Field Botany – Au Sable Institute – June 8, 2023

Forest Community Sampling

In Thursday's field work (and continuing next Tuesday), you will learn three methods of forest community sampling (point quarter, quadrat, Daubenmire) and the parameters used to describe, compare, and contrast forest communities. To describe a particular plant community, ecologists usually do not make a complete census of the community (i.e., measure or account for every tree in the forest). Instead, they sample a small proportion of that total community and consider it to be representative of the community as a whole. This is exactly what we will do in each of the northern Great Lakes forest stands this session. We will use the following parameters to describe the community of trees in each stand with the unit area of one hectare or 100m X 100m (10,000m^2, 1 ha = 2.47 acres).

- **Density**: The number of rooted individuals in a certain area:

$$Density = \frac{number\ of\ individuals\ of\ a\ species}{unit\ area}$$

- **Dominance**: Also known as **cover** (or **coverage**), dominance refers to the amount of ground surface area that occurs beneath the crown of a given species. Cover is often expressed as percent cover, or the proportion of the total ground area covered by the canopy of a particular species. Typically, ground cover of trees is assumed to correlate with trunk cross-sectional area, or **basal area**. Basal area is calculated simply using the formula for the area of a circle (= πr^2), where r is the radius of the tree (r = half of diameter at breast height, dbh). Basal area is calculated individually for each tree, and then all the values for a given species are summed together. Basal area is commonly expressed per unit area:

$$Basal\ area = \frac{cross\ sectional\ area\ of\ trees\ (at\ breast\ height)}{unit\ area}$$

- **Frequency**: Also known as percent encounter, frequency refers to the percentage of total quadrats that contain at least one rooted individual of a given species.

$$Frequency = \frac{number\ of\ quadrats\ in\ which\ species\ occurs}{total\ number\ of\ quadrats\ sampled} \times 100$$

- **Relative values**: For any given species, all three of the parameters above can be relativized and expressed as a percent of all species present in the sample:

$$\textit{Relative Density} = \frac{\textit{density of a species}}{\textit{sum total density of all species}} \; X\ 100$$

$$\textit{Relative Dominance} = \frac{\textit{dominance of a species}}{\textit{sum total dominance of all species}} \; X\ 100$$

$$\textit{Relative Frequency} = \frac{\textit{frequency of a species}}{\textit{sum total frequency of all species}} \; X\ 100$$

- **Importance Value (IV)** is a synthetic measure of the relative contribution of the species to the composition and structure of a community (it is not necessarily a measure of each species "importance" in all ecosystem processes and functions). Importance is an attempt to express relative dominance, relative density, and relative frequency in a single parameter:

Importance Value = Relative Dominance + Relative Density + Relative Frequency

Thus, importance value has a maximum value of 300. (Some sampling methods may not gather dominance, resulting in a maximum of 200). Importance value can also be relativized simply by dividing by 3 (or 2 if dominance is not assessed), resulting in values ranging from 0 to 100.

Specific Sampling Methods

1. Forest tree canopy

We will use the **Point-Quarter Method** (see attached description and data sheets) to sample the density, frequency, dominance, and importance value of each tree species in the two forests. Two teams of students will lay out 100m transects and sample 4 trees at each 10m point (10m, 20m, . . . 100m); so a total of 20 points and 80 trees.

Record the species of the closest tree (>15cm dbh) in each of the four quadrants from the point, record the distance (m) from center of tree to point, and record the dbh (cm) of the tree. You will eventually summarize per species: frequency, density, dominance (basal area), and Importance Value.

2. Shrub/sapling layer

We will use the **Quadrat Method** to sample the density, frequency, and importance value of each shrub/sapling species in the two forests. Each team, after sampling the tree canopy, will lay out a circle quadrat of $20m^2$ from each point; so a total of 20 circles or $400m^2$.

