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SHORT COMMUNICATION

METHODS OF MEASURING THE PROPORTIONS OF PLANT SPECIES PRESENT IN FOREST AND THEIR EFFECT ON ESTIMATES OF BIRD PREFERENCES FOR PLANT SPECIES

Summary: Stem density, basal area, vegetation cover and vegetation surface area were compared as measures of the proportions of plant species present in North Okarito Forest, South Westland, for use in determining bird preferences for plant species. In general, stem density estimates of the proportions of canopy species were about 10 times lower than basal area estimates. The converse was true for estimates of the proportions of sub-canopy and understorey species. The proportions estimated from vegetation cover and vegetation surface area were similar for most species, and were intermediate between the proportions estimated from stem density and basal area. However, in the upper forest tiers, vegetation cover gave lower estimates for the proportions of canopy species and higher estimates for the proportions of sub-canopy species than given by vegetation surface area. These differences affect calculation of bird preferences for plant species. We recommend vegetation surface area as a measure of the proportional availability of plant species to birds because it is appropriate to most birds in New Zealand forests, is likely to be more accurate than visual estimates of vegetation cover, and can be measured on the same plots separately for trunks, branches, foliage, and fruit.

Keywords: podocarp forest; botanical composition; birds; habitat-selection; South Westland.

Introduction

Bird preference for a plant species may be expressed as the difference between the bird's proportional use of the plant species and the proportion of the plant species present in the habitat (Holmes and Robinson, 1981; Airola and Barrett, 1985; Thomas and Taylor 1990). Thus, a plant species used proportionally more often than it is present is preferred or selected by birds, whereas one used proportionally less often is avoided. The method of measurement of both components (proportional availability and proportional use) will obviously affect estimates of bird preference. In this paper, we investigate the effect of the method of measuring the first component (proportional availability of plant species) on estimates of bird preference for plant species in a forest habitat.

Various measures have been used for estimating the proportions of plant species present in bird habitat; e.g., stem density (Peck, 1989), stem basal area (Franzeb, 1985), foliage cover (Airola and Barrett, 1985), foliage volume (Balda, 1969; Franzreb, 1978), foliage surface area (MacArthur and MacArthur, 1961), and total biomass of each species (Anderson and Shugart, 1974). The reason for choosing a particular measure is seldom given. However, Smith (1977) justified the use of stem density by noting that "each tree species has a more or less distinctive configuration that may be important to a certain bird species". Basal area has been claimed to be a reliable indicator of substrate availability for birds that forage from trunks (Franzreb, 1985), and foliage cover for birds that glean from foliage (O'Donnell and Dilks, 1987). However, most birds in New Zealand forests are generalists, and utilise both trunks and foliage. For this reason, O'Donnell and Dilks (1987) used three methods (stem density, basal area, and foliage cover) to determine overall bird preferences for plant species in South Westland.

Theoretically, the surface area of trunks, branches, and foliage is the most relevant measure of plant species availability to insectivorous birds that spend a large proportion of their time searching plant surfaces for insects; and the biomass of foliage and fruit is the most relevant measure for frugivorous birds. For such species, it is not the number of stems or the percent cover of foliage but the surface area of stems and foliage or biomass of leaves and fruit that is important. Vegetation surface area and biomass, however, are difficult to measure, especially in tall forest.

The probable reasons for measuring stem density, basal area, and foliage cover in bird habitat studies are that they are standard forest inventory measurements and relatively easy to record. Their use is legitimate provided they accurately reflect the proportions of plant species present in terms meaningful to birds. However, this has seldom been tested.

In this study, we compare estimates of the proportions of plant species given by three standard forest inventory measurements (stem density, basal area, and vegetation cover) with the theoretically more meaningful measurement of vegetation surface area.

Study Area

The study area covered 100 ha of mixed-age forest within North Okarito Forest (8760 ha), South Westland. The forest canopy was dominated by rimu *(Dacrydium cupressinum)*[1] (James, 1987). Other canopy species included miro *(Prumnopitys ferruginea),* silver pine *(Lagarostrobos colensoi),* Hall's totara *(Podocarpus hallii),* and southern rata *(Metrosideros umbellata)*. Sub-canopy and understorey species included kamahi *(Weinmannia racemosa),* quintinia *(Quintinia acutifolia),* pokaka *(Elaeocarpus hookerianus),* mapou *(Myrsine australis),* rohutu *(Neomyrtus pedunculata),* and mountain toatoa *(Phyllocladus aspleniifolius* var. *alpinus).*

Methods

Stem density and basal area for each woody species were determined from thirty 20 x 20-m plots (Allen and McLennan, 1983), established randomly in different stand types in the study area.

Vegetation cover for each woody species was determined from reconnaissance (recce) descriptions using six height tiers as specified by Allen and McLennan (1983). Seventy descriptions were made at 50-m intervals along transects in the study area. The individual tier percentage cover-class mid-points were weighted by the tier height-intervals and summed to give a total cover value for each plant species. The 12+ m tier extended from 12 m to the mean top height (27.2 m), and the emergent tier from the mean top height to the maximum height recorded (36 m).

