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Date: January 11, 2001

Subject: Comments on the Hunsaker et al. manuscript, "Relations Between Occurrence and Productivity of California Spotted Owls and Canopy Cover," and its use in the FEIS.

To: Kent Connaughton and Peter Stine
Sierra Nevada Framework for Conservation and Collaboration
801 I Street, Room 419
Sacramento, CA 95814

Dear Kent and Peter,

In an earlier email correspondence to Peter and other members of the SNFP staff (12/21/00), and again in the conference call that we collectively participated in with Brad Powell, Garland Mason, and Jim Baldwin (ca. 12/22/00), I raised concerns about inferences drawn by SNFP staff from the Hunsaker et al. (2000) California spotted owl (CASPO) productivity study. My concerns were twofold. First, it appeared that statements were being made in the FEIS, and attributed to Hunsaker et al., which could not be inferred legitimately from that report. More importantly, such specious inferences were being used both as a rationale for developing standards and guides, and as the basis for evaluating the relative effectiveness of varying management alternatives. Given the prominence of the Hunsaker et al. report in the FEIS, I believed that a more critical examination of the data was warranted.

Since our earlier conversations, Carolyn Hunsaker and George Steger graciously provided their data to me and I've been able to analyze the data directly. Thus, now I can more thoroughly examine a range of inferences that might be made. I describe my analysis and what it suggests in the attached document, but here is a brief summary of my conclusions:

- The sampling framework used in the Hunsaker et al. study generates an unavoidable bias in the results. That is, some sites are predisposed to have lower productivity scores than others simply because of the years in which they were (or were not) sampled. This bias was not accounted for in the original analysis. A nonparametric resampling routine adjusts for bias and permits more robust comparisons.
- Adjusted for bias, there are statistically significant differences in canopy cover between productive and non-productive sites, as defined by Hunsaker et al. The relationship between canopy cover and relative productivity is not the same, however, in productive and non-productive sites.
- In non-productive sites (generally sites where nesting has never been observed), the chances of observing a pair of owls rather than single owls increases with increasing canopy cover.
- In productive sites (generally sites where owls have actively nested), there is no apparent relationship between canopy cover and relative productivity. That is, increased canopy cover is not positively correlated with increased productivity provided the site has sufficient canopy cover to support active nesting. More is not better.

- Nesting criteria, defined as the levels of canopy cover above which 1) active nesting occurs, and 2) further increases in canopy cover have no measurable effect, can be defined in a variety of ways. No criteria are without flaw. A reasonable choice for nesting criteria given the data is 50% of the larger home range should have 50% or greater canopy cover and no more than 25% of the home range should have less than 20% canopy cover.
- The choice of the SNFP standard of 60% of the home range in 50% or greater canopy cover cannot be scientifically defended using the Hunsaker et al. data. It performs poorly in distinguishing productive sites from non-productive sites, and being above or below the standard confers no apparent advantage among active nest sites.

Please see the attached document for details. As always, I'm available to discuss these findings with you or your staff.

Sincerely,

/s/ Danny C. Lee

Danny C. Lee

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January 11, 2001

Supplemental Analysis of Relations Between Occurrence and Productivity of California Spotted Owls and Canopy Cover in the Sierra National Forest

Danny C. Lee
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Introduction

In the document, "Relations between occurrence and productivity of California spotted owls," Hunsaker and others (2000)[1] present an analysis of 49 potential owl nest sites in the Sierra National Forest. In the words of the authors:

> We examined the variability of relations between occurrence and productivity of California spotted owls (*Strix occidentalis occidentalis*) and canopy cover based on two different sources (aerial photography and satellite imagery, Landsat Thematic Mapper). Analysis areas for owl use were based on telemetry data for sixteen owls collected during the breeding period. Nine years of demographic data provided the empirical information for defining occurrence in terms of occupancy and productivity. Three hypotheses were evaluated: (1) no difference between the composition of canopy-cover classes in the study area as a whole and in sites used by spotted owls, (2) no difference in the composition of canopy-classes among analysis areas exhibiting different levels of occupancy and productivity, and (3) no difference in conclusions about relations between owl occupancy and productivity and canopy-cover classes based on aerial photography or Landsat. We rejected all three hypotheses.

The Hunsaker report takes on particular importance within the Sierra Nevada Forest Plan Amendment Process (SNFP). In the FEIS, the Hunsaker report is prominently cited as the basis for statements about the inadequacy of existing forest conditions to support spotted owls. Furthermore, median canopy cover values have been taken from the report and proposed for use as management standards. Clearly, such use of the report goes beyond testing of the simple hypotheses identified above by the research study authors.

The potential ramifications of taking Hunsaker et al.'s research results and applying them directly to management decisions in the Sierra Nevada are large. Thus, careful scrutiny of the study is warranted to better define defensible inferences, and to evaluate the reasonableness of management direction purportedly based on the study. I report here on my reexamination of some of the data used by Hunsaker et al., focusing on the relationship between canopy cover and occupancy and productivity. I did not look at

[1] Hunsaker, C. T., B. B. Boroski, G. N. Steger, and J. Verner. 2000. Relations between occurrence and productivity of California Spotted owls and canopy cover. USDA Forest Service, Pacific Southwest Research Station, Fresno, CA. 21 pp. For brevity, this report is referred to hereinafter as the Hunsaker report.

hypotheses (1) and (3), above. In terms of management direction, my analysis is limited to whether the research data suggest empirically based criteria, defined in terms of desired levels of canopy closure, which will promote increased occupancy and productivity of spotted owls.

