1.0 Introduction / Orientation Notes

Course Goals

Gain familiarity with assessment of:

1) tree and stand attributes,
2) common stand and forest sampling / inventory techniques,
3) primary forest products,
4) tree and stand growth and yield analysis.

After completing this course students will be able to characterize and analyze data from common natural resource sampling protocols in order to make management decisions.

Students will also gain a general appreciation and understanding of the methodologies and the utility of mathematical description of tree and forest characteristics and their change over time.

Course Approach

Mostly a “How to” approach

Despite recent advances, such as electronic data capture, GPS, LIDAR, weight scaling of wood – still measuring tree size, tree form, biomass, timber volume, cull factors, growth & mortality as we have been for decades

Course Emphasis

Regardless of land management / stewardship objectives terrestrial vegetation in general and the upper canopy in particular must be quantified in quite some detail for informed decision making

- Wildlife habitat depends to large extent on overstory
- Water yield is related to composition & density of tree canopy
- Aesthetics / Recreation potential is related to many variables, including overstory
- etc.

Measurement principles & sampling protocols we’ll discuss are equally applicable to other natural resources that require quantitative info

Lots to do with Trees! (or, forest overstory species)

- measuring / estimating components of trees (crowns, boles, logs, etc.)
- measuring standing trees in detail
- quantifying stand characteristics
- sampling techniques for designing a survey of forest resources
- measuring past growth & predicting future change

1.1 Need for and Principles of Measurement

Sustainable Management / Stewardship / Conservation / Preservation of forestland requires knowledge of the location, quantity, and extent of timber, wildlife, water, recreation, and rangeland resources

- Role of measurements is to provide the numerical data to make prudent mgt. decisions
- Need quantitative info for making silivicultural decisions and designing harvesting systems to accommodate ecological, engineering, and economic objectives
- Estimates of forest growth may be required for various management strategies

"Hierarchy" (phases) of Measurement

- Direct measurement: requires appropriate use of instruments to obtain the desired datum
- Sampling: employed because forests are so extensive (vast)
    - Common to make direct measurements on a sample of trees, then expand the sample values appropriately to obtain estimates for the population of interest
    - Science of statistics plays a major role
- Prediction: employed when direct measurements are impossible
    - Weight or biomass of a standing tree
    - Future growth of an individual tree
    - Statistics plays a major role,
    - Math is fundamental to measurement / statistics: complexity of problems and quantities of data make electronic data processing a necessity

Cost of measurement

- Always a primary consideration
- Continuous search for more efficient methods
- Measurement adds no real value to materials being assessed → usually subordinate to productive phases of the operation
- Often overlooked fact: amount expended for a given inventory task should be linked to the value of the products, services or benefits being derived
- The nearer you approach the final product, environmental service, or ultimate benefit, the greater the cost you can incur to measure

Scales of Measurement

A measurement is the assignment of numerals to objects or events according to rules

Assigning numerals under different rules has led to different measurement scales; four are commonly recognized

Nominal Scale. Variable under study is classified only by some quality or attribute it possesses. Often used to number objects for identification. Because the attribute is assigned only for identification, frequency of occurrence (counting) is the sole analysis method.

- gender
- species codes
- lumber grades

Ordinal Scale. Variable is classified according to relative difference, i.e., an ordering or ranking is produced. Successive intervals on the scale may not be equal, therefore a difference of one unit may mean different things depending on scale position. Counting and ranking can be carried out.

- young, juvenile, adult
- survey responses (strongly agree, agree, …)
- site-quality classes (I, II, III, IV, V)
- Moh hardness scale (talc, …, diamond)
- tree crown classes (dominant, co-dominant, …)

Interval Scale. Measurement scale that possesses a constant interval size, but not a true zero. Valid mathematical operations include counting, ranking, adding and subtracting, multiplication or division by constants.

- temperature (Fahrenheit, Celsius)
- calendar year

Ratio Scale. Measurement scale which possesses a constant interval size AND a true zero. All mathematical operations are permissible on ratio-type data.

- plant height
- number of offspring in brood
- white blood cell count

Units of Measurement

Fundamental units. Regarded as independent properties of nature: length, mass, time, frequency.

Derived units. Expressed in terms of fundamental units or in units derived from fundamental units: area, volume, velocity, force, etc.

Variables

A variable is a characteristic that can take on or assume any given value or set of values

A variate is the value of a specific variable

Continuous - capable of exhibiting every possible value within a certain range

Discrete - (or discontinuous) values jump from one number or position to the next

- all nominal and ordinal-scaled variables
- some ratio-scaled variables, e.g., counts

Common symbols for variables used in forest measurement

ac - acre (43,560 sq. ft. of land, measured horizontally)

B, b - cross-sectional area of a log or bolt at large, small end

BA, ba - Basal Area of stand, tree (sometimes G, g)

BAF; baf - Basal Area Factor (point sampling)

bd ft, BF - board foot

cd - cord

ch - chain (measurement unit equal to 66 ft.; 10 ch^2 to the acre)

cu ft; ft^3 - cubic foot (or feet)

D, d - tree or log diameter (at any specified point)

DBH; dbh - Diameter Breast Height

Dib; dib - diameter inside bark

Dob; dob - diameter outside (or "over") bark

F, f - Form class, form factor

L, l - log, bolt length

M - Roman Numeral for one thousand (Others: D= 500, C= 100, L= 50)

MBF - thousand board feet

MMBF - million board feet (not 2000 BF, as Rom. Num's would imply)

MC - moisture content

N, n - number of (something) in population, sample

P; p - probability of (something)

sp gr, sg - specific gravity

sq ft, ft^2 - square foot (or feet)

TF - Tree Factor

V, v - stand, tree volume

XF - eXpansion Factor (in general; can be VF, HF, etc.)

Precision, Accuracy & Bias

Precision and Accuracy are frequently used interchangeably in common, non-technical parlance

Precision - in all sciences, used to refer to the resolving power of a particular instrument, or the smallest unit in observing a measurement. In this sense, the more decimal places, the more precise

- in mensuration circles, most commonly it refers to the degree of agreement in a series of measurements

Accuracy - refers to closeness of a measurement to the true value

Bias - refers to systematic error(s) that may result from faulty measurement procedures, instrumental errors, flawed sampling techniques, computational errors, etc.

In sampling (statistical) circles …

Accuracy refers to the size of the deviation of a sample estimate from the population value

Precision refers to the magnitude of dispersion of sample values from their mean (or average) value, most often expressed as standard deviation

Accuracy (A), Bias (B), and Precision (P) are all related:

$$A^2 = B^2 + P^2$$

Thus, if bias is non-existent or negligible, Accuracy equals Precision

Measurements basic to Natural Resources Measurement

- linear, time, weight, area, and volume

More refined definition of a measurement:

A particular value …

of a numerical variable …

designating a quantitative concept …

representing a property …

of a concrete system.

The seemingly simple process of reading a value from a measurement device should be preceded by careful thought!