LONG-TOED SALAMANDER
YEAR ROUND HABITAT

HABITAT SUITABILITY INDEX MODEL
VERSION 5

Last Modified: 20 October 1999

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1. INTRODUCTION

Habitat Suitability Index (HSI) models predict the suitability of habitat for a species based on an assessment of habitat attributes such as habitat structure, habitat type and spatial arrangements between habitat features. This HSI model for the long-toed salamander *(Ambystoma macrodactylum)* applies to habitats of the Foothills Model Forest (FMF) in west-central Alberta. The intended use is to predict habitat suitability at landscape scales and over long time periods. The model will be used to determine potential changes in long-toed salamander habitat area and carrying capacity throughout an entire forest management cycle (200 years). Results from Karen Graham's study on long-toed salamander habitat use and distribution in the FMF have been incorporated into the model.

2. SPECIES DESCRIPTION AND DISTRIBUTION

The adult long-toed salamander is approximately 10-20 cm long, slender, with brown or dark green glossy skin, usually with a yellow dorsal stripe (Russell and Bauer 1993). The larvae (up to 7.5 cm long) are typically found in fishless permanent ponds (Graham 1997) and are light olive-grey to brownish grey, with a large head and large external gills (Russell and Bauer 1993).

The species is distributed throughout British Columbia (Bishop 1943, Ferguson 1961) and in clusters along the Rocky Mountains and Foothills in Alberta (Powell et al. 1997, Walsh 1998), south into the Pacific Northwest States, and California (Ferguson 1961, Nussbaum et al. 1983). In Alberta, the long-toed salamander is considered a sensitive species because populations only occur in small pockets along the western edge of the province (Wildlife Management Division 1996). Long-toed salamanders are found in ponds, marshes, and land along the major river valleys (Stebbins 1966, Gadd 1995). In Alberta, long-toed salamanders were in ponds as high as 1930 m in Waterton Lakes National Park. In the FMF, populations were in ponds along the Athabasca River watershed as far east as Obed (Graham 1997). No populations were south of Teepee Creek or as far north as Switzer Park (Graham 1997).

3. FOOD

Long-toed salamander larvae feed on all aquatic animals small enough to be ingested (Sheppard 1977). Adults eat a variety of invertebrates including snails and worms (Farner 1947, Ferguson 1961, Fukumoto 1995). Adults roam around clearings and forested areas in search of food, often at night or when it is raining (Fukumoto 1995, Powell et al. 1997).

4. COVER

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Adults spend the majority of the summer underground in small mammal burrows or under rocks, bark, or logs (Anderson 1967, Sheppard 1977, Douglas 1981). They crawl around on the ground at night in search of food, but during the day they stay well hidden. Winter hibernation aggregations are located under ground below the frost line (Sheppard 1977). Hibernation sites are often associated with root systems or other crevasses (W. A. Hunt, Life history of the northern long-toed salamander, unpublished report, Edson Fish and Wildlife Library, 1987). Although some salamanders travel up to 900 m (Powell et al. 1993), most remain within several hundred metres of the nearest pond (Graham 1997).

Within the FMF, adult salamanders were up to 750 m from the suspected breeding pond, however most were within 250 m of the pond (Graham 1997). Long-toed salamanders were associated with well-drained uplands that had a thick litter layer. A comparison of captures in forested, clearcut and wet sites resulted in similar numbers being caught in the clearcut and forested sites and relatively few captures at sites with saturated soil (Graham 1997).

5. REPRODUCTION

Migration from overwintering sites to breeding ponds occurs in early spring. Males usually arrive before the females (Nussbaum et al. 1983). Eggs are deposited singly or in clumps (Graham 1997) in the shallow areas of ponds (Sheppard 1977, Salt 1979, Graham 1997), on vegetation, logs or sticks (Graham 1997), often before all the ice has melted (Kezer and Farner 1955, Knudsen 1960, Anderson 1967, Beneski et al. 1986). The average number of eggs laid by a female in the FMF was 221 (range = 213-231, N = 4; Graham 1997). Metamorphosis typically occurs in August in the FMF (Graham 1997) but in a high elevation pond (1930 m) in Waterton Lakes National Park, larvae overwintered and metamorphosed the second summer (Fukumoto 1995).

In the FMF, adult salamanders were found breeding in ponds as small as 9 m^2, but the largest populations were in large, permanent ponds (5 ha) with no fish. Little to no breeding occurred in ephemeral ponds (Graham 1997).

Larval development varies over the geographical range due to the wide variance in timing and length of breeding season (Kezer and Farner 1955, Nussbaum et al. 1983). Fish are detrimental to salamander larvae and generally only fishless ponds or ponds with shallow areas and hiding places for larvae will successfully maintain salamander populations (Powell et al. 1997).

