2c. Example of overall habitat suitability rating.

Upland				Stream				Overall habitat suitability				
High	**Mod**	**Low**	**Nil**	**High**	**Mod**	**Low**	**Nil**	**High**	**Mod**	**Low**	**Nil**	**Class**
1	0	0	0	1	0	0	0	1	0	0	0	High_>75
1	0	0	0	1	0	0	0	1	0	0	0	High_>75
0	1	0	0	0.92	0.06	0	0.02	0.92	0.06	0	0.02	High_>75
1	0	0	0	1	0	0	0	1	0	0	0	High_>75
1	0	0	0	1	0	0	0	1	0	0	0	High_>75
0	1	0	0	1	0	0	0	1	0	0	0	High_>75
1	0	0	0	1	0	0	0	1	0	0	0	High_>75
1	0	0	0	1	0	0	0	1	0	0	0	High_>75
0.03	0.42	0.56	0	1	0	0	0	0.44	0	0.56	0	Low_>50
0.03	0.42	0.56	0	1	0	0	0	0.44	0	0.56	0	Low_>50
0.03	0.42	0.56	0	1	0	0	0	0.44	0	0.56	0	Low_>50
1	0	0	0	1	0	0	0	1	0	0	0	High_>75
0	1	0	0	1	0	0	0	1	0	0	0	High_>75
1	0	0	0	1	0	0	0	1	0	0	0	High_>75
0	1	0	0	1	0	0	0	1	0	0	0	High_>75
0	1	0	0	1	0	0	0	1	0	0	0	High_>75
0	0	1	0	1	0	0	0	0	0	1	0	Low_>75
0	1	0	0	1	0	0	0	1	0	0	0	High_>75
1	0	0	0	1	0	0	0	1	0	0	0	High_>75
0	1	0	0	1	0	0	0	1	0	0	0	High_>75
0	0.44	0.56	0	0.17	0.5	0.17	0.17	0.07	0.30	0.46	0.17	Low_>25
0	0.56	0.44	0	0.17	0.5	0.17	0.17	0.09	0.37	0.37	0.17	Moderate_>25
0.08	0.47	0.44	0	0.17	0.5	0.17	0.17	0.13	0.33	0.37	0.17	Low_>25
0.03	0.42	0.56	0	0.17	0.5	0.17	0.17	0.09	0.28	0.46	0.17	Low_>25
0	0.44	0.56	0	0.17	0.5	0.17	0.17	0.07	0.30	0.46	0.17	Low_>25
0	0.56	0.44	0	0.17	0.5	0.17	0.17	0.09	0.37	0.37	0.17	Moderate_>25