Study Area and Data

The study area and methods for collecting data are well described in the Hunsaker report and are not repeated here. My analysis uses two components of their data, graciously provided by Carolyn Hunsaker and George Steger. The first component is the productivity indices by year for the 49 sites on the Sierra National Forest (Table 1; table 5B-1 in the Hunsaker report). The yearly productivity indices are averaged to produce a summary score. If the summary score is less than or equal to 2, then the site is designated "non-productive." Otherwise, the site is classified as "productive." Eighteen sites were classified as non-productive versus 31 productive sites. Of the 18 non-productive sites, 16 are sites where no active nesting was reported. That is, single owls or pairs were observed on these sites, but no attempt at nesting was reported (Figure 1). The two remaining non-productive sites report only one nesting attempt each during the period of study. Both attempts were in the early years of the study (1990 and 1992) and both very successful, with 2 fledglings at one site and 3 fledglings at the second.

The second data component used in the analysis is the corresponding estimates of percent area in five canopy-closure classes (0-19%, 20-39%, 40-49%, 50-69%, and 70-100%), estimated using aerial photographs for each of three analysis areas (72, 168, and 430 hectares). Three additional summary classes were created that represent percent area with greater than 20%, greater than 40%, and greater than 50% canopy closure by summing the area in the upper 4, 3, and 2 classes respectively.

<u>Potential for Bias</u>

It is immediately apparent from inspection of Table 1 that missing values make up a substantial portion of the data matrix. More importantly perhaps, the pattern of missing values is not random with respect to time. For example, 19 sites were not sampled prior to 1994 and several sites have gaps of two years or more. This pattern of missing years confounds potential site effects with time effects to create sampling artifacts. For example, if there is a trend (in time) in the data, then sites sampled only in the latter portion of the sample period will have different expectations than sites measured during the entire period. It is not necessary that a definite trend exists; there only has to be a substantial "year" effect (i.e., substantive differences between years) to potentially bias the results. The trend of concern here is different than a trend in population numbers, hence the "lambda" discussions are not particularly relevant. Annual variation in recruitment that makes certain years more productive than others across all sites is widely known for spotted owls, and is a potential source of bias.

For example, consider sites 38, 58, 84, 228, 230, and 234. In years that all six sites were measured (1994-1998), they exhibit identical results, which are constant index values of 2 in each year. Such results provide no reason to distinguish among sites. Sites 38, 58, and 84, however, were also observed in years 1990-1993; each observed site had at least one year in the early period when multiple fledglings were produced. We cannot judge whether sites 228, 230, and 234 might also have produced fledglings in that period; there are no data. Under the protocol used by Hunsaker and others, sites 38, 58, and 84 are classified "productive," while sites 28, 230, and 234 are "non-productive."

Notably, 11 (out of 19 possible) of the 18 "non-productive" sites have no pre-1994 data, compared to only 7 non-productive sites (out of 30 possible) with pre-1994 data. The average number of years in the sample for productive sites is 7.5; the non-productive mean is 5.2. These observations are sufficient to raise questions about the appropriateness of traditional statistical tests with underlying assumptions of random sampling. It does not matter if one finds a "significant difference" in site characteristics (e.g., canopy cover) between productive and non-productive sites if certain sites are predisposed to be judged non-productive based on the sampling scheme, independent of whatever effect the site characteristic might have.

In the Hunsaker report, Pearson correlation coefficients were calculated between productivity scores and the proportion of site with canopy cover greater than 50% (Hunsaker table 5B-4). The reported probability values associated with the correlation coefficients could be in error because they do not account for bias introduced by the sampling scheme. In addition, median canopy cover values were reported for productive and non-productive sites. No statistical comparison of these median values was attempted. Regardless of whether a statistical test was made, the principle is much the same. One cannot judge the importance of an observed difference, and certainly cannot ascribe causality, without adjusting for potential bias appropriately.

Reanalysis Using Permutation Tests

While a bane for standard statistical tests (especially the pre-packaged kind), bias offers no particular obstacle to non-parametric tests based on resampling or permutation tests.[2] Rather than rely on mathematical formulas and assumptions about normalcy and randomization, permutation tests are computer intensive techniques in which the expected distribution of the test statistic under the null hypothesis is generated from the observed data. Permutation tests are relatively straightforward in both theory and application, as the following analysis of the spotted owl data demonstrates.

The first step in the analysis is to choice which elements of the experiment will remain constant versus which elements will be resampled using bootstrap techniques. The central question that I am interested in is whether site characteristics, as measured by canopy cover, affects owl occupancy and reproduction. For each site, there is a suite of canopy measurements, and there also is a sampling frame (i.e., a set of years in which observations were made). These two are considered fixed elements of the experimental design. We also know that "year" is an important indicator of environment conditions

[2] See Efron, B., and R. J. Tibshirani [1993. An introduction to the bootstrap. Chapman and Hall, New York] for an excellent overview of resampling methods.

that determines reproduction. For the moment, I am not interested in measuring the year effect, only in controlling its influence on potential test statistics.[3] The random elements within the experiment are the yearly productivity indices. Under a null hypothesis of no difference among sites, the expected productivity index should be the same for all sites. Any particular realization of the experiment would represent a random draw of productivity values from an appropriate probability distribution.

To simulate an experiment under the null hypothesis of no difference among sites, all of the observed productivity values are pooled by year to create annual empirical frequency distributions. A data vector for each site in turn is then simulated by randomly drawing with replacement from these annual distributions, depending on whether that site was sampled in that year. Once an appropriate series of productivity values has been randomly assigned to each site, then a set of summary statistics can be generated. For example, summary productivity scores can be calculated for each site, sites can be classified as productive or not, and correlation coefficients can be calculated between productivity values and site characteristics.