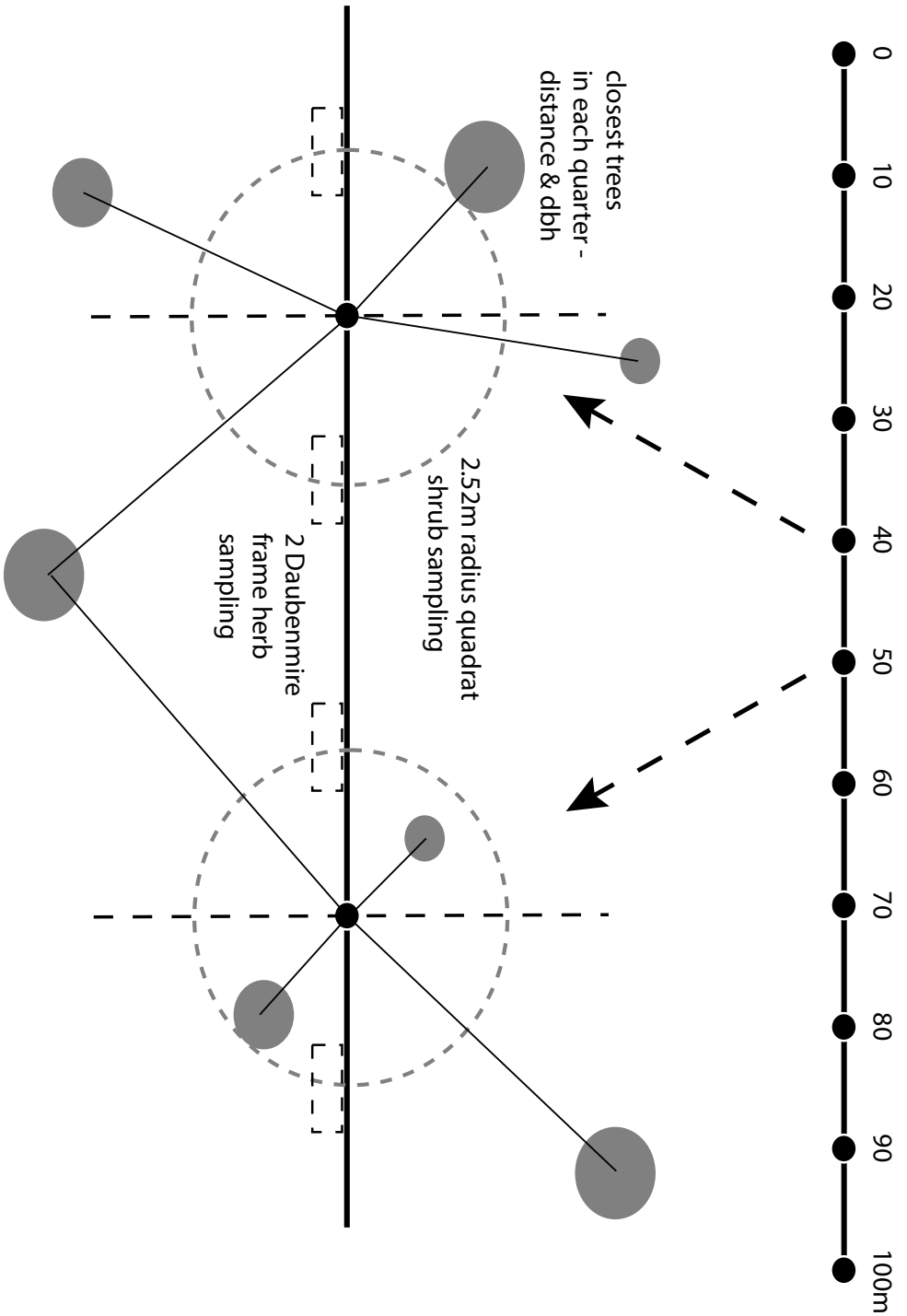
Record the species and number of all shrubs/saplings (at least 1m tall, <15cm dbh) in a circle with radius 2.52m. You will eventually summarize per species: frequency, density, and Importance Value.