6. HABITAT AREA

Home ranges of long-toed salamanders in the Bow Corridor in Alberta were 115.6 m^2, 167.5 m^2 and 281.6 m^2 for females, males and juveniles respectively. Breeding population estimates from ponds in the FMF based on egg abundance ranged from 1 breeding female in a 0.1 ha pond to 838 breeding females in a 5 ha pond. No density estimate was made for terrestrial salamanders, however based on pitfall captures in the FMF, an estimate of 25 salamanders in an optimal hectare of habitat is assumed (K. Graham, personal observation)

7. HSI MODEL

7.1 MODEL APPLICABILITY

Species: Long-Toed Salamander (*Ambystoma macrodactylum*).

Habitat Evaluated: Adult Foraging and Cover Habitat.

Geographic area: This model is applicable to the Foothills Model Forest of west-central Alberta.

Seasonal Applicability: This model produces values for year round habitat.

Cover types: This model applies to all forested and non-forested habitat of the Lower and Upper Foothills Montane and Subalpine Natural Subregions (Beckingham et al. 1996) since suitability is determined from structural characteristics within stands rather than classified forest stands directly. This model is applicable to areas in which there are known to be populations of this species. The model should also be broadly applicable to other habitat areas dominated by vegetation similar to that in this region, including pure deciduous, mixedwood and pure coniferous forest types, as well as wetland and riparian forests, meadows, shrublands, and areas regenerating after forest harvesting.

Minimum Habitat Area: There is no minimum habitat area required by long-toed salamanders.

Model Output: The model will produce Habitat Units (HU) of year round habitat for each stand or type based on HSI value and stand or type area. HU are calculated by multiplying the HSI score with the area in hectares. The HU will then be used to determine the potential carrying capacity of adult salamanders in early spring.

Carrying Capacity (Adult Salamanders per ha where HSI = 1.0): Based on local information, the current estimate of the maximum number of long-toed salamanders per optimal hectare is 25 (K. Graham, personal observation).

Verification Level:

Application: This HSI model is designed to assess habitat suitability for relatively large forest landscapes using generalized species-habitat relationships and stand-level vegetation inventory. Its purpose is to predict relative changes in long-toed salamander habitat supply at the landscape level over long time periods (200 years), for integration with forest management planning. The models is not designed to provide accurate prediction of suitability or use at the stand level. Approximate population size can be calculated by assuming linear habitat-population relationships, but the model is not designed to provide accurate population density estimates. Any attempt to use the model in a different geographic area or for other than the intended purpose should be accompanied by model testing procedures, verification analysis, and other modifications to meet specific objectives.

7.2 MODEL DESCRIPTION

The HSI model for the long-toed salamander is for year round habitat. The model is based on distances to lentic ecosystems (still open water) that are known to have salamander populations and ground cover. The salamander does not live in lotic (flowing water) ecosystems.

7.2.1 Habitat Variables and HSI Components

The limited dispersal of long-toed salamanders restricts this salamander to areas where other long-toed salamander populations occur. The first variable is the distance to the nearest known breeding pond. Only ponds within 10 km of the known long-toed salamander range in the FMF are considered suitable.

The second variable is the distance from the nearest nonflowing waterbody that does not contain fish. This is used to define the area around a waterbody that is available to long-toed salamanders.

The third component determines the terrestrial microsite suitability in which salamanders spend most of their life when they are not breeding. The microsite where most salamanders were found had a thick litter layer (Graham 1997), therefore, any vegetation (including coarse woody debris) that contributes to the litter layer enhances terrestrial habitat for long-toed salamanders.

Table 1. Relationship between habitat variables and life requisites for the long-toed salamander model.

HSI Component	Life Requisite	Habitat Variable	Habitat Variable Definition
S_1	Habitat Area	Distance to Active Pond (km)	Linear distance to nearest pond with recorded long-toed salamander population.
S_2	Habitat Area	Distance to Nearest Pond (m)	Linear distance to nearest permanent fishless water body (still, open water).
S_3	Foraging and Daytime Cover	Habitat Cover (%)	Shrub cover + herb cover + horsetail cover + grass cover + moss cover + downed wood cover.

7.2.2 Graphical HSI Component Relationships

S_1 — S_1 has been set at 1 for the distance of 0-10 km, and immediately drops to 0 at further distances (Figure 1a).

S_2 — Salamander abundance is related to the distance of the breeding pond. As distance from the pond increases the number of salamanders decreases until a distance of 750 m is reach. Thus S_2 has been defined such that it has a value of 1 at the pond edge to 250 m, and this then declines linearly to a value of 0 at 750 m (Figure 1b).