This simulation process is repeated over and over to replicate the stochastic nature of the experimental process. The end results are frequency distributions for each data element and for all summary statistics that can be calculated from the data. If enough simulations are done correctly, then the computer-generated frequency distribution should approximate the probability distribution of any statistic of interest that can be calculated from the data. Comparing the observed statistic from the real-world data with the computer-generated distribution provides a measure of significance. For example, if the observed correlation between summary productivity scores and mean canopy closure is greater then the 95th percentile value of the null frequency distribution, one is justified in stating that it is highly unlikely that the null hypothesis is correct given the observed data (i.e., reject the null hypothesis). Alternatively, if the observed value resembles the median value of the distribution, one can be comfortable concluding that the null hypothesis is likely correct.

For the spotted owl analysis, the simulation procedure described above was repeated 20,000 times. For each realization, summary statistics were calculated and sites were classified as productive or non-productive based on the summary productivity scores. Empirical frequency distributions for all summary statistics were tabulated using the SAS© PROC Univariate procedure. Comparisons were made between the sample-based statistics and percentile values of the computer generated statistics (i.e., the value that corresponds to the simulated 90th, 95th, and 99th percentile). No attempt was made to precisely estimate probabilities for a given statistical value.

Results

The results of the simulation under the null hypothesis allow one to quantify the suspected bias imparted by the sampling scheme. In some ways, bias is of less importance once the resampling approach has been evoked because the test statistics is

[3] If I were interested in estimating the year effect, I'd worry about bias introduced by different sites.

generated with the same bias as the original data. Nevertheless, it's of some academic interest if only to demonstrate that the permutation tests were worth the effort. Figure 2 depicts the observed summary productivity scores plotted against the expected value for each site, where expected value is simply the mean value observed in the simulated null hypothesis scenario. The spread of points along the horizontal axis (expected values) in Figure 2 validates the concern that the sampling scheme favors some sites over others in terms of expected value. Interestingly, the correspondence between expected value and observed value is not overtly strong. The number of non-productive sites in the original data, 18, is also significantly more ($p<0.05$) than the expected number under the null hypothesis, 12.8. Collectively, this information suggests that there are explanatory factors other than sampling bias in play.

Consistent with the analysis in the Hunsaker report, I calculated Pearson regression coefficients (r) between productivity scores and the aerial extent of each site with greater than 50% canopy cover. I made the same calculations for aerial extent with greater than 40% canopy cover, and with greater than 20% canopy cover. I estimated these statistics for all sites combined, and for productive and non-productive sites independently (Table 2). I also calculated the difference in median canopy cover values for productive versus non-productive sites. Probability values (p) for each statistic were based on one-tailed comparisons with computer-generated percentile values, looking at the positive, upper end of the distribution.

The statistics summarized in Table 2 indicate some interesting properties of this data set. Consistent with results in the Hunsaker report, the correlation between site productivity and area with 50% or greater canopy cover is significant (Hunsaker table 5B-4). Based solely on the correlation coefficients, the relationship between productivity and canopy cover is strengthened if the 40-50% canopy class is grouped with the higher canopy levels. As the Hunsaker report notes, productive sites have higher median values for area with 50% or greater canopy cover than nonproductive sites. My analysis suggest that the difference is not significant in the inner 72 ha area, nor do differences in other zones exceed expectations as much as one might think. The expected values of the differences in medians remind us again of the extent of the sampling bias.

The story does not end here, however. The most insightful result is what happens when the productive sites are separated from the non-productive sites. When productive sites are evaluated independently, the correlation between productivity and canopy cover drops to essentially zero. Figure 3 provides a graphical view of this relationship for the 430 ha assessment area. Points above the horizon line (productivity index > 2) show no relationship between productivity and the percentage of area with 50%+ canopy cover. If anything, the trend is negative, as indicated by the negative (but non-significant) correlation of –0.1. Similar patterns are evident in the 72 and 168 hectare areas, whether the 40%+ or 50%+ canopy classes are used (Figures 4-6).

The significance of the correlation in the overall comparisons appears to be an artifact of pooling of the two samples. This is a familiar phenomenon to those who understand how to lie with statistics. The significance of any sample correlation can be enhanced by strategically adding large numbers of uncorrelated observations. In this case, I'm confident of no intent to deceive. The nature of the data is that the productive observations lie to the upper right of the non-productive sites in the bivariate space (Figure 3). Thus, an extrapolation of the regression line through the non-productive observations and on through the productive observations does not change the magnitude of the correlation substantively, while the addition of more observations increases the precision of the statistical estimate (and hence significance). If instead the productive observations had fallen coincident with the non-productive observations, then the positive correlation in the non-productive sites would have been lost in the overall correlation.

Potential Management Implications

Given that the productivity-canopy cover relations are clearly different in the productive and non-productive sites, it is useful to review what constitutes each class. If I understand the productivity index correctly, non-productive sites are almost exclusively sites where no active nesting was observed. The difference between a low score (0 or 1) and a high score (2) in non-productive sites is one of occupancy. That is, are there no owls, single owls, or pairs of non-nesting owls on that site? In contrast, productive sites are distinguished by having active nesting observed sometime in the past on the site. Relative differences among productive sites speak to the frequency with which the nesting pairs successfully fledged young. My analysis of the data from the Hunsaker report suggests that owls preferentially nest in areas having higher levels of canopy closure than areas that they don't nest in. This comes as no surprise given the existing literature and conventional wisdom.

