Analysis of an Agroforest: The Variable Radius Quadrat Method[1]

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Abstract: Procedures and methods used to determine the structure of an agroforest are presented. Simple statistical procedures to present the data in a meaningful form are also discussed.

Agroforests are an important vegetation type in Micronesia and the Pacific Basin. Given the many different physical and cultural environments in which agroforestry is practiced, agroforests differ greatly in their composition, productivity, and interaction between species. Even on the same island, no two agroforests are alike. Unlike a tomato or taro field, the agroforest is extremely complex. Many students of agroforestry ask the basic question "How do we analyze an agroforest so that we can get meaningful and comparatively useful results?" Or, "Is there a method that we can use to get some idea as to what is in an agroforest?" Closely related to that question, is "How productive is an agroforest and how do we measure the productivity of the components of the agroforest?" In order to answer the latter question, however, we need to determine the structure (composition, number of species, number of trees, ages of trees, etc.) of the agroforest.

Some Initial Considerations

Because agroforests are composed of many different species which vary in age, height, DBH and other characteristics, and are found in different physical and cultural environments, no two agroforests are exactly alike. Thus it is important to use standardized methods and procedures such that comparisons can be made between the agroforests on different islands and areas. However, before a standard method of analysis can be applied, three initial considerations need to be made:

1. The site (quadrat area) selected for study must be representative of the agroforest under study. In other words, the site chosen must be as similar as possible to the surrounding agroforest. For example, if in a particular agroforest, taro is a commonly found species in the undergrowth, but your quadrat area does not have any taro, then your study site is not representative. It may be best to select another study site within the agroforest, especially if you don't have time to analyze a large number of quadrats.

This assessment of representativeness is usually made visually, but is based on a fairly good working knowledge of the range of agroforestry types. In turn, knowledge of the range of agroforestry types can be gained through a reconnaissance of the island, field interviews, or informal discussions with landowners, to name a few. When analyzing an agroforest for its components, an agroforester will constantly ask whether the site under analysis is representative, and, if not, should a more appropriate site to study be found.

2. The site must be large enough to contain the range of species found in the agroforest. If the agroforest at the site is too small, it may not be a representative site. It may also contain species commonly found in other ecosystems. For example, the composition of an agroforest near a pathway or roadside will contain somewhat different species than the center of an agroforest. By selecting a large enough site, such effects are minimized and the likelihood of getting good data are greatly increased.

3. The agroforest and the quadrat in particular should be homogenous in terms of the distribution of its components. However, within every agroforest, there are bound to be differences in the pattern of vegetation. As the investigator, you need to decide whether the differences represent a situation on non-homogeneity. If such patterns are common enough, they need to also be analyzed. For example, in the Mwoakillese agroforests at Sokehs, Pohnpei, there are patches of *Cyrtosperma chamissionis.* Such patches should be described separately as a subunit of that agroforest.

Other factors that need to be considered include sampling design (whether random, stratified, or other), availability of time and money for analysis, the number of agroforestry types, and the purposes of your study, to name a few. These topics are beyond the scope of this paper, but there are many references available.

The Variable Radius Quadrat

The variable radius quadrat is a relatively easy method to use in agroforests. Unlike fixed area quadrats or sampling plots, the variable radius quadrat depends on the number of trees (or other plants) to determine the size of sampling area. This method is called the variable area quadrat method because the area of trees (of a particular number) will vary from place to place. An important characteristic of the agroforest is the density of trees, which can be determined by using this method. The procedures for using this method and the accompanying Form 1 are presented below:

1. Fill in the preliminary information found at the top of Form 1. Other information of your choosing can be added to the sheet.

2. Locate a point (randomly or systematically) in the agroforest.

3. Mentally locate or physically mark the 10 (or 20) closest trees/shrubs that have a d.b.h. (diameter at breast height or 1.3 m above the ground), starting at the center and moving outward. It is better to use 20 trees than 10 trees, particularly if you have

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time. Multi-stemmed trees should be treated as individual trees if the branching begins below breast height.

4. List each tree or shrub by their local and scientific name in the appropriate space.

5. Using the information below, indicate the lifeform of the species in the appropriate space.

T = Tree - any plant taller than 5 m, which can be subdivided into:

GT = Giant tree - any tree greater than 25 m
LT = Large tree - any tree between 10 - 25 m
MT = Medium-sized tree - any tree between 2 - 10 m
ST = Small tree (saplings) - any tree between 0.5 - 2 m
HT = Banana - a herbaceous tree

S = Shrub - woody plants between 50 cm and 5 m tall

S 1 = Shrub - woody plants between 2 and 5 m tall
S2 = Shrub - woody plants between 50 cm and 2 m tall

