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POWER ANALYSIS FOR ABERT'S SQUIRREL SIGN FREQUENCY COUNTS

Background

From 29 March through 2 June, 2005, 79 plots were sampled for Abert's squirrel feeding sign on the Columbine, Dolores, and Pagosa districts of the San Juan National Forest in southern Colorado. A grid of 256 sampling points was placed in each 60-acre sampling plot and fresh feeding evidence including green (or mostly green) clipped needle clusters, white peeled twigs, red or orange cone cores, and well-defined fungi digs without litter or soil obscuring the hole win 1-m^2 sampling quadrats was recorded (Ghormley 2005). Plots are the sampling units in this sampling design, and feeding evidence in 1-m^2 sampling quadrats are the elements measured in the design. Plots were stratified into 2 strata (optimal and marginal) according to suitability of Abert's squirrel habitat.

Sample Size and Power

- I used Program Monitor (Gibbs 1995) to evaluate power to detect trend over 2 time periods. I selected a 5-year trend analysis period because that is the period of interest outlined in the San Juan National Forest monitoring plan (Ghormley 2005). I also evaluated power based on a 10-year period, because the farther apart first and last sampling periods are, the more likely it is that trends in counts can be detected (Gibbs 1995). An additional purpose in evaluating power for a 10-year monitoring period is to compare to power based on a 5-year monitoring interval

- I computed power for both optimal and marginal strata with the n = 37 transects in marginal strata and n = 42 transects in optimal strata monitored in spring 2005

- In each strata I computed sign frequency for Abert's squirrel as $\text{sign frequency} = \left(\frac{\text{feeding sign counts}}{\text{adjusted sample points}} \right) \times 100$, where the standard 256 sample points were reduced when sample points in a plot were not found in ponderosa pine (*Pinus ponderosa*) habitat

- Program Monitor requires entry of standard deviations (SDs) of mean counts from each transect to incorporate temporal variation within transects. Because each transect was only visited once during the spring 2005, I had no measure of SD and thus computed SDs as 5%, 10%, and 25% levels of the mean track index. For example the 10% SD was computed as mean index × 1.10. To incorporate spatial variation, I entered a standard value for SD of 0.10

- Power was evaluated in 10,000 iterations and based on an exponential decline. I selected the exponential model because I assumed that decline in each successive observation would be proportional to the magnitude of the current population level (Thompson et al. 1998). For the exponential model, Program Monitor generates lognormal sample counts for each survey occasion (i.e., each year of monitoring) that are log-transformed prior to the regression analysis (Gibbs 1995). Lastly, I tabulated power results according to number of years of monitoring and temporal variation level (SD of the mean track index)

Results and Discussion

Average Abert's squirrel sign frequency in the marginal strata was 1.3 (SE = 0.3, range = 0.0–7.0, *n* = 37). In the optimal strata, average sign frequency was 2.0 (SE = 0.3, range = 0.0–7.0, *n* = 42). Zero index values were present at l3 (35%) of the total sample plots in the marginal strata (Table 1), and in the optimal strata, indices for 15 (36%) sample plots were zeros (Table 2).

For the marginal strata, power to detect a 10% decline in the frequency of Abert's squirrel sign ranged from 0.755 to 0.816 for a 5-year monitoring effort and from 0.957 to 0.972 for a 10-year monitoring effort (Table 3). For the optimal strata, power to detect a 10% decline in the frequency of Abert's squirrel sign ranged from 0.846 to 0.877 for a 5-year monitoring effort and from 0.988 to 0.992 for a 10-year monitoring effort (Table 3).

The intent of monitoring abundance of Abert's squirrel on the San Juan National Forest with a sign frequency index is to provide at least 80% power to detect a 10% annual decline in marten tracks over 5 years (Ghormley 2005). Power of 80% or higher to detect a 10% decline over 5 years of monitoring was achieved in the optimal strata at 3 levels of simulated temporal variation (Table 3). Power of 80% or higher to detect a 10% decline over 5 years in the marginal strata was not as high as in the optimal strata, but was no lower than 75.5% across the 3 levels of simulated temporal variation (Table 3). Monitoring over a longer period of time such as 10 years is an option that could be considered because the farther apart first and last sampling periods are, the more likely it is that trends in counts can be detected (Gibbs 1995). However, monitoring over a 5-year period may better meet forest planning needs.