The data do not support the hypothesis that ever-increasing amounts of canopy cover will improve owl productivity, as measured by fledgling success, in areas suitable for nesting. There is not even a hint of such a relationship. Interestingly, the top 7, and 8 of the top 10 productive sites have 30% or more of the larger 430 ha area in canopy closure of less than 40%. This doesn't look like coincidence, and challenges the notion that more is always better, a question that Alan Franklin's work with northern spotted owls also strongly refutes. Also recall that in the two non-productive sites where a single nesting attempt did take place, these attempts were very successful. Both of these sites appear to lack the canopy cover features (they have less) of other active nesting sites. There is more to this riddle than we have discerned thus far.

There remains the question of how to translate inferences drawn from these data into management direction. One suggestion has been to establish a standard for owl habitat based on the median value for productive sites: owl home ranges would be managed to have 60% or more of the home range in 50% or greater canopy cover (the 60/50 rule). How well would such a criterion distinguish productive sites? Applied to the data in hand, 13 of 18 (72%) of the non-productive sites would be corrected classified as non-productive (Table 3, Figure 7). Fifteen of 31 (48%) of the productive site would also be incorrectly identified as non-productive, including some of the most productive sites on the Sierra National Forest. One can easily imagine valuable resources being expended (or opportunities forgone) in trying to achieve higher canopy levels in these erroneous labeled “non-productive” sites. To what avail? There is no indication that increasing canopy cover in productive nest sites will make them more productive, and it could place them at higher risk to other types of disturbance.

It is important to establish nesting criteria based on the data that are reasonably accurate in distinguishing both productive and non-productive sites. If sites are correctly labeled, then scare resources can be focused on the truly non-productive areas (with potentially more flexibility in managing the national forests). Based on a quick visual inspection of the data, one alternative is 50% of the home range in 50% or greater canopy cover and no more than 25% of the home range with less than 20% canopy cover. Applying this alternative (with rounding to the nearest %) to the data in hand, 11 of 18 (61%) non-productive sites and 27 of 31 (87%) productive sites are correctly classified. While the prediction of non-productive sites is marginally poorer (2 additional sites are misclassified), there is substantial improvement is identifying productive sites (11 more sites are correctly identified). Even better performance might be achieved through additional analysis. Tailoring this standard to natural vegetation potential in different bioregions is a logical next step.

Table 1. Productivity indices for California spotted owls on the Sierra National Forest.

Site ID	1990	1991	1992	1993	1994	1995	1996	1997	1998	Summary score	Years surveyed
3	2			1	1	0	0	0	0	0.571	7
4	7	2	8	2	8	2	2	2	4	4.111	9
5			0	1		1	0	1		0.600	5
6	7			1	1	2	2	2	4	2.714	7
9					2	1	0	0		0.750	4
15	2				0	0	0	0		0.400	5
25	8	7	7	2	4	4	2	1	7	4.667	9
31						0	1	0	1	0.500	4
33	8		7	7	2	2	2	0		4.000	7
35	2	2	9	2	7	2	7	2	2	3.889	9
36	2	1		0	0	0	0	0	0	0.375	8
38	2	2	8	8	2	2	2	2	2	3.333	9
41	2	2	4	7	4	4	4	2	4	3.667	9
43	2		9	2	2	2	2	0	2	2.625	8
48	1	2	7	2	2	2	2	2	0	2.222	9
49	8	2	9	4	4	4	2	4	0	4.111	9
53	8	2	8	8	2	1	2	2	1	3.778	9
57		7	8	2	0	0	0	0		2.429	7
58	2	7	8	2	2	2	2	2	2	3.222	9
61	7	7	8	8	4	2	2	2	7	5.222	9
62	8	2	2	8	2		0	0		3.143	7
64		1	9	2	4		2	8	4	4.286	7
65	7	2	7	8	2	4	4	2	1	4.111	9
67	2	2	8	4	7	2	2	2	2	3.444	9
70	2	1	1	1	2	1	0	1		1.125	8
77	8	2	9	7	2	2	2	2	1	3.889	9
80	8	2	0	1	1	0	0	0		1.500	8
83	1	2	9	2	2	0	0	0	0	1.778	9
84	2	2	8	2	2	2	2	2	2	2.667	9
87	2		7	2	7	2	8	8	2	4.750	8
91b									4	4.000	1
91a	8	4	8	2	4	4	2	2	4	4.222	9
100	1	2	8	2	8	2	2	2	2	3.222	9
219					2	2	1	2	2	1.800	5
221					7	2	2	8	2	4.200	5
225						2	0	0		0.667	3
227					2	2	2	2		2.000	4
228					2	2	2	2	2	2.000	5
229b					1		2	1	2	1.500	4
229a					8	2	2	2	2	3.200	5
230					2	2	2	2	2	2.000	5
234					2	2	2	2	2	2.000	5
239					8	2	8	2	0	4.000	5
241					8	2	2	2	8	4.400	5
244					2	7	2	2	1	2.800	5
245					8	2	2	2	2	3.200	5
247					8	2	2	8	7	5.400	5
257							2	0		1.000	2
266					2		0	0		0.667	3
Average	4.4	2.8	6.8	3.4	3.5	1.9	1.9	1.9	2.4	2.779	6.6

Legend: 0 = no owls; 1= single owl; 2=non-nesting pair; 4=failed nest; 7=one fledgling; 8=two fledglings; 9=three fledglings. Summary score = (sum of annual scores / years surveyed).

