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# ESTIMATING THE SNOW TRACK INDEX FOR AMERICAN MARTEN ON THE SAN JUAN NATIONAL FOREST, COLORADO

## Background

From December through March, 2005, 18 transects were sampled for American marten tracks on 3 ranger districts of the San Juan National Forest in southern Colorado. Ten transects were sampled on the Columbine Ranger District, 3 on the Dolores Ranger District, and 5 on the Pagosa Ranger District. Transects are the sampling units in this sampling design, and American marten tracks crossing or within 5 meters from transects are the elements measured in the design. Transects were stratified into 2 strata according to suitability of marten habitat. Across the San Juan National Forest, 88% of marten habitat is deemed suitable and 12% is deemed marginal.

## Estimating the Abundance of Marten with the Snow Track Index

Transects ranged in length from approximately 6 to 24 km ($\bar{x}$ = 13 km). Marten crossings were tallied each 0.4 km and summed across the length of each transect. Abundance of marten was calculated by dividing the sum of track crossings by the total length (km) of each transect. My statistical notation largely follows that of Schaeffer et al. (1996).

The estimator for the population mean ($\mu$) for a stratified random sample is:

$$\overline{\overline{y}}_{st} = \frac{1}{N}\sum_{i=1}^{L} N_i \bar{y}_i \qquad (1)$$

where $\overline{\overline{y}}_{st}$ = mean estimator for a stratified random sample, $N$ = number of sampling units, $L$ = total number of strata, and, $\bar{y}_i$ = mean for stratum $i$ computed as a simple random sample:

$$\bar{y} = \frac{\sum_{i=1}^{n} y_i}{n}$$

In the sampling protocol, tracks are only included in the data set when they cross the sampling unit or approach within 5 meters of the road prism on which observers travel (Ghormley 2005). Each transect is linear and the search area around each transect is ill-defined, varying from 5

meters to the exact point where tracks cross each transect, with observers making an effort to not count tracks that re-cross the transect; thus, transects, or sampling units are one-dimensional and results cannot be applied in a density context. The direct consequence of one-dimensional sampling units are that the an infinite number of sampling units exist on the landscape, hence obviating knowledge of *N*, or the total number of sampling units.

To compute a mean under these circumstances I modified the stratified random sampling estimator for one-dimensional sampling units. The area (*A*) of each stratum is incorporated in each estimator. This type of analysis is aided by computation of areas of each stratum in a GIS:

$$\overline{\overline{y}}_{st} = \sum_{i=1}^{L} \frac{A_i}{A} \bar{y}_i \tag{2}$$

Alternatively, if the proportionate area of each stratum is known, then that proportionate area can be included as a weight (w) for each stratum (*i*) in the computation of a mean:

$$\overline{\overline{y}}_{st} = \sum_{i=1}^{L} w_i \bar{y}_i \tag{3}$$

The variance estimator for $\bar{y}_{st}$ is:

$$\hat{V}(\bar{y}_{st}) = \frac{1}{N^2} \sum_{i=1}^{L} N_i^2 \left( \frac{N_i - n_i}{N_i} \right) \left( \frac{s_i^2}{n_i} \right) \tag{4}$$

Where,

$n_i$ = number of sampling units in stratum *i*, and
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$s_i^2$ = sample variance for stratum *i* computed as a simple random sample

Because $\left( \frac{N_i - n_i}{N_i} \right) \geq 0.95$ for each stratum, I removed the finite population correction $\left( \frac{N_i - n_i}{N_i} \right)$ and *N* to compute the variance as follows:

$$\hat{V}(\bar{y}_{st}) = \sum_{i=1}^{L} w_i^2 \left( \frac{s_i^2}{n_i} \right) \tag{5}$$

Standard errors (SE) are computed by taking the square root of the variance estimator above and confidence intervals are computed as $\overline{y_{st}} \pm t_{\alpha/2,\, n-1} \times \text{SE}$.

$$SE(\bar{y}_{st}) = \sqrt{\sum_{i=1}^{L} w_i^2 \left( \frac{s_i^2}{n_i} \right)} \qquad (6)$$

**Results and Discussion**

According to simple random sample estimators, $\bar{x} \pm$ SE American marten tracks/km were 1.3 ± 1.1 for the marginal stratum, and 1.0 ± 0.3 for the suitable stratum. American Marten tracks/km based on the weighted stratified random estimator for one-dimensional sampling units was 1.1 ± 0.3 (95% CI = 0.5–1.6). *Please see Excel spreadsheet for calculations.*

Because there were only 2 sampling units in marginal habitat, it would be advisable to increase the number of transects in an effort to reduce variation in the estimates. However, at present the number of transects is assigned proportional to the availability of each stratum across the landscape. Increasing samples in 1 stratum will thus result in a need to proportionally increase the number of samples in the second stratum. Power analysis and sample size computations should provide a better understanding of the number of samples needed to detect trend in the American marten snow track index.

**Literature Cited**

Ghormley, R. 2005. MIS monitoring plan for the American marten on the San Juan National Forest: initial monitoring protocol. San Juan National Forest, Colorado. March 2005.

Scheaffer, R.L., W. Mendenhall III, and R. L. Ott. 1996. Elementary survey sampling, 5th ed. Duxbury Press, Boston, MA.