Mountain Pine Beetle

Dendroctonus ponderosae Hopkins
Coleoptera: Curculionidae

Safranyik, L.; Linton, D. A. 2002. Line transect sampling to estimate the density of lodgepole pine currently attacked by mountain pine beetle. Inform. Rpt. BC-X-392. Victoria, B. C.: Natural Resources Canada, Canadian Forest Service, Pacific Forestry Centre; 10 p.

Objective: To develop an efficient line transect method for estimating densities of trees infested by *D. ponderosae*, as judged by signs of recent beetle activity.

Abstract: Mountain pine beetle, *Dendroctonus ponderosae* Hopkins, is a serious pest of lodgepole pine, *Pinus contorta* Dougl. ex Loud, in western North America. Other hosts include ponderosa pine, *Pinus ponderosa* Dougl. ex Laws., sugar pine, *Pinus lambertiana* Dougl., and western white pine, *Pinus monitcola* Dougl. ex D. Don. Generally *D. ponderosae* will attack host pines stressed by mechanical or fire damage, growing on poor sites, attacked by pathogens or other insect pests, or are overmature or overcrowded. During outbreaks of *D. ponderosae*, even healthy trees may be attacked and extensive tree mortality may occur.

Regression analysis was used to determine the probability of correctly identifying lodgepole pines attacked by *D. ponderosae* located at varying distances from a transect line. Two cruisers independently walked and counted all infested trees along 36 50-m transects. Fixed plots were established over the center of each transect and all trees within each plot were examined for infestation. Prism sampling was also conducted at three locations along the transect line.

The relationship between the probability of detecting an infested tree and the perpendicular distance of an infested tree from the transect line was used to construct a detection curve (i.e., numbers of infested trees observed along the transect vs. the distance of observed trees from the transect). The detection curve was used to estimate $\hat{u}$ using the following equation:

$$\hat{A} = n/2L\hat{u}$$

where $\hat{A}$ = the general estimator of infested trees per unit area, n = the number of trees observed with an active infestation, L = transect length in meters, and $\hat{u}$ = an estimate of one half of the effective strip width about the line transect. Line transects conducted in southern British Columbia indicated that the density of currently infested lodgepole pines per hectare could be determined as $\hat{A} = 10{,}000nb/La^2$, where b and a are the slope and intercept of the detection curve and the other variables are defined as above. The estimate of $\hat{A}$ did not differ from estimates from the fixed plots and prism plots, but the line transect method took only 2–3 minutes on a 50-m line compared to approximately 15 minutes for conducting fixed or prism plots along the same ground. While experience in recognizing recently

infested trees did not appear to affect the average density of infested trees identified in this study, each cruiser should develop a personal detection curve and equation for estimating infested trees using this method. If cruisers work in pairs, the detection curve data for each pair can be combined into a single curve.

Sampling Procedure: Each cruiser should develop a personal detection function by conducting preliminary transect surveys. The total length of the preliminary transect should be long enough that a cruiser sights a minimum of 200 infested trees, but this minimum can be divided among separate transects.

Set a transect by pulling a 50-m tape taut on the ground. Walk along the length of this transect and tally all trees with signs of recent *D. ponderosae* activity on one side of the transect. Keep to a walking pace without stopping to examine any trees in detail. When a suspected infested tree is seen along the transect, record the distance of the tree along the 50-m tape from the start of the transect line. At the end of the transect, return to the starting point and proceed along the other side in the same manner.

Count and record the number of recently infested trees and their distances from the starting point on both sides of the transect, then measure and record the perpendicular distance of each observed tree from the transect line. Examine each observed tree to confirm that it is currently infested or not. Determine the maximum distance that a confirmed, attacked tree was observed from along the transect. Add 2 m to this distance to calculate the half-width of a fixed plot to be centered over the transect length. Examine each tree within the fixed plot and record whether it has a current infestation or not. Make note of all trees that cruisers did not observe from the transect.

Calculate the number of currently infested and noninfested trees per hectare using the fixed plot data. Sort the transect data into total trees per 2-m wide strips up to a maximum distance of 20 m from the transect line. Calculate the average proportions of confirmed infested trees, infested trees not observed from the transect, and trees misidentified as infested.

Construct a histogram for the mean number of confirmed, currently infested lodgepole pine trees detected by a cruiser along the transect (Y) against the distance of the trees from the transect line in 2-m increments (X). Estimate the value of $\hat{u}$ by integrating the detection curve from zero to a perpendicular distance equal to the x-intercept of a linear regression.

To use this method in practice, randomly establish transect lines through the area of interest and record the number of observed infested trees and the distance walked along the transect for each observation. The appropriate total length of a transect line (L) can be estimated using the following formula:

$$L = (c/CV^2)(L_1/n_1)$$

where c = the number of observed infested trees, CV^2 = the desired coefficient of variation, L_1 = the length of a preliminary walk along L, and n_1 = the number of observed infested trees along L_1.

Estimate the value of $\hat{u}$ as the integral from 0 to the point where the regression line intercepts the x-axis ($X = a/b$), with a = the intercept and b = the slope from the linear regression of the developed detection curve, so that $\hat{u} = a^2/2b$. Estimate the density of infested trees ($\hat{A}$) per hectare using the equation $\hat{A} = 10{,}000n/2L\hat{u}$, where n = the number of currently infested trees observed along the transect, including any trees that might prove to be uninfested with later examination, and L = the length of the transect.

Note: If trees are tallied on only one side of the transect, use the formula $\hat{A} = [n/2L\hat{u}]2$. Refer to the original publication for more detail on creating the detection curve and its use in estimating $\hat{u}$. A logistic regression may provide a better fit than a simpler linear regression.