`The most likely reason leading to low power is the high number of plots with 0 values. Removing some of these plots would result in lower variation among transects. It is recommended that if plots are to be removed then they should be from the list of those with 0 frequencies. However, because the goal is to evaluate squirrel abundance across the landscape, it is important to monitor areas with little squirrel activity. It is probable that in following years, squirrel sign will be detected in areas with 0 counts in 2005. Because the frequency index is used as input into an actual density estimate (Ghormley 2005), it is best to evaluate power with density estimates, and not the index used to compute them. I will wait for this regression equation before proceeding.

Literature Cited

Ghormley, R. 2005. MIS monitoring plan for the Abert's squirrel on the San Juan National Forest: initial monitoring protocol. San Juan National Forest, Colorado. May 2005.

Gibbs, J. P. 1995. Monitor version 6.2 users manual. Exeter Software, Setauket, New York, USA.

Thompson, W. L., G. C. White, and C. Gowan. 1998. Monitoring vertebrate populations. Academic Press, San Diego, California.

Table 1. Frequency of Abert's squirrel sign from 37 sampling points in marginal strata monitored from April–June 2005, San Juan National Forest, Colorado.

Plot (Grid) #	Ranger district	Sample date	Number sample points	Adjusted sample points[a]	Feeding sign count	Adjusted frequency index[b]
Armstrong Canyon	Columbine	10/05/2005	256	256	0	0.001
Bear Creek	Columbine	02/05/2005	256	256	6	2.344
Blind Gulch	Columbine	09/05/2005	256	232	0	0.001
Bull Creek	Columbine	26/04/2005	256	256	0	0.001
Carson Creek	Columbine	28/04/2005	256	256	0	0.001
First Notch	Columbine	20/04/2005	256	256	18	7.031
Haviland Lake	Columbine	25/04/2005	256	256	5	1.953
Ignacio Creek #2	Columbine	31/05/2005	256	252	2	0.781
Middle Sauls Creek	Columbine	19/04/2005	256	237	0	0.001
Sawmill Canyon	Columbine	16/05/2005	256	256	17	6.641
Burns Canyon	Pagosa	02/04/2005	256	256	9	3.516
Devil Mountain	Pagosa	01/04/2005	256	256	0	0.001
East Fork Piedra	Pagosa	12/05/2005	256	256	8	3.125
Echo	Pagosa	22/04/2005	256	256	0	0.001
Fawn Gulch	Pagosa	31/03/2005	256	256	0	0.001
Hotz Spring	Pagosa	21/04/2005	256	256	0	0.001
Monument Park	Pagosa	21/04/2005	256	256	1	0.391
Rito Blanco	Pagosa	16/04/2005	256	256	6	2.344
Sheep Cabin Spring	Pagosa	16/04/2005	256	256	1	0.391
South Laughlin	Pagosa	17/04/2005	256	256	0	0.001
Treasure	Pagosa	29/03/2005	256	256	1	0.391
Turkey Mountain	Pagosa	14/04/2005	256	256	1	0.391
Aaron Reservoir	Dolores	24/05/2005	256	256	4	1.563
Boggy Draw	Dolores	02/06/2005	256	256	5	1.953
Colt Reservoir	Dolores	02/06/2005	256	256	1	0.391
Cow Canyon	Dolores	25/05/2005	256	256	1	0.391
Doe Canyon	Dolores	23/05/2005	256	256	0	0.001
Haycamp Point	Dolores	31/05/2005	256	256	1	0.391
Hoppe Point	Dolores	01/06/2005	256	256	5	1.953
Horsetooth Reservoir	Dolores	30/05/2005	256	256	0	0.001
Narraguinnep	Dolores	19/05/2005	256	256	0	0.001
Smoothing Iron	Dolores	01/06/2005	256	256	8	3.125
Spruce Water Canyon	Dolores	01/06/2005	256	256	1	0.391
Trimble Point	Dolores	12/05/2005	256	256	8	3.125
Waterhole	Dolores	31/05/2005	256	256	1	0.391
Wild Bill	Dolores	23/05/2005	256	256	9	3.516
Wolf Den	Dolores	18/05/2005	256	256	2	0.781

[a]Adjusted to represent the number of sample points in ponderosa pine habitat.

[a]Frequency index adjusted by dividing the feeding sign count by the number adjusted sample points.

Table 2. Frequency of Abert’s squirrel sign from 42 sampling points in optimal strata monitored from April–May 2005, San Juan National Forest, Colorado.