Appendix 3. Classification of test data

ID	Site	P[1]	Width	Depth	Gradient[2]	L RC[3]	LQ[4]	LStg[5]	Lshrub	R RC[3]	RQ[4]	R Stg[5]	R shrub	Upland suitability				Stream suitability				Overall suitability				Class[6]
														H	M	L	N	H	M	L	N	H	M	L	N	
Testshim1	Salmon R	N	5-10m	<2m	<45	M	N	M	67-100%	S	N	TS	67-100%	1	0	0	0	1	0	0	0	1	0	0	0	H >75
Testshim2	Salmon R	N	5-10m	<2m	<45	M	N	M	67-100%	S	N	TS	34-66%	1	0	0	0	1	0	0	0	1	0	0	0	H >75
Testshim3	Salmon R	N	5-10m	<2m	<45	B	N	Y	34-66%	B	N	Y	5-33%	0	1	0	0	1	0	0	0	1	0	0	0	H >75
Testshim4	Salmon R	N	5-10m	<2m	<45	B	N	Y	67-100%	S	N	TS	67-100%	0	1	0	0	1	0	0	0	1	0	0	0	H >75
Testshim5	Trinity Western	N	<5m	<2m	<45	S	N	TS	67-100%	S	N	TS	67-100%	0	1	0	0	1	0	0	0	1	0	0	0	H >75
Testshim6	Trinity Western	N	<5m	<2m	<45	B	N	M	67-100%	S	N	TS	67-100%	1	0	0	0	1	0	0	0	1	0	0	0	H >75
Testshim7	Trinity Western	N	<5m	<2m	<45	B	N	M	67-100%	M	N	TS	67-100%	1	0	0	0	1	0	0	0	1	0	0	0	H >75
Testshim8	Trinity Western	N	<5m	<2m	<45	B	N	M	67-100%	M	N	TS	67-100%	1	0	0	0	1	0	0	0	1	0	0	0	H >75
Testshim9	Trinity Western	N	<5m	<2m	<45	M	N	M	67-100%	M	N	M	67-100%	1	0	0	0	1	0	0	0	1	0	0	0	H >75
Testshim10	Trinity Western	O	*	*	*	B	N	*	*	B	*	*	*	.01	.34	.65	0	0	0	.98	.02	0	.34	.64	.02	L >50
Testshim11	Trinity Western	O	*	*	*	B	N	*	*	B	*	*	*	.01	.34	.65	0	0	0	.98	.02	0	.34	.64	.02	L >50
Testshim12	4 Pipe	N	<5m	<2m	<45	B	N	M	67-100%	B	N	M	34-66%	1	0	0	0	1	0	0	0	1	0	0	0	H >75
Testshim13	Clayburn Trib.	N	<5m	<2m	<45	B	N	Y	34-66%	B	N	Y	67-100%	0	1	0	0	1	0	0	0	1	0	0	0	H >75
Testshim14	Clayburn Trib.	N	<5m	<2m	<45	S	N	LS	67-100%	B	N	Y	67-100%	0	1	0	0	1	0	0	0	1	0	0	0	H >75
Testshim15	Clayburn Trib.	N	<5m	<2m	<45	S	N	TS	67-100%	S	N	TS	67-100%	0	1	0	0	1	0	0	0	1	0	0	0	H >75
Testshim16	Clayburn Trib.	N	<5m	<2m	<45	B	N	M	34-66%	B	N	Y	34-66%	1	0	0	0	1	0	0	0	1	0	0	0	H >75

ID	Site	P[1]	Width	Depth	Gradient [2]	L RC[3]	LQ[4]	LStg [5]	Lshrub	R RC[3]	RQ[4]	R Stg[5]	R shrub	Upland suitability H	M	L	N	Stream suitability H	M	L	N	Overall suitability H	M	L	N	Class[6]
Testshim17	Clayburn Trib.	N	<5m	<2m	<45	B	N	M	67-100%	M	N	M	67-100%	1	0	0	0	1	0	0	0	1	0	0	0	H >75
Testshim18	DND wetland	M	*	*	*	B	D	Y	5-33%	S	*	*	*	0	.11	.89	0	0	.44	.54	.02	0	.11	.87	.02	L >75
Testshim19	DND wetland	N	*	*	*	B	N	Y	5-33%	S	*	*	*	0	.11	.89	0	.44	.03	.51	.02	.05	.06	.87	.02	L >75
Testshim20	DND wetland	N	*	*	*	B	N	Y	34-66%	S	*	*	*	.03	.97	0	0	.44	.03	.51	.02	.44	.54	0	.02	M >75
Testshim21	DND wetland	N	*	*	*	B	N	Y	34-66%	S	*	*	*	.03	.97	0	0	.44	.03	.51	.02	.44	.54	0	.02	M >75
Testshim22	DND wetland	N	*	*	*	M	N	Y	34-66%	S	*	*	*	.03	.97	0	0	.44	.03	.51	.02	.44	.54	0	.02	M >75
Testshim23	Chilliwack R.	N	*	*	*	C	*	*	*	C	N	M	5-33%	.03	.97	0	0	0	0	0	1	0	0	0	1	N >75
Oldrecord 1	Gebauer Sumas	N	5-10m	<2m	<45	S	D	LS	5-33%	H/G	D	LS	5-33%	0	0	1	0	1	0	0	0	0	0	1	0	L >75
Oldrecord 2	Sickmuller Sumas	N	5-10m	<2m	<45	B	N	Y	67-100%	B	N	Y	67-100%	0	1	0	0	1	0	0	0	1	0	0	0	H >75
Oldrecord 3	Knopp Sumas	N	<5m	<2m	<45	M	N	Y	67-100%	M	N	Y	67-100%	0	1	0	0	1	0	0	0	1	0	0	0	H >75
Oldrecord 4	Ryder Coq	N	<5m	<2m	<45	M	N	*	67-100%	M	N	*	67-100%	0.6	0.4	0	0	1	0	0	0	1	0	0	0	H >75
Oldrecord 5	Zuleta Coq	N	<5m	<2m	<45	M	N	*	67-100%	M	N	*	67-100%	0.6	0.4	0	0	1	0	0	0	1	0	0	0	H >75
Oldrecord 6	Zuleta Hatzic	N	<5m	<2m	<45	C	N	M	67-100%	C	N	M	67-100%	1	0	0	0	1	0	0	0	1	0	0	0	H >75
Oldrecord 7	Zuleta Fergusck	N	5-10m	<2m	<45	M	N	M	67-100%	M	N	M	67-100%	1	0	0	0	1	0	0	0	1	0	0	0	H >75
Oldrecord 8	Ryder Langley1	N	10-20m	<2m	<45	W	N	*	<5%	W	N	*	Less than 5	0	0.6	0.4	0	0	1	0	0	0	0.6	0.4	0	M >50
Oldrecord 9	Leavens Chill.	N	<5m	<2m	<45	B	UR	Y	5-33%	B	UR	Y	5-33%	0	0	1	0	1	0	0	0	0	0	1	0	L >75
Oldrecord 10	Knopp Harrison	N	5-10m	<2m	<45	M	N	Y	5-33%	M	N	Y	5-33%	0	0	1	0	1	0	0	0	0	0	1	0	L >75

