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 golden-crowned kinglet (Regulus satrapa) applies to 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 golden-crowned kinglet habitat area and carrying capacity throughout an entire forest management cycle (200 years). The model was primarily developed using literature review.

2. SPECIES DESCRIPTION AND DISTRIBUTION

The golden-crowned kinglet is a very small bird (9-10 cm long), greenish-gray in colour, with a fine-pointed bill and a brilliant yellow crown bordered by black and a white stripe just above the eye. The male is differentiated from the female by having more of an orange-yellow crown (Peterson 1961). This species breeds across Alaska and Canada in coniferous forests, and along the Rocky Mountain and Coast Ranges in California, Arizona and New Mexico. In Alberta, golden-crowned kinglets breed throughout the Boreal, Rocky Mountain and Foothills Forest Regions (Salt and Salt 1976). Golden-crowned kinglets are not considered to be at risk and their habitat is secure in Alberta (Wildlife Management Division 1996). Golden-crowned kinglets are usually in west-central Alberta from early May until the end of September (Gadd 1995) and winter in southern Canada and farther south throughout the U.S. and Central America.

3. FOOD

Golden-crowned kinglets glean and hover for invertebrates in the foliage of conifers and exhibit a strong preference for spruce (Picea spp.) and fir (Abies spp.; Bock and Lynch 1970, Hamel et al. 1982, Franzreb 1984, Mannan et al. 1984, Mannan and Meslow 1984). This preference may be a result of the branching structure of these tree species which increases food availability and/or facilitates prey capture (Mannan and Meslow 1984). Golden-crowned kinglets forage most frequently in the middle third of a tree, at a height of approximately 10 m (Franzreb 1984).

4. COVER


In west-central Alberta, golden-crowned kinglets were found exclusively in unlogged forests that were dominated by white spruce and subalpine fir. Forests were well developed with trees that were at least 21 m in height (D. R. Farr, Validation of habitat suitability models for birds and squirrels in west-central Alberta, unpublished report, 1994).

5. REPRODUCTION

The nest of the golden-crowned kinglet is a globular mass of lichens, mosses and leaves with an opening at the top (Salt and Salt 1976, Hamel et al. 1982). Nests are usually located high in the canopy of mature coniferous trees (Salt and Salt 1976, Hamel et al. 1982, Mannan and Meslow 1984, Godfrey 1986). Nest height ranges from 2-16 m (Salt and Salt 1976, Hamel et al. 1982, Franzreb 1984, Mannan and Meslow 1984). The female typically builds the nests and incubates the eggs for 14-15 days (Ehrlich 1988). The kinglet produces 5-11 eggs each breeding season (Ehrlich 1988) and can have two broods per summer (Ehrlich 1988). Fledging occurs in 14-19 days (Ehrlich 1988).

6. HABITAT AREA

In deciduous forest in central Alberta, densities of 0.028 pairs/ha were recorded (Westworth et al. 1984). This figure is very low when compared to densities from mature coniferous forests from across North America. Densities cited are: 0.44 pairs/ha in California (Bock and Lynch 1970), 0.81 pairs/ha in Maine (Titterington et al. 1979), 1.12-1.37 singing males/ha in British Columbia (Wetmore et al. 1985), 0.36, 0.55, 0.62 and 0.77 birds/ha in Oregon (Anderson 1972, Mannan and Meslow 1984, Anthony et al. 1996), 0.66-0.77 birds/ha in Arizona (Franzreb and Ohmart 1978), and 1.30 birds/ha in Ontario (Welsh 1988). In the FMF, Farr (1992) found a density of 0.63 pairs/ha in old (> 180 years) spruce forests.

7. HSI MODEL

7.1 MODEL APPLICABILITY

Species: Golden-Crowned Kinglet (*Regulus satrapa*).

Habitat Evaluated: Reproductive Habitat (Food, Cover, and Breeding).

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

Seasonal Applicability: Mid-spring to Mid-summer.

Cover Types: This model applies to all forest and non-forest habitat areas 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. 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: Minimum habitat area is defined as the minimum amount of contiguous habitat to which the model will be applied. The high mobility of this species should result in all suitable habitat being available to it, regardless of interspersion with other habitat types. Therefore, no minimum contiguous habitat area is specified.

Model Output: The model will produce a single HSI value based on food, cover and the reproductive needs of the golden-crowned kinglet. Habitat Units (HU) will then be determined by multiplying the HSI value by each stand’s area. The performance measure of the model is carrying capacity (breeding pairs per ha). Model outputs must therefore be correlated to estimates of carrying capacity.

Carrying Capacity (Breeding Pairs per ha where HSI = 1.0): Based on Farr (1992), the current estimate of the maximum number of golden-crowned kinglet breeding pairs per hectare is 0.63.
**Verification Level:** The reliability of this model has not been evaluated against local data. The verification level is 4: local data was used to develop the model, but model predictions have not been tested.