3. Herbaceous ground cover

We will use the **Daubenmire Cover Class Method** to estimate ground cover of each species of herbaceous plants (>1m tall). See attached description and data sheets for more information. Each team, after sampling the tree canopy and shrub/sapling layer, will place the 20cm X 50cm ($0.1m^2$) Daubenmire frame along the right side of the transect tape at two intervals (2.5 and 7.5m) of each 10m stretch; so a total of 20 samples for each group, or a total of 40 samples for each forest.

Record the species and coverage class (5, 25, 50, 75, 95, 100%) for each species of herbaceous plants (forbs, graminoids, seedlings – all <1m tall) at each sample point. You will eventually summarize per species: frequency and % cover.

Sampling scheme along 100m transect – point quarter method for trees, circle quadrat for shrubs, and Daubenmire frame for herbs at each 10m interval



Assignment — due Monday, June 26

Describe the two forest communities we sampled — Northern Hardwood Forest (mesic forest) and Pine –Oak Forest (mesic-xeric forest) — using the parameters mentioned above to compare and contrast the community composition of the two stands. As we sampled trees (point quarter method), shrubs/saplings (quadrat method), and herbaceous cover, separate analyses will need to be done on each of the three. Frequency, density, and dominance were estimated for the tree canopy, so Importance Values for trees will have a maximum value of 300. Frequency and density were estimated for shrubs/ saplings, so Importance Value will have a maximum of 200. Frequency and % coverage only will be estimated for herbaceous cover.

Report Format

In about 4-5 pages (single spaced), discuss the data the class collected in terms of structure and composition of the two forest types. Bring into the discussion ideas of differences in species diversity, stand density, age structuring in the forest (e.g., tree vs. shrub/saplings layers), natural history of the dominant plants, light regime, soil features, perhaps something about likely previous history of these sites (i.e., pre-settlement forest, species that should have been at each site, logging era, recent selective logging, fire or lack thereof), and the future prospects of the forests based on what you see there now. Attach only the data **summary** sheets (trees and shrub/saplings) to your report. **Use citations and check for spelling**.

The report format should have the following sections: I. **Title**; II. **Introduction** (pre-settlement vegetation, state the objectives of the study); III. **Materials and Methods** (location of the stands, field procedures for each type of measurement, light, soil); IV. **Results** (summarize major results and cite tables or figures; these should be numbered consecutively – e.g., Fig. 1, Table 1 with each having figure or table legend); V. **Discussion** (3-4 pages; compare and contrast the two forest stands; how similar/different; type of glacial landforms; soil differences; light regime differences; importance of different tree species; shade tolerance or lack thereof; probable changes since pre-settlement and impact on structure of three forests; disturbance such as fire, deer, selective logging, etc.; where is the forest headed, successional changes); VI. **References** (use as *at least four* that are relevant to your discussion; cite any reference used; these should be indicated in the text — e.g. (Curtis, 1955; Barnes and Wagner, 2004)).

Readings:

- *Michigan Trees*, pp. 373-393 (provided)
- *The Forests of Michigan*, pp. 52-71 (provided)
- Whitney 1987 paper (provided on course website)
- "Mesic Northern Forest" and "Mesic-Xeric Northern Forest" Community Abstracts from the Michigan Natural Features Inventory (provided on course website)

Other optional readings: (both books in lab, please keep them there)

- John Curtis' *Vegetation of Wisconsin*: chapter 9 ("Northern forests-general") describes in general terms these three forests; chapter 10 ("Northern forest-mesic") includes natural history sections on yellow birch, hemlock, beech, and the ground layer; and chapter 11 ("Northern forests-xeric") describes the natural history of pine forests.

- Gordon Whitney's 1994 book *From Coastal Wilderness to Fruited Plain: a History of Environmental Change in Temperate North America 1500 to the Present*. Chapter 4 ("Forest Primeval") has some good information on pre-settlement forests — check out Table 4.1 (p.62), Table 4.2 (p.73), Fig. 4.3 (p.78). Chapter 8 ("Assault upon the forest: the lumber industry") has good discussion on rate and effect of logging in Michigan.

