Evaluation of canopy estimation techniques and repeatability of the Monitoring Protocols for Central Pine Barrens Field Plots

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July 29, 2005

Prepared in partial fulfillment of the requirements of the Office of Science, Department of Energy's Science Undergraduate Laboratory Internship under the direction of Timothy Green and Robert Anderson Natural Resources at Brookhaven National Laboratory.

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Abstract Evaluation of canopy estimation techniques used in monitoring the Central Pine Barrens of Long Island. MATTHEW KULL- Binghamton University, Binghamton, NY 13902 ROBERT ANDERSON Brookhaven National Laboratory, Upton, NY 11973

The Central Pine Barrens of Long Island is an important and unique region of an ecosystem of which little is known. Due to anthropogenic disturbance, however, there is an ever-decreasing amount of this important community type. The Central Pine Barrens of Long Island is instrumental for maintaining a proper functioning aquifer essential for Long Island and thus merits study. A baseline index for the Pine Barrens is currently underway, but the effectiveness and accuracy of the protocol used is unknown. One of the most important parts of scientific endeavors is maintaining repeatability. I evaluated the densitometer measurements to check for accuracy and repeatability, using repeated plots to highlight both. The repeated plots demonstrated possible problems in terms of repeatability and accuracy, having large differences between the first and second data sets. The data also showed large discrepancies between the measured densitometer readings and visual estimation, indicative of inaccuracies most likely from observer bias. The purpose of using the densitometer is to have a more accurate measurement than estimation, but if the densitometer is not accurate this can cause problems with naming the community type and may merit amending the Protocols.

Introduction The Central Pine Barrens of Long Island encompasses roughly 100,000 acres, 52,000 belonging to a core preservation area, never to be developed. Due to mismanagement the Pine Barrens community type has drifted towards an unnatural state of climax. It has been estimated that over half of the naturally occurring Pine Barrens has either been developed or reverted to unnatural climax community (Noss et al., 1995). The fire suppression in the Pine Barrens causes the forest to revert to a closed canopy system where tree oaks dominate (Jordan et al., 2003). There are currently fire management projects underway in the Pine Barrens to attempt to restore what is thought to be the more natural community type.

However what is the natural species composition compared to the unnatural? This baseline index of species composition is requisite for proper management of the Pine Barrens. Fortunately a project started this summer is taking on this task. The data being collect is critical for the future of the Pine Barrens, which is a unique and necessary ecosystem. Besides being a taxonomic treasure trove of coarse droughty soil loving organisms, the Pine Barrens are essential for maintaining a proper functioning aquifer for Long Island. The Pine Barrens is also critical for a number of rare Lepidoptera (Wagner et al. 2003; Grand & Mello 2004).

This examination will focus on the canopy estimation of the baseline species index, concerning the repeatability and accuracy of a vertical densitometer. Canopy estimation techniques are numerous but necessary; estimating fuel amounts (Andersen 2005) to judge future fire potential, to estimating Leave Area Index (LAI) for canopy productivity (Eriksson 2005). The measure of the canopy can have a great impact on the understory vegetation. The openness of the canopy can lead to more or less species and affect great aspects of their ecology (Brosofke et al. 2001). Canopy cover is also important for fauna as well, habitat for squirrels and other arboreal animals is great affected by the amount of canopy cover, and measuring the canopy can be indicative of potential habitat (Nelson et al. 2005).

There are also a number of methods to implement while attempting to estimate canopy cover. Aerial estimating techniques like LIDAR are costly but extremely accurate (Andersen et al. 2005), other methods include hemispherical photographs; the PCA (Plant Canopy Analyzer: an instrument for measuring LAI) are both useful but have their limitations (Soudani et al. 2001).

Our method of using the vertical densitometer saves money over some other options, but how accurate it is should be evaluated and compared to other methods of estimation. In this scenario optical estimates are also being taken along with the densitometer readings, these will be compared. Also, different persons, to check for observer bias, will repeat of a select number of plots. The two data sets will then be examined for congruence, because maintaining repeatability in science is quintessential.

Methods and Materials For a more thorough account of the sampling methods see *Monitoring Protocols for Central Pine Barrens*, Michael S. Batcher 2005. To collect data on the Pine Barren species composition 400 m^2 plots were established according to the Protocols. GIS generated random plots in known community types, established using a vegetation map prepared by The Nature Conservancy. Plots were rejected if they were within 50 meters of any anthropogenic source of disturbance (e.g. roads, logging, trails, etc.). If the location was accepted a 25 by 16 meter plot was established and sampled using line transects 1.5 meters apart starting at a random locating along the 16-meter line between 0.5 and 2.5 meters. At 20 points on the line transects, one meter apart starting at a random point between 0.5 and 5.4 meters, data was recorded for vegetation cover, canopy cover and soil (litter, duff, mineral or other).