**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 golden-crowned kinglet habitat supply at the landscape level over long time periods (200 years), for integration with forest management planning. The model 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

It is difficult to differentiate variables belonging to any specific life requisite (e.g. food, cover or reproductive needs) because the golden-crowned kinglet uses the same habitat to meet all life requisites. As a result, food, cover and reproductive needs are considered equally limiting. This model contains no spatial components as it is assumed that golden-crowned kinglets are associated with particular habitat conditions rather than relationships between habitat areas. Thus, the golden-crowned kinglet is not assumed limited by human use or landscape management activities as long as the needed structural elements exist within a particular habitat.

#### 7.2.1 Habitat Variables and HSI Components

The golden-crowned kinglet model is developed based on three elements of habitat structure. These are mean conifer canopy height ($S_1$), canopy closure ($S_2$), and percentage of spruce and fir in the tree canopy ($S_3$) (Table 1). Conifer height represents the development of a mature forest that has suitable food and nesting habitat. Dense tree canopy closure is also associated with good kinglet habitat. Golden-crowned kinglets show a high preference toward spruce and fir trees. Spruce and fir trees have more vegetated branches along the trunk and provide good cover for nesting and feeding kinglets.

<table>
<thead>
<tr>
<th>HSI Component</th>
<th>Life Requisite</th>
<th>Habitat Variable</th>
<th>Habitat Variable Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>$S_1$</td>
<td>Food/Cover/Reproduction</td>
<td>Conifer Canopy Height (m)</td>
<td>Average top height of 100 coniferous trees/ha that have the largest diameter at breast height (dbh at 1.3 m).</td>
</tr>
<tr>
<td>$S_2$</td>
<td>Food/Cover/Reproduction</td>
<td>Tree Canopy Closure (%)</td>
<td>Percent of ground covered by a vertical projection of tree crown areas onto the ground. Includes all trees ≥ 8 cm dbh.</td>
</tr>
<tr>
<td>$S_3$</td>
<td>Food/Cover/Reproduction</td>
<td>Spruce + Fir in Tree Canopy (%)</td>
<td>% Spruce (Black + White + Engelmann) and % Fir (Subalpine + Balsam) in tree canopy.</td>
</tr>
</tbody>
</table>

#### 7.2.2 Graphical HSI Component Relationships

- **$S_1$**  
  Conifer stand height ≥ 25 m is good for golden-crowned kinglet foraging habitat ($S_1 = 1$). Anything < 10 m is not suitable (Figure 1a). This was based on the golden-crowned kinglets preference for forests greater than 80 years old in the Pacific coastal areas and Maine. In west-central Alberta, growth rates of trees are significantly lower than in the Pacific coastal areas and Maine. Site productivity varies within regions therefore stand age is not necessarily indicative of habitat quality. It was determined that height would be used as an index of age. The lower limit for conifer stand height is 0 at 10 m and the upper limit is 1 at 25 m (the average height for 80-100 year spruce in the Upper Foothills).

- **$S_2$**  
  Crown closure ≥ 70% is considered good for golden-crowned kinglets. These stands are assumed to protect nests and conceal kinglets from predators. Since golden-crowned kinglets are not found in open stands, $S_2$ was given the value of 0 at 5% or less. Suitability then increases linearly from 6% up to 70% (Figure 1b).
Spruce and fir in the tree canopy ≥ 70% is considered good ($S_3 = 1$). The HSI value of 0 was set at 0% spruce and fir in the tree canopy because golden-crowned kinglets were found to inhabit areas with a single spruce or fir in the canopy (Figure 1c).

7.3 MODEL ASSUMPTIONS
1. Food, cover, and reproductive habitat are provided by the same structural habitat elements and all are equally limiting.
2. Golden-crowned kinglets are not limited by water or mineral resources.
3. Golden-crowned kinglets are not affected by human uses, and are not dependent on the spatial arrangement of habitat types. They are only affected by structural elements within a habitat area.
4. Tree height is indicative of mature forest conditions, which are preferred by the golden-crowned kinglet.

Figure 1. Graphical relationship between habitat variables and HSI components in the golden-crowned kinglet model.

7.4 EQUATION
This equation assumes that all the variables are compensatory because a low value in one component can compensate for by a high value in another.

$$HSI = (S_1 \times S_2 \times S_3)^{1/3}$$

8 SOURCES OF OTHER MODELS
No other HSI models on the golden-crowned kinglet were found.

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 Mark Piorecky in a habitat modelling course at the University of Alberta.
- Version 4 (1996) was edited and reformatted by Wayne Bessie.
- Version 5 (1999) was revised by Karen Graham, Rick Bonar, Barb Beck, and Jim Beck to incorporate information from recent literature.

9. LITERATURE CITED


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