Sampling unit	District	Sample date	Original sample points	Adjusted sample points[a]	Feeding sign counts	Adjusted frequency index[b]
Chris Park	Columbine	21/04/2005	256	244	7	2.9
Dry Lake Reservoir	Columbine	27/04/2005	256	256	11	4.3
East Creek	Columbine	12/05/2005	256	256	3	1.2
Fosset Gulch	Columbine	25/05/2005	256	256	14	5.5
Indian Creek West	Columbine	09/05/2005	256	253	3	1.2
Junction Creek East	Columbine	21/04/2005	256	256	5	2.0
Saul's Creek	Columbine	20/04/2005	256	256	0	0.0
Saul's Creek	Columbine	02/06/2005	256	256	5	2.0
Scaffold Lick	Columbine	02/05/2005	256	216	0	0.0
Shamrock	Columbine	18/04/2005	256	256	7	2.7
Tripp Gulch	Columbine	05/05/2005	256	256	0	0.0
Turkey Creek	Columbine	26/04/2005	256	240	0	0.0
Peterson Gulch	Columbine	13/06/2005	256	256	12	4.7
Upper Bull Canyon	Columbine	21/05/2005	256	256	0	0.0
Ice Cave Ridge	Pagosa	04/05/2005	256	256	17	6.6
Kenney Flats A	Pagosa	17/05/2005	256	256	6	2.3
Kenney Flats C	Pagosa	04/04/2005	256	256	1	0.4
Kenney Flats H	Pagosa	02/04/2005	256	256	0	0.0
Lower Horse Creek	Pagosa	25/05/2005	256	256	0	0.0
Lower Valle Seco	Pagosa	13/04/2005	256	256	6	2.3
Piedra	Pagosa	28/05/2005	256	256	6	2.3
Turkey Springs A	Pagosa	19/04/2005	256	256	9	3.5
Turkey Springs D	Pagosa	09/04/2005	256	256	0	0.0
Turkey Springs E	Pagosa	18/04/2005	256	256	0	0.0
Turkey Springs G	Pagosa	20/04/2005	256	256	0	0.0
Turkey Springs I	Pagosa	09/04/2005	256	256	0	0.0
Turkey Springs K	Pagosa	11/04/2005	256	256	18	7.0
Bean Canyon	Dolores	28/04/2005	256	256	10	3.9
Bean Reservoir	Dolores	10/05/2005	256	256	0	0.0
Big Water	Dolores	18/05/2005	256	256	6	2.3
Dunham Point	Dolores	25/05/2005	256	256	11	4.3
East Lost Canyon #2	Dolores	17/05/2005	256	256	0	0.0
Italian Canyon	Dolores	10/05/2005	256	256	18	7.0
Joe Moore	Dolores	16/05/2005	256	256	4	1.6
Lake Clydia	Dolores	19/05/2005	256	256	12	4.7
Little Bill	Dolores	17/05/2005	256	256	7	2.7
Little Buck Canyon	Dolores	18/05/2005	256	256	1	0.4
McPhee Park	Dolores	06/05/2005	256	256	0	0.0
Millwood	Dolores	17/05/2005	256	256	0	0.0
Plateau	Dolores	26/05/2005	256	256	4	1.6
Trail Canyon	Dolores	25/05/2005	256	256	2	0.8

[a]Adjusted to represent the number of sample points in ponderosa pine habitat.

[b]Frequency index adjusted by dividing the feeding sign count by the number adjusted sample points.

Table 2. Power to detect 10%, 5%, and 3% decline in trend of the mean frequency index of Abert's squirrel sign across 5 and 10 years in marginal and optimal strata. Power analysis based on 37 sampling units (plots) in marginal and 42 sampling units (plots) in optimal strata in suitable ponderosa pine habitat on the San Juan National Forest, spring 2005. The power analysis was one-tailed at alpha = 0.20, and included a trend variation (SD = 0.10) parameter to represent spatial variation, which considered the degree to which a given trend varies at random among the sampling units within strata. To represent temporal variation in sign frequency for each transect, SDs of the mean were computed as 5%, 10%, and 25% of the frequency index. Power analysis was conducted with Program Monitor (Gibbs 1995).

	Standard Deviation of the Mean Frequency Index		
Decline in trend	5%	10%	25%
Marginal strata			
5 years			
–0.10	0.816	0.794	0.755
–0.05	0.509	0.508	0.480
–0.03	0.368	0.354	0.339
10 years			
–0.10	0.972	0.968	0.957
–0.05	0.640	0.628	0.590
–0.03	0.375	0.375	0.356
Optimal Strata			
5 years			
–0.10	0.877	0.868	0.846
–0.05	0.569	0.562	0.531
–0.03	0.402	0.392	0.372
10 years			
–0.10	0.992	0.992	0.988
–0.05	0.736	0.726	0.690
–0.03	0.466	0.444	0.419