Table 2. Pearson correlation coefficients calculated between site productive scores and canopy cover measurements. Probability values are estimated using a permutation test involving 20,000 replicates. Differences in medians are between productive and non-productive sites.

Analysis Area	**72 hectare**			**168 hectare**			**430 hectare**		
Canopy Cover	**20% +**	**40% +**	**50% +**	**20% +**	**40% +**	**50% +**	**20% +**	**40% +**	50% +
				Correlation coefficients					
Productive sites *(n=31)*	-0.09	0.05	-0.02	-0.1	-0.03	0.01	-0.01	-0.2	-0.09
Prob. (p)	.5<p<.75	.25<p<.5	.25<p<.5	.5<p<.75	.5<p<.75	.25<p<.5	.75<p<.9	.75<p<.9	.25<p<.5
Non-prod. sites *(n=16)*	-0.19	0.59	0.69	-0.23	0.55	0.61	-0.11	0.54	0.65
Prob. (p)	.50<p<.75	.01<p<.05	.01<p<.05	.75<p<.90	.05<p<.10	.01<p<.05	.50<p<.75	.01<p<.05	.01<p<.05
All sites *(n=49)*	0.1	0.45	0.3	0.23	0.45	0.35	0.32	0.42	0.37
Prob. (p)	.25<p<.5	p<.01	.01<p<.05	.05<p<.1	p<.01	.01<p<.05	.01<p<.05	p<.01	p<.01
				Median Aerial Extent					
Productive sites *(n=31)*	93%	83%	75%	91%	77%	67%	89%	70%	60%
Non-prod. sites *(n=16)*	87%	72%	63%	81%	64%	57%	81%	60%	49%
Difference	5.5%	11.3%	11.5%	9.7%	13.1%	10.7%	7.6%	10.5%	10.7%
Prob.(p)	.05<p<.1	.05<p<.1	.1<p<.25	.01<p<.05	p<.01	.01<p<.05	.1<p<.25	p<.01	.01<p<.05
Expected difference	-0.7%	3.2%	5.8%	0.6%	3.8%	4.8%	3.0%	2.2%	4.4%

Table 3. A comparison of two criteria for distinguishing productive and non-productive sites, as applied to the data from the Sierra National Forest.

Rule 1. 60% or more of the home range is in 50% or greater canopy cover.

Classification by Rule 1	*Observed*		*Total*
	Non-productive	Productive	
Non-productive	13 (72%)	15 (48%)	28 (57%)
Productive	5 (28%)	16 (52%)	21 (43%)
Total	18	31	49

Rule 2. 50% or more of the home range is in 50% or greater canopy cover, and 25% or less of the home range is in 20% or less canopy cover.

Classification by Rule 2	*Observed*		*Total*
	Non-productive	Productive	
Non-productive	11 (61%)	4 (13%)	15 (31%)
Productive	7 (39%)	27 (87%)	34 (69%)
Total	18	31	49

Figure 1. Summary productivity scores plotted versus maximum observed annual value. Sites with summary scores of 2 or less are considered non-productive.

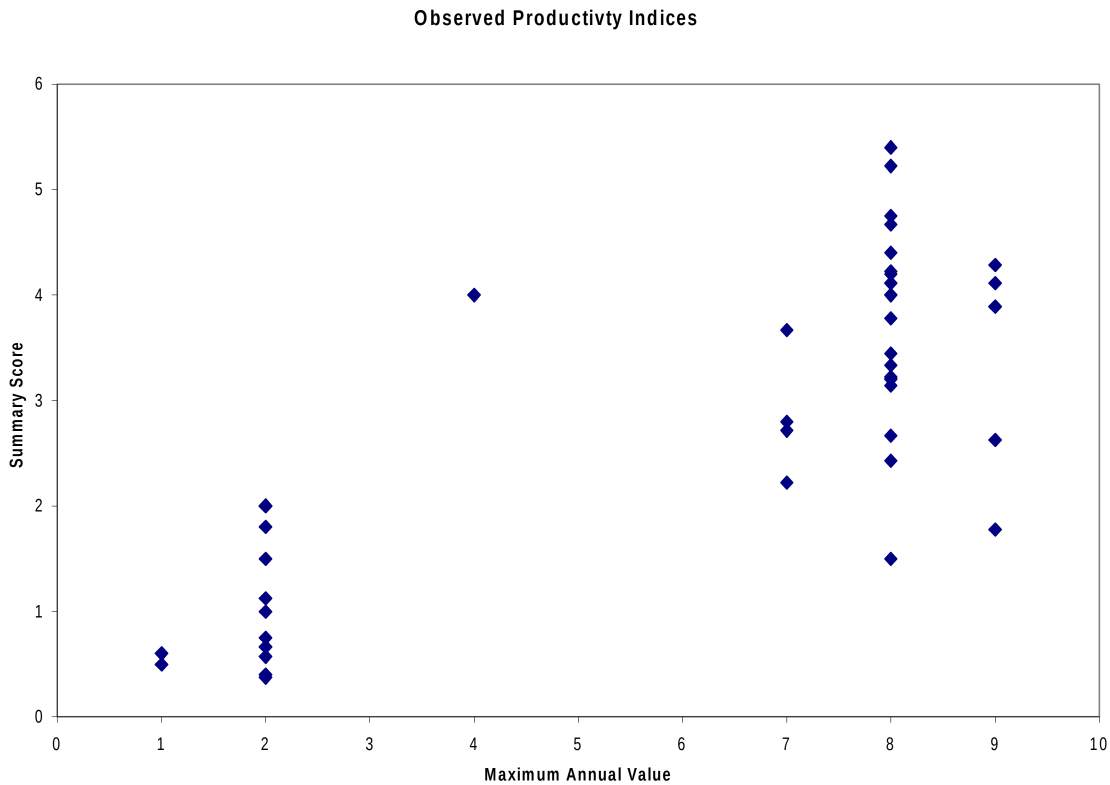


Figure 2. Potential bias introduced by the sampling scheme. The observed productivity values are plotted on the vertical axis, versus expected values under the null hypothesis on the horizontal axis.

