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Version 10

Note: This version incorporates a modified Location Factor, where the threshold limits for scores have been altered and the values for the lower limits have been raised somewhat.

A Susceptibility and Risk Rating System for the Spruce Beetle *Dendroctonus rufipennis*

L. Safranyik and T.L. Shore
Canadian Forest Service
Pacific Forestry Centre

INTRODUCTION

The spruce beetle susceptibility and risk rating system has been developed along the lines of the mountain pine beetle susceptibility and risk rating system developed by Shore and Safranyik (1992). This approach considers the short term risk of loss to a stand as a function of both stand susceptibility and beetle population pressure.

This manuscript is a work in progress and can be used to provide susceptibility and risk rating indices for the spruce beetle. The authors welcome all comments and criticisms and will incorporate useful suggestions in subsequent system revisions.

I. Overview of Characteristics included in the System

A. Characteristics Related to Stand Susceptibility

1. Site quality
2. Stand age
3. Stand density (growth rate)
4. Percentage susceptible spruce basal area
5. Stand location i.e. elevation, latitude, longitude, aspect

B. Characteristics Related to Beetle Population Pressure

1. Standing infested trees
2. Windthrow
3. Logging
4. Fire history

II. The Susceptibility Rating System (need to insert latest version with L factor updated)

The susceptibility rating model involves assigning scores (or weights) to the characteristics included in the system on the basis of available research and/or the authors' knowledge of the insect. Some of these scores have been adjusted to conform to the constraints of the system design (e.g. the relative weights of each characteristic in the system and the imposed constraint that the susceptibility index should range between 0 and 100), The rationale for the assigned scores and the mathematics involved in their incorporation into the model will be explained in a later section. The Susceptibility Index (S) is derived from two subset indices S_1 and S_2.

Calculation of S_1

Determine the scores for the following four variables:

1. Site Quality (Q)

	Site Class		
	Good	Medium	Poor
Score	1.14	0.60	0.27

2. Stand Age (A)

	Age of Dominant/Codominant Spruce		
	> 120	100 - 120	< 100
Score	1.21	0.74	0.07

3. Percentage susceptible spruce basal area (P)

This value is expressed as a percentage and is calculated as follows:

$$P = \frac{\text{basal area of spruce} \geq 25 \text{ cm}}{\text{basal area of all species} \geq 12.5. \text{ cm}} \times 100$$

4. Location (L)

This is a complex variable incorporating elevation, latitude and longitude. In addition, we have given extra weight to stands with a northerly aspect.

L = 24.4(Longitude) - 121.9(Latitude) - Elevation + 4408.1

	Value of Y			
Score (L)	Y ≥ 0	0 >Y ≥ - 400	-400 > Y ≥ - 900	Y < - 900
North	1.08	1.01	0.7	0.4
Other	1.01	0.94	0.6	0.21

Multiply the four scores: $S_1 = Q \times A \times P \times L$

Calculation of S_2

Stand density/growth rate (S_2)

Both stand density and growth rate are important characteristics influencing spruce beetle epidemics. These variables have been combined in the following equation:

$$Y = \frac{(99\,Z - 1)}{(Z + 1)}$$

where Y = estimate of % of spruce killed

$$Z = e^{(-0.53 - 1.92 \ln (X) + 0.006 (N))}$$

X = mean radial growth of spruce during past 5 years (mm)
N = number of **spruce** trees per ha ≥ 12.5 cm
e = 2.718 the base of natural logarithms

If mean radial growth (X) is unknown it can be estimated as a function of stand density by the equation:

$$X = 12.961 - 1.360 \ln (T)$$

where T = number of trees of **all species** ≥ 12.5 cm

Y is interpreted as follows:

	Y ≥ 40	39 > Y ≥ 20	Y < 20
Score (S_2)	0.67	0.40	0.13

Calculation of the Susceptibility Index (S)

The Susceptibility Index (S) is calculated in two parts (S_1 and S_2) and then combined as follows:

$$S = 10 \times (S_1 \times S_2)^{0.5}$$

III. Beetle Population Pressure Factors

A number of factors can be used to indicate the beetle population pressure on a given stand. Unlike the mountain pine beetle system where only infested standing trees are included, the spruce beetle system includes some sources of preferred host material such as windfall, logging debris, and fire-killed trees. While these may not initially be beetle population sources, experience has shown that due to the ubiquitous distribution of this insect this material likely will become infested quickly.

1. Windfall (W)

Choose the score associated with the description which best describes the windfall conditions in the stand.

Score	Description

1.0	Mature spruce windfall, down one to three years scattered in stand or small patch blowdown averaging more than 2 trees per 100 m transect across opening or more than 5 trees per 100 m along stand edges.
0.5	Same as above but averaging between 1 and 2 trees per 100 m transect in opening or between 2.5 and 5 trees per 100 m along stand edges.
0.2	Same as above but averaging less than 1 tree per 100 m transect in opening or less than 2.5 trees per 100 m transect along stand edges.
1.0	Sheet windthrow greater than 50 ha in the stand being assessed or the adjacent stands.
0.6	Same as above but 10 to 50 ha.
0.2	Same as above but less than 10 ha.

2. Standing Infested Trees (I)

The standing infested tree score is determined by estimating the number and proximity of infested trees affecting the stand being rated. To arrive at the score for this section, first determine the size category (small, medium or large) of the infestation from Table 1. After you have determined the size category of the infestation use Table 2 to determine the score for that size category.

Table 1. Use this table to determine the relative size of a spruce beetle infestation within 3 km of the stand being rated

Number of Infested trees outside stand within 3 km	Number of Infested Trees inside the Stand		
	< 2 per ha	2 - 6 per ha	> 6 per ha
≤ 6 per ha	Small	Medium	Large
> 6 per ha	Medium	Large	Large

Table 2. Use this table to determine the standing infested tree score (I)

Relative Infestation Size	Standing Infested Tree Score (I) Distance to Nearest Infestation (km)					
	in stand	0-1	1-2	2-3	3-4	4+
Small	0.4	0.3	0.2	0.1	0.08	0.05
Medium	0.7	0.6	0.5	0.3	0.2	0.08
Large	1.0	0.9	0.7	0.5	0.2	0.10

3. Logging (L)

Recent logging (within the previous two years) in stands adjacent to the stand being rated will provide breeding material for the spruce beetle.

Score	Size of Cutblocks
1.0	> 100 ha
0.5	50 - 100 ha
0.3	20 - 49 ha
0.2	5 - 19 ha
0.1	< 5 ha

4. Fire History (F)

Recent fires (within the previous two years) in stands adjacent to the stand being rated will provide breeding material for the spruce beetle.

Score	Size of Fire
1.0	> 100 ha
0.5	50 - 100 ha
0.3	20 - 49 ha
0.2	5 - 19 ha
0.1	< 5 ha

Calculation of a Beetle Pressure Index (B)

The Beetle Pressure Index (B) is calculated as the highest value of W, I, L or F.

V. Combining the Susceptibility Index and the Beetle Population Pressure Scores into a Risk Index (R)

A Risk Index (R) is determined as a function of stand susceptibility and beetle population pressure as follows:

$$R = 2.74[S^{1.77}\, e^{-0.0177S}][B^{2.78} e^{-2.78B}]$$

where: e = 2.718, the base of natural logarithms
S = the susceptibility index as calculated above
B = the beetle pressure index as calculated above

References

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