S_3 Microsites with vegetation cover that results in a thick litter layer increases habitat suitability. Suitability increases from 0-1 over the range 0-100% cover (Figure 1d). It is possible that cover will be > 100%, however anything > 100% gets a rating of 1.

7.3 MODEL ASSUMPTIONS

1. Pond chemistry does not affect terrestrial habitat associations.
2. Salamanders are limited in dispersal.
3. Pesticides, herbicides or fungicides are not being used in the area.
4. Areas with dense vegetation cover will have a thick litter layer.

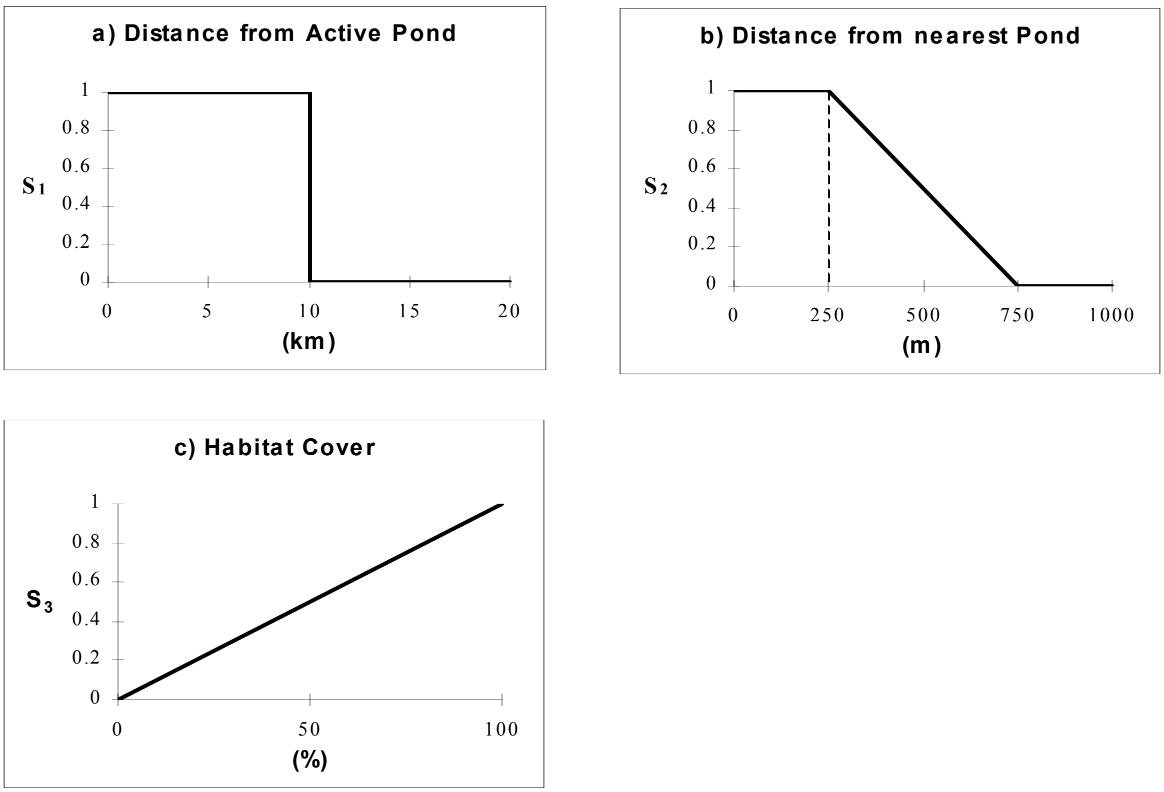

Figure 1. Graphical relationships between habitat variables and HSI components in the long-toed salamander model.

7.4 EQUATIONS

The component S_1 determines whether the area is in the range of long-toed salamanders within the FMF. It is multiplied directly to S_2, which ensures only areas in the vicinity of ponds are counted and S_3 rates the habitat around individual ponds. All three variables are considered equally important.

$$HSI = S_1 \times S_2 \times S_3$$

8. SOURCES OF OTHER MODELS

There were no other HSI models for the long-toed salamander.

Model History

All of the HSI models for the Weldwood Forest Management Area have undergone several revisions, and they will be revised again as new information becomes available. Contact Rick Bonar for information about the most current version.

- Version 1 (1989) was developed by the Weldwood of Canada Integrated Resource Management Steering Committee (IRMSC).
- Version 2 (1994) was revised by Barb Beck and Melissa Todd.
- Version 3 (1995) was written by Andrea Hoover for a special topics course in habitat modelling at the University of Alberta.
- Version 4 (1996) was edited and reformatted by Wayne Bessie and sent to species experts for critical comment.
- Version 5 (1999) was revised by Karen Graham, Rick Bonar, Barb Beck, and Jim Beck to incorporate reviewer comments and information from recent literature.

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