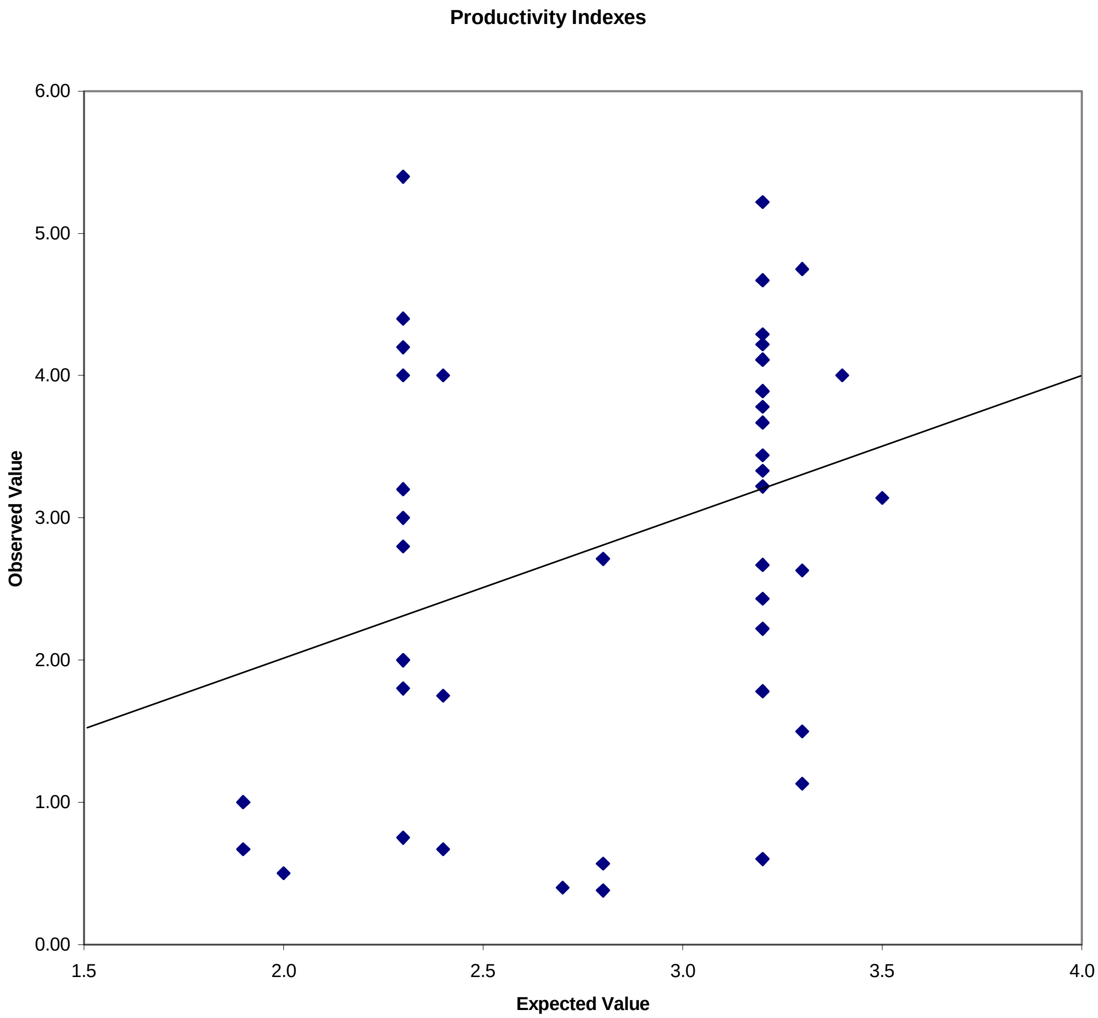
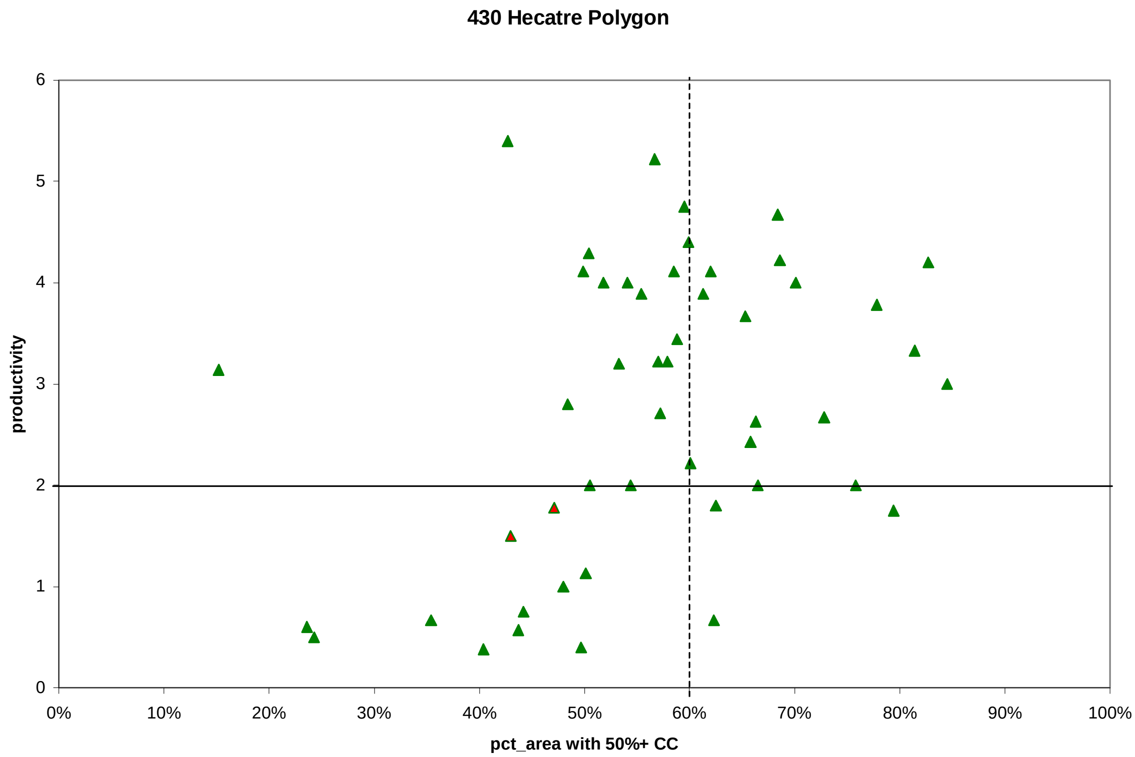