An index of the surface area of stems, branches, and foliage of each woody species was determined from the number of vegetation intercepts on point-height -intercept (PHI) plots (after MacArthur and MacArthur, 1961; Park, 1973; Leathwick, Hay and Fitzgerald, 1983). At each of 1040 points established randomly at 1 to 20-m intervals along the recce description transects, a vertical sight-line was made through the vegetation using a gimbal-mounted 2.5x telescope. The heights of vegetation (trunks, branches, and foliage) intercepting this line were recorded with the aid of a graduated pole below 5 m and range-finders above 5 m. Because Park (1973) recommended that the technique should be used only in forests with a canopy 15 m or lower, the technique was modified as follows:

a) The vertical line was expanded to a vertical cylinder with a 5-cm radius, which a plant species had to intercept to be recorded as present;
b) The presence of plant species intercepting this cylinder was recorded in I-m height intervals, instead of the exact height of each intercept.
c) The relative abundance of plant species within the 1-m height intervals was recorded on a linear scale of 1-10 (where 1 = 1-10% of the cylinder intercepted), instead of the exact number of intercepts.

Intercepts were classed as either foliage (leaves and twigs ≤2 cm diameter), branches (> 2 cm diameter), or trunks.

Results

Three factors influenced estimates of the proportions of plant species present in North Okarito Forest:

1) The method of measurement. The proportion of rimu, the dominant canopy species, estimated from stem basal area was nearly twice that estimated from vegetation cover and vegetation surface area, and 10 times that estimated from stem density (Table 1). Proportions estimated from vegetation cover and vegetation surface area were similar for most plant species. In general, canopy trees such as rimu, miro, and southern rata comprised a larger percentage of the total basal area, vegetation cover, and vegetation surface area than of the number of stems in the forest. The converse was true for sub-canopy and understorey species such as kamahi, mountain toatoa, and rohutu. The species with the greatest proportion of stems was kamahi, but the species with the greatest proportion of basal area, vegetation cover, and vegetation surface area was rimu (Table 1).
2) The height of measurement. Vegetation cover and vegetation surface area were the only measures that gave the height distribution of the vegetation (Fig. 1). The upper tiers of the forest were dominated by rimu, and the lower tiers by kamahi. Above 12 m (the top two tiers for recce descriptions), rimu comprised 57% of the vegetation cover and 75% of the vegetation surface area. Below 12 m, kamahi comprised 38% of the vegetation cover and 33% of the vegetation surface area (and rimu comprised 11 % and 9% respectively). Below 2 m, vegetation cover and vegetation surface area were dominated by kamahi (21 % for both) and rohutu (20% and 19%, respectively), stem density by kamahi (46%) and rohutu (17%), and basal area by rimu (62%).

[1]Plant nomenclature follows Allan (1961) and Connor and Edgar (1987), and bird nomenclature follows Turbott (1990).

Table 1: *Percent plant species composition, North Okarito Forest; comparison of four measures.*
[1]*Mainly* Metrosideros fulgens *but includes* M. diffusa.

Plant species	Stem density	Basal area	Vegetation cover	Vegetation surface area
Canopy species				
rimu	6.4	62.4	36.6	33.3
miro	1.3	5.9	8.3	5.2
silver pine	1.1	1.6	0.8	0.5
Halls's totara	0.6	0.6	0.6	0.7
southern rata	0.4	5.2	4.5	3.2
Subcanopy/understorey				
kamahi	45.6	14.0	19.9	22.5
quintinia	8.2	8.3	15.8	10.9
mountain toatoa	5.5	1.1	2.8	3.1
pokaka	2.2	0.3	0.7	1.2
rata vine [1]	0.2	0.1	1.4	2.6
rohutu	17.1	0.1	2.4	6.0
mapou	3.0	0.1	0.9	1.0
Others	8.1	0.5	5.5	9.7

The part of the plant measured. Vegetation surface area was the only measure that gave separate estimates for foliage, branches, and trunks. About 90% of the vegetation surface area was foliage, and 10% branches and trunks. Rimu comprised 32% of the total foliage surface area (similar to its percent vegetation cover) and 64% of the total trunk and branch surface area (similar to its percent basal area).

Discussion

The different estimates of the proportions of plant species present given by the different measures are generally explicable. For example, the high percentage of rimu estimated from basal area is a result of large trees having a higher basal area-to-foliage ratio than smaller trees (c.f. Beets, 1980). Thus, use of basal area to measure plant species' proportions would over-estimate the vegetation surface area of rimu compared to smaller plants in the forest. Conversely, use of stem density would under-estimate the vegetation surface area of rimu because it ignores the size of stems and amount of foliage they carry.