ID	Site	P[1]	Width	Depth	Gradient[2]	L RC[3]	LQ[4]	LStg[5]	Lshrub	R RC[3]	RQ[4]	R Stg[5]	R shrub	Upland suitability				Stream suitability				Overall suitability				
														H	M	L	N	H	M	L	N	H	M	L	N	Class[6]
Oldrecord 11	Knopp Alder1	N	<5m	<2m	<45	B	N	Y	34-66%	B	N	Y	34-66%	0	1	0	0	1	0	0	0	1	0	0	0	H >75
Oldrecord 12	Knopp Alder2	N	<5m	<2m	<45	B	N	Y	34-66%	B	N	Y	34-66%	0	1	0	0	1	0	0	0	1	0	0	0	H >75
Oldrecord 13	Ryder Alder1	N	5-10m	<2m	<45	B	N	Y	67-100%	B	N	Y	67-100%	0	1	0	0	1	0	0	0	1	0	0	0	H >75
Oldrecord 14	Ryder Alder2	N	5-10m	<2m	<45	B	N	Y	5-33%	B	N	Y	5-33%	0	0	1	0	1	0	0	0	0	0	1	0	L >75
Oldrecord 15	Ryder Langley2	N	5-10m	<2m	<45	W	N	M	67-100%	W	N	M	67-100%	1	0	0	0	1	0	0	0	1	0	0	0	H >75
Oldrecord 16	Ryder Langley3	N	5-10m	<2m	<45	S	N	LS	67-100%	S	N	LS	67-100%	0	1	0	0	1	0	0	0	1	0	0	0	H >75

[1] Primary stream class: N = Natural, M = Modified, O = Other
[2] Gradient: Note – except for test SHIM data, gradient was not recorded. Based on descriptions, all sites were assumed to have a low gradient
[3] (L or R bank) Riparian class: B = Broadleaf forest; C = Coniferous forest; H/G = Herbs & grasses; M = Mixed forest; S = Shrubs; W = Natural wetland
[4] (L or R bank) Qualifier: N = Natural; D = Disturbed; UR = Urban residential
[5] Structural Stage: LS = Low shrubs; M = Mature forest; TS = Tall shrubs; Y = Young forest
[6] Overall habitat suitability rating: H = High; M =Moderate; L = Low; N = Nil

Appendix 4. Example of habitat suitability map for Pacific water shrew in South Surrey. Coding reflects both the habitat suitability, as well as the confidence of the rating.