Maps: on the course flash drive I have placed pre-settlement forest maps of Kalkaska and Crawford Counties – these are pdfs. Geographic information for the two sites are given here:

site 1 (Northern hardwood forest): Kalkaska Co., Blue Lake Township [R5W T28N sect. 20], SW corner of Papoose Lake and Kennel Roads. [N 44 ^{o} 48.026'; W 84 ^{o} 57.044']

site 2 (Pine-oak forest): Crawford Co., Frederik Township [R4W T28N sect. 30], 1 1/2 miles N of Highway 612 along Manistee River Road. [N 44^{o} 47.597'; W 84 ^{o} 49.988']

You are welcome to (and encouraged to) work on the analysis together — but please make sure you know how the data is crunched. The written portion should be of your own genius. The report will be due by end of the day on **Monday, June 26**.

Data Analysis

The data (trees, shrubs/saplings) should be collated together by members of the class. You should place this data on Excel to do the number crunching. The raw data for each of the two sites should include (i) the point quarter data for trees (>15 cm dbh) representing 20 sampled points, thus 80 trees, for both forest types; and (ii) the shrub/saplings (each point sampled is 20m^2) for 20 sampled quadrats. For each of the two forest layers (trees, shrubs/saplings) you need to calculate density (number of individuals per hectare) and frequency (how often a species showed up at a given point). For trees you also need to calculate dominance for each species (amount of square meters that each species takes up by its stem area).

Using the handouts and lecture notes from Thursday, fill in the table for the tree species — additional copies of the table are in the lab. Remember that for frequency, each point (not quadrant) is used; i.e., if sugar maple is one of the four possible trees at each point, it has frequency of 100%. All values for trees will be based on a hectare (100m X 100m or 10,000 m^2). Refer to your handout on the point quarter method to figure out how to calculate the numbers for the trees. For the shrub/sapling layer, calculate density (numbers of individuals per hectare [100m X 100m]) and frequency (percentage of sampling points with an occurrence) for each species; convert these to relative density and frequency (as with the trees); and then calculate an importance value for each of the shrub/saplings (relative density + relative frequency). **Record the shrub/sapling values**

on the attached sheet; the tree values on the handout previously supplied – more copies available on lab.

Here are some helpful hints on how to do your analyses. Please make sure you (or your group) are doing it correctly by checking with others before going too far along with the analyses.

Quadrat analyses (shrub/saplings)

density = $\frac{\text{number of individuals}}{\text{area sampled}}$	(put in units of hectare or 10,000 m^2)
frequency = $\frac{\text{number of plots in which species occurs}}{\text{total number of plots sampled}}$	(give as percentage; e.g., 0.55)
relative density = $\frac{\text{density for a species}}{\text{total density for all species}}$	(give as percentage; rel. dens. should add to 1.00)
relative frequency = $\frac{\text{frequency value for a species}}{\text{total of freq. values for all species}}$	(give as percentage; should add to 1.00)
importance value = rel. density + rel. freq. X 100	(therefore, highest value possible is 200)

Point Quarter method (trees)

Step 1: Calculate density of all individuals of all species — or in other words, the total tree density. This has to be done first as we do not know the area that was actually sampled as it is a plotless sampling method. Do this by adding **all** point to-plant distances for **all** species (4 at each point, so 80 values per forest if 20 points sampled). Divide this total distance by number of trees (80 in this example) to get mean point-to-plant distance. This mean point-to-plant distance is then squared and divided into 10,000 m^2 (a hectare, the unit area being used) to come up with the **total density of all species.**

Step 2: Once total density of all species is obtained, the following values for **each species** are easy to calculate (see handout): **relative density, density**

Step 3: Determine dominance values for each species. First determine the **number of individuals** of each species. The basal area for individuals of each species should then be summed and divided by the number of individuals of the species to give **average dominance values**. Using the formulas provided, **dominance** (m^2 per hectare) and **relative dominance** can then be calculated.

Step 4: Finish **frequency**, **relative frequency**, and **importance values [(Rel. frequency + Rel. density + Rel. dominance) X 100]**.