The canopy cover data was recorded using a vertical densitometer. A densitometer is a "t" shaped tube with two levels and a mirror allowing you to see the point just above you, and identify the canopy cover. For our purposes the canopy cover was recorded as pine, hardwood or sky. Percentage cover of emergent, canopy and sub-canopy categories also estimated canopy cover. Those three categories, however, were estimated without aid of instrumentation. The canopy data was also collected twice in select plots by a different team of researchers to provide a means for checking observer bias and repeatability.

The data was examined using percentages and comparison; the repeated plots were analyzed using a T-test.

Results The data for the densitometer readings were changed into percentages to ease comparison between those measured and those estimated (from now on "estimated" will be those data gleaned without instrumentation and "measured" will be those gleaned with the densitometer). As visible in the Canopy cover table, there are large amounts of disparity between the estimated and the measured.

As a whole, the estimated numbers appear to be low of the measured values, though no statistical significance could be attained due to lack of fields. Some of the differences are very large, as in plots 1 and 31 being a factor of two apart.

The repeated plots (noted here as being "XXb") are impressive as well. Plots 25 and 31 demonstrated statistically significant results using a T-test of $P < 0.01$. Though the other plots were not statistically significant the differences are worthy of note and consideration.

Discussion The difference between the measured and the estimated data within plots could be explained in several ways. Either the densitometer or the estimation data collection could have been incorrect as in a flaw in the protocol or in the recorder. Another concern could simply be that the technique isn't very accurate. Lastly, it could be that one is biased in its outcome. When examined, the estimation technique would naturally be the choice as being biased, its methodology as flawed, and susceptible to incorrect recording. The densitometer readings, however, are not inherently immune from any of these criticisms either. One could easily not be holding the instrument level, or using the sighting mechanism correctly, or simply choosing a different option than shown by using the densitometer. One would assume, however, that the estimation is the flawed collection method here as it is up to complete observer bias to decide the figures.

The data demonstrate no visible preference, with both estimation and measuring differing on average 13.5% on the repeats. This does not seem to be indicative of a direct disparity for one technique over the other, but inconsistency between them exists. More replications are needed to make any convictions with reasonable accuracy, since precision is not extricable from this data. One assumes the estimation is the flawed technique, but without data to support a conclusion it is purely speculation.

The repeated plots do show significance. Two of the plots showed a significant difference between the measured and the estimated via t-test. The estimated values can be explained in terms of observer bias, since it is simply estimation. The densitometer readings, however, are collected data using an instrument and would hopefully be accurate.

An explanation of flawed densitometer outcomes involving random points questions the accuracy and precision of the Protocol. Twenty points along each line transect may not be enough for an accurate representation of the canopy. A possible thought would be that because of the reselection of random numbers, the exact points sampled would be different. The difference in the measured canopy cover because of different random points could demonstrate non repeatability aspect of the protocol. Observer bias can always be demonstrated, however, through incorrect use of the instrument or blatant erroneous recording; the latter hopefully could be discarded as a genuine explanation, but it is possible.

To add points to the line transects could possibly adversely affect the sampling by adding too much work, making the job too cumbersome and adding unnecessary time to sampling. Further testing of this technique would be necessary to make an accurate judgment. The protocols should be examined in greater depth to determine whether or not it is repeatable.

With the preliminary data showing a possible flaw in the densitometer measurements the accuracy of the plot community type may also be erroneous. The end community type is determined by the percentage of canopy cover. If we examine plots 25 and 25b, with a gap of 25% cover, we see the possibility of a mislabeled plot. If those numbers were 49% and 73%, in a Pitch Pine community, the original data would have given it an open woodland designation, while the latter would be designated as a forest community.

Acknowledgements I would like to thank many in the natural resources division of Brookhaven Lab. First my mentors, Tim Green for the opportunity to work at the lab; and Robert Anderson for making sure we always had plots to sample. I would also like to thank a guest researcher here at the lab, Valorie Titus; in helping me to this position, stats, and opportunities to help out in other areas of work being done at the lab. Jennifer Higbie for doing all the GIS and for playing with the startlingly incorrect map from TNC. Lastly my fellow interns and teammates, Chauncey Leahy and Miranda Davis; and to all others who participated on FERN's founding project this summer.

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Tables and Figures

TABLE #1- Canopy cover as a percentage											
Plot #	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Est.	23	90	52	35	70	55	90	95	65	95	60
Meas.	60	92	80	54	76	84	91	96	74	90	72
Plot #	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**
Est.	80	60	67	65	45	50	110	75		90	100
Meas.	77	79	78	83	68	70	83	84		95	90
Plot #	**23**	**24**	**25**	**25b**	**26**	**27**	**28**	**29**	**29b**	**30**	**30b**
Est.	67	39	30	40*	1	95		70	90	88	103
Meas.	77	75	51	75*	35	92		94	101	97	91
Plot #	**31**	**31b**	**32**	**32b**	**33**	**34**	**34b**	**35**	**36**		
Est.	36	50*	65	79	85	103	95	90	80		
Meas.	73	57*	78	96	85	105	95	95	88		

Key:
Est. – Estimated percentages, without instrumentation.
Meas. - Measured percentages, with densitometer.
* - Indicates statistically significant results, P> 0.01