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Procedures to determine the amount of plant cover/basal area in field plots

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Abstract

Plant species compete for ground space in a variety of ways. The purpose of this research was to describe procedures to determine plant basal area (plant cover) to help understand ecosystem structure of a desert ecosystem. For one field plot (1089 m^2), distance and direction of each plant were measured from either another plant or from a field marker. The diameter and height were recorded for each plant. Computer programs (1) provided the distances and directions among all the plants in the plot, (2) provided a listing of the plants (including species name, distance, direction, height, diameter and condition) within a pre-determined radius of each plant (a target plant), (3) computed the area of plant basal area (plant cover) within a 5-m radius around each plant in the plot and (4) produced a two-dimensional diagram to show the location of plant cover of all plants around each target plant with calculations of plant cover area for each plant. Two examples were selected to illustrate the versatility of the technique. For one example, the target plant with seven other plants within the 5-m radius (78.5 m^2 total area) had a total plant cover of 10.2 m^2. For this first target plant, the plant cover within a 3-m radius (total area of 28.3 m^2) was shown to be 4.88 m^2. For a second example target plant, there were 10 plants within a 5-m radius area that provided 21.6 m^2 plant cover. For this second target plant, the calculated plant cover within a 3-m radius area was 12.6 m^2. From the 5-m radius analysis to the 3-m radius analysis, only one of the 10 plants was not excluded. We believe that the combination of procedures and computer programs provide an accurate estimate of the amount of plant cover (basal area) around plants within desert field plots. These procedures may be combined with other ecological parameters, such as association analysis to make better estimates of ecosystem structure.

Keywords: Plant cover; Basal area; Desert ecosystem; Plant shading/competition; Computer program; Plant population density; Plant associations; Modeling vegetation plots

1. Introduction

Plants compete for light used for photosynthesis. Under a cloud-free sky, photosynthetically active radiation (PAR) is about 400–500 W m^{-2} (Salisbury and Ross, 1992). At a PAR level of 400–500 W m^{-2}, photosynthesis of most plants is maximized (Berry, 1975; Salisbury and Ross, 1992). However, some plants, such as forest understory plants, show a maximum level of photosynthesis at light intensities less than 100 W m^{-2} (Berry, 1975). Salisbury and Ross (1992) purport that highest photosynthetic rates occur for annuals and grasses that grow in deserts where light is not limiting and other resources are intermittently abundant. Shade plants never achieve such high photosynthetic rates as sun plants and can be damaged (photoinhibition) by light level that are not even saturating for sun plants. Is it possible that desert plants do not exhibit photoinhibition?

Deserts are areas of spare vegetation in which transpiration/evaporation rates are much higher than precipitation rates (Bender, 1982). In general, primary production (expressed as plant biomass per unit area per year) is usually much lower for deserts than for many other ecosystems (Smith, 1996). Deserts are areas of low vegetation density. Even in deserts, plants compete for sunlight by shading other plants.

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Although, plants may compete for sunlight, there are some conditions in which plants of various species may be associated with other species. Steenburgh and Lowe (1977) among others have shown that young saguaro (*Carnegiea gigantea*) cacti (a columnar cactus species) are associated with older plants of mesquite (*Prosopis velutina*) in Arizona and northwest Mexico. Data of Valient-Banuet and Ezcurra (1991) show a similar relationship between young columnar cacti of *Neobuxbaumia tetetzo* and older plants of *Mimosa luisana* in central Mexico. These relationships are explained by statements that plants of the older species (nurse plants) provide protection for younger seedlings of the columnar cacti. In addition to the above examples of plants being positively associated with plants of other species, there are many examples of plants being associated with conspecifics. For example, Phillips and MacMahon (1981) provided data to show that *Larrea tridentata* was associated with conspecifics and also with plants of *Ambrosia dumosa*. Moreover, *A. dumosa* was associated with conspecifics and with plants of *L. tridentata*. For *A. dumosa* and *L. tridentata*, as shade (plant cover, basal area) area of two associated plants increased, the distance between the plants increased. The above examples of plant associations show that although plants compete for light for photosynthesis, other factors may be involved with plant-to-plant relationships.

One of the most used parameters in ecology is association analysis (Brower et al., 1990). Association analysis involves spatial distribution. What spacing connotes association? What distance between plants establishes association? The purpose of this research effort is to (1) determine spatial characteristics of plants of all species in a plot and (2) describe a procedure to determine the amount of plant cover (basal area) around plants of several desert plant species. We believe that our procedures provide an accurate estimate of the amount of basal area around plants within field plots. Results of such investigations should be helpful in studies of associations among plant species. Overall, this procedure also provides the ability to join with other ecological parameters to provide better estimates of ecosystem structure.

2. Materials and methods

2.1. Field data taken

The field plot of this study was located in Tucson Mountain Park near Tucson, AZ. The field plot was located within 200 m west of automobile turnout K16 along Kenney Road. This field plot was 1089 m^2, 33 m on each side. This plot was subdivided into nine smaller contiguous subplots arranged in a 3×3 grid network. Each subplot was 121 m^2, 11 m on each side. A temporary marker was placed at each of the four corners of each subplot. Each plant was given a number within the plot. Each plant was measured from either a field plot marker or another plant within an *X*-, *Y*-coordinate system within the plot. The first plant in each plot was measured from the southeastern-most plot marker. The next plant was either measured from the southeastern-most plot marker or from the first plant measured. All measurements were made to the nearest 0.05 m. *X*-values to the east were given negative values while *X*-values to the west were given positive values. *Y*-values to the north were given positive values while *Y*-values to the south were given negative values. Only perennial plants that were more than 0.2 m in height were included in this study. Small perennials, such as bursage (*Ambrosia deltoidea*), ephemerals, annuals and/or grasses were excluded from this study. Within each plot, each plant selected was given a number. The species name, distances of each plant from a marker or another plant was recorded. In addition, the height, diameter and condition were recorded for each plant. Height was recorded to the nearest 0.1 m. Diameter of each plant was determined based upon an average of the shortest and the longest diameter measurements to the nearest 0.1 m. The following perennial plant species were the only species present in the study plot considering the restrictions given above:

Opuntia phaeacantha var. *discata* (Griffiths);
P. velutina (Torr.);
C. gigantea (Engelmann);
Cylindropuntia acanthacarpa var. *major* (Engelmann and Bigelow);
Fouquieria splendens (Engelmann);
Cercidium microphyllum (Torr.);
L. tridentata var. *tridentata* (DeCandolle);
Ferocactus wislizeni (Engelmann);
Mammillaria microcarpa (Engelmann).

2.2. Procedure to determine the distances between all plants of a plot

As stated above, the north–south and east–west distances of each plant to another plant or from a marker were recorded. A Visual Basic™ program (Microsoft Visual Basic™, Sales International, Conyers, GA) was developed and used to determine the distances and directions between all the plants in a plot. Since *X*-, *Y*-coordinate distances were measured for each plant relative to one other plant or to a plot marker, the *X*-,*Y*-location of each plant was established within the plot. Because the *X*-,*Y*-location of each plant was known, a computer program was used to calculate the linear distance between each plant and every other plant in the plot. A separate program was developed that allowed a user to inquire which plants were within a specified distance from every other plant.

2.3. Procedure to determine plant cover within a specified radius for each plant

Once the distance from each plant to all other plants was available, we determined the amount of plant cover (basal area) around each plant. The first step in this process was to