H = Herb layer - plants (usually weeds) up to 1 m tall

Hl = Tall Herbs - plants between 30 cm and 1 m tall
H2 = Medium Herbs - plants between 10 to 30 cm tall
H3 = Low Herbs - plants less than 10 cm tall

M = Moss and Lichens - usually less than 10 cm tall

C = Cultivated species

6. Determine the distance between the center point and the 10th and/or 20th tree. If you intend to map the distribution of trees, you should measure the distances between the center point and each tree. The distances to the 10th and/or 20th closest trees or shrubs will be used to determine the sampling areas of the first 10 and the second 10 trees. These two distances define the radii of 2 circles, that of the first 10 trees and the second 10 trees, respectively. These radii can be used to determine the areas of the 2 circles (using the formula $A = 7t\ r^2$), and tree densities (number of trees/area) for the 10 and 20 trees in question.

7. Determine the compass bearing from the center point to each tree. This step is optional, but should be done if you intend to map the distribution of trees.

8. Estimate each tree's height (in meters to the nearest tenth of a meter).

9. Measure each tree's d.b.h. (in cm).

10. Using the d.b.h. data, determine the basal area of each tree according to the formula (Basal Area = πr^2), where $r = d/2$.

11. Add up the basal areas and enter the total in the appropriate space.

12. Determine the Braun-Blanquet cover value for each tree species by visual estimation of the area that it covers. The modified Braun-Blanquet scale is as follows:

5 = covering more than 75 percent of the area (quadrat)
4 = covering 50 to 75 percent of the area
3 = covering 25 to 50 percent of the area
2 = any number of individuals covering 10 to 25 percent of the area
1 = numerous, covering 5 to 10 percent of the area
+ = sparse, covering less than 5 percent of the sample area
r = rare and covering less than 1 percent of the sample area (usually only 1 example)

Note: Often, there may be more than one tree of the same species. If all of these trees are at the same height, a single Braun-Blanquet value will suffice. If, however, these trees belong to different canopy layers, then separate Braun-Blanquet values will be necessary. These layers are based on tree height as indicated in item 5 above.

13. Within the same quadrat and following steps 4, 5, 6, 7, 8, and 12 (substituting trees with weeds, cultivated plants, etc., as appropriate), determine the composition of other cultivated species, weeds, small trees, and shrubs in the agroforest. Identify cultivated species by their local varietal name if known. Record the data on Form 2.

Final Comments

Because of differences in species composition, the history of human manipulation of the agroforest, species interactions and life cycles, habitat differences, and a range of other factors, no two sites within an agroforest are the same. Thus it is often necessary to analyze more than one site within an agroforest in order to determine what a representative agroforest is. Often, a researcher will try to analyze between 2 and 4 quadrats per agroforest in order to get a larger sample and a better idea of what an "average" agroforest contains. While further manipulation of the data will be necessary, the standardized procedures described above will provide the basic information needed for describing and comparing the structure of Pacific islands' agroforests. An understanding of the structure of the agroforest is a prerequisite for understanding the functional aspects of the agroforest including productivity.

References

Shimwell, D. W. 1971. The description and classification of vegetation. Seattle, WA: University of Washington Press.

Form 1: Trees and shrubs in Agroforests

Variable radius quadrat

Agroforest Owner____________ Date________________
Agroforest Location ______ Assessor(s)________________
District ____________________ Aspect ________________
Soils ____________________________ Garden I.D. No. ________
Slope __________________________________

Species (d.b.h. >2.54 cm)	Lifeform	Height (m)	d.b.h. (cm)	Basal Area (cm^2)	Distance (m)	Bear (deg)	BB Value
1.							
2.							
3.							
4.							
5.							
6.							
7.							
8.							
9.							
10.							
11.							
12.							
13.							
14.							
15.							
16.							
17.							
18.							
19.							
20.							

Totals

Distance to the 10th tree __________(meters).
Area of circular quadrat for 10 trees _________ .
Density (10/area) ________.

Distance to the 20th tree __________ (meters).
Area of circular quadrat for 20 trees _________.
Density (20/area)_______.

Keys: d.b.h.: Diameter at Breast Height (in cm)
Bear = Compass Bearing (in degrees)
BB Value = Braun-Blanquet Cover
Dist = Distance from center to tree (in m)

Form 2

Agroforest I.D. No. ______
Assessor(s)____________________________
Garden Location __________________________
Recorder(s)______________
Soils ____________________________________
Aspect____________________
Slope ____________________________________

Other Cult. Species, Small Trees, Shrubs and Herbs	Lifeform	No.	Hgt (m)	Distance (m)	Bearing (degree)	BB Value
1.						
2.						
3.						
4.						
5.						
6.						
7.						
8.						
9.						
10.						
11.						
12.						
13.						
14.						
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17.						
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21.						
22.						
23.						
24.						
25.						
26.						
27.						
28.						
29.						
30.						

Key. No = Number of individual plants(ings)