Figure 3. Productivity indices from 49 sites plotted against the amount of the assessment area with 50% or greater canopy cover. The horizontal line represents the productivity value (2) used as the criterion for distinguishing productive (>2) sites from non-productive sites. The vertical dashed line at 60% aerial coverage represents the SNFP suggested standard for distinguishing productive sites (>60%). Any site to the left of the dashed line and above the horizontal line, or to the right of the dashed line and below the horizontal line will be misclassified under the proposed standard.



Figures 4, 5, and 6. Productivity indices from 49 sites (horizontal axis) plotted against the amount of the assessment area with 50% or greater canopy cover, and 40% or greater canopy cover (vertical axis) for 3 different home range areas.

Figure 4. 430 ha polygon

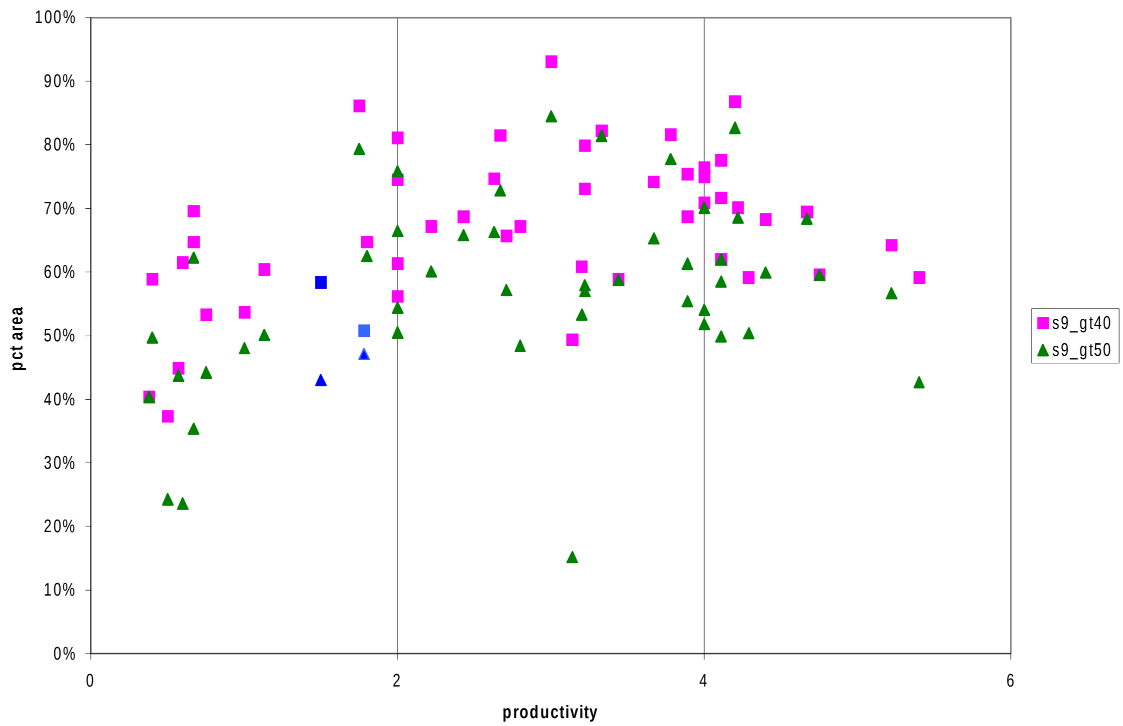


Figure 5. 168 ha Polygon

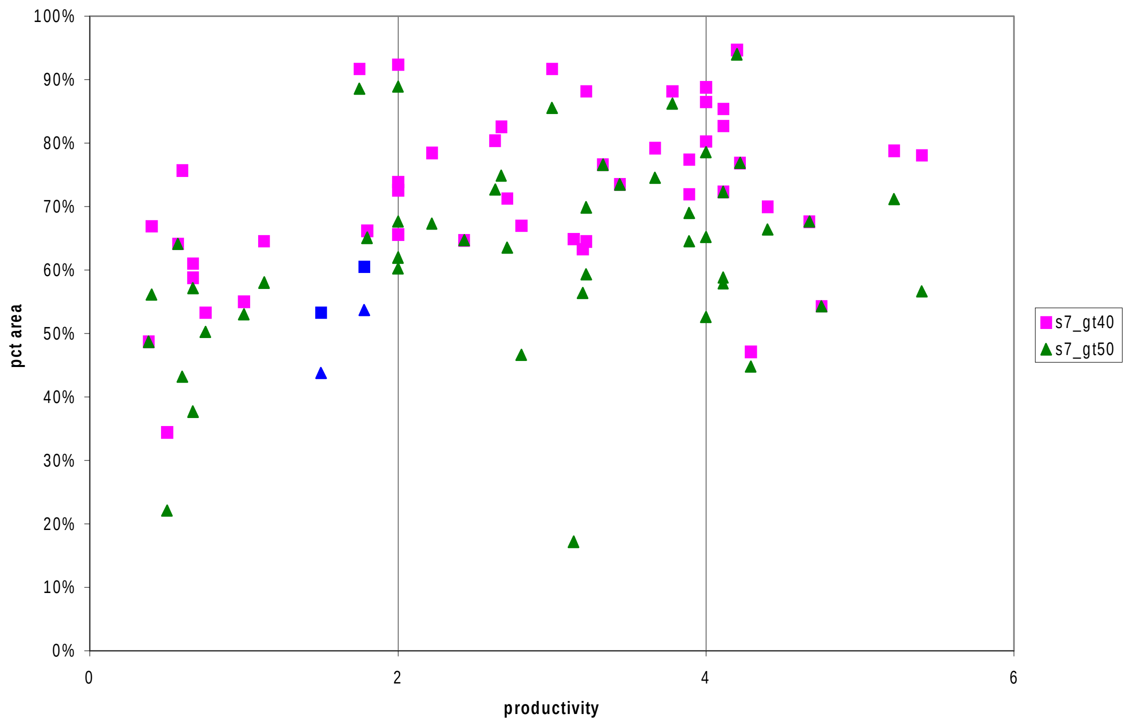


Figure 6. 72 ha Polygon

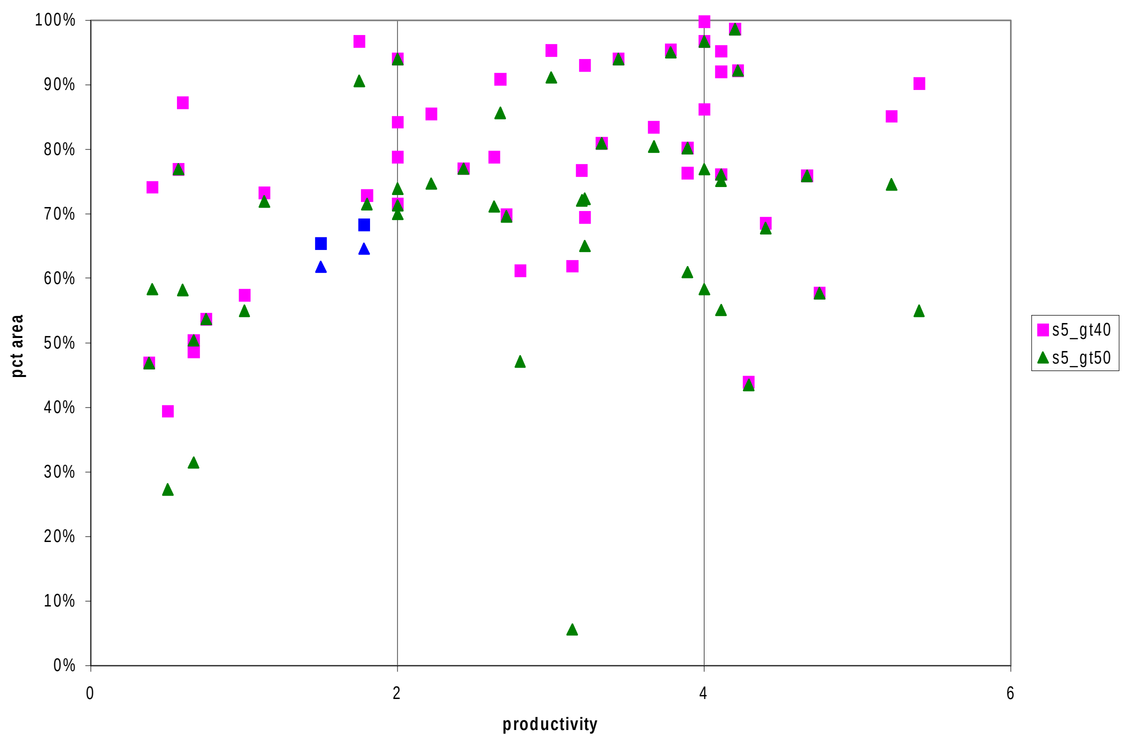


Figure 7. Nest site composition in terms of the percent area with greater the 50% canopy cover (vertical axis) versus the percent of the area with greater than 20% canopy cover. Sites are differentially plotted (squares or diamonds) based on their observed productivity scores. The lines drawn on the plot refer to alternative means of designating productivity class. The solid horizontal line at 60% represents the SNFP proposed standard for designating productive habitats ("productive" sites are above this threshold). The dashed lines at 50% on the vertical axis and 75% on the horizontal axis represent a second alternative ("productive" sites are above both thresholds in the upper right).