The low percentage of rimu above 12 m estimated from vegetation cover compared to vegetation surface area is a result of the use of inappropriate tiers in relation to the tall profile of rimu when measuring

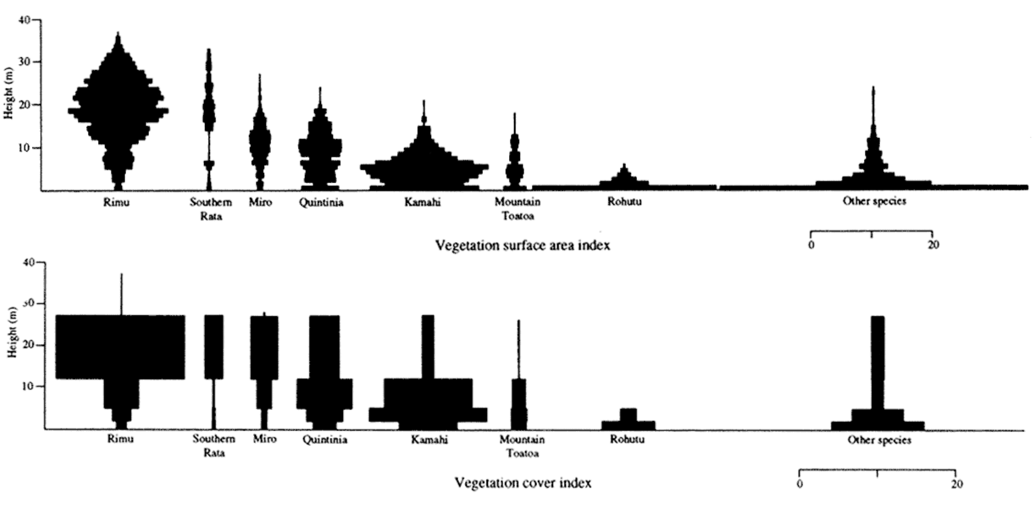

Figure 1: *Vegetation cover (%) and vegetation surface area (intercepts/100 points) of plant species in relation to height, North Okarito Forest, South Westland.*

vegetation cover, and/or of not measuring the mean top heights of individual plant species. Vegetation cover above 12 m was measured in only two tiers (after Allen and McLennan, 1983). The cover of sub-canopy species such as kamahi and quintinia, which extend panly into the 12+ m tier, were weighted by the full tier height interval. Consequently, the cover of these species was over-estimated, resulting in the cover of canopy species such as rimu (which extend right through the tier) being under-estimated. If cover had been measured in more tiers above 12 m, or if top heights of individual species had been measured, rimu would have made a greater contribution to forest cover above 12 m.

The accuracy of our measurements of vegetation surface area has not been validated. There is an acknowledged problem in establishing a vertical line from a point with no horizontal dimensions, especially in tall, dense forest. We attempted to overcome this by using a vertical cylinder instead of a vertical line. The thickness of the line (or point) affects estimates of the number of intercepts on individual plant species, but as noted by Warren Wilson (1963a) errors tend to cancel out when the results are expressed as percentages of plant species present. The accuracy of surface area measurements could theoretically be improved by recording intercepts on a line inclined at an angle from a point (Warren Wilson, 1963b), although MacArthur and Horn (1969) noted that measurements made from a vertical line are very similar to those made from a horizontal line. Elliott (1990) has devised a new method combining the use of Warren Wilson's inclined angle with MacArthur and Horn's method of recording only the first intercept. Despite problems with our method, measurements of vegetation surface area are likely to be more accurate than visual estimates of vegetation cover (c.f. Block, With and Morrison, 1987).

The different measures of the proportions of plant species present in the forest affect estimation of bird preferences (i.e., proportion of bird use minus proportion of plant species present). For example, estimates of bird preference for rimu would be greater if the proportion of rimu present was determined from stem density (rimu = 6% of the stems present) than from basal area (rimu = 62% of the basal area). If a bird species used rimu 30% of the time, its preference for rimu would be (0.30-0.06) = +0.24 when the proportion of rimu is determined from stem density, and (0.30-0.62) = -0.32 when the proportion of rimu is determined from basal area. A positive value indicates selection for the plant species, whereas a negative value indicates avoidance. In the first instance, the bird species appears to select rimu, but in the second instance it appears to avoid rimu. Correct estimation of bird species' preferences is critical, for example, when considering the impact of harvesting a tree species on bird populations.

Our data supports previous authors' claims (see Introduction) that basal area is a reasonable indicator of trunk surface area, and foliage cover is a reasonable indicator of foliage surface area. If it is desired to have separate measures of trunk and foliage surface area, these can be obtained directly from one method (PHI plots) instead of making separate measures of basal area (from 20 x 20-m plots) and percent cover (from recce descriptions). Funhermore, PHI plots provide information on the vertical distribution of substrates, which is important when considering bird utilisation of canopy trees in contrast to understorey trees.

The surface area of vegetation is, of course, not the only component of the habitat important to birds. The presence of fruit, for example, is important for frugivorous birds, and hollow trees for cavity-nesting birds (Spurr, 1986). However, use of fruit and nesting cavities is seasonal. Other components of the habitat must be important at other times of the year. For omnivorous species such as silvereyes *(Zosterops latera lis)* which feed on insects as well as fruit, and for cavity-nesting species such as riflemen *(Acanthisitta chloris),* which feed primarily on insects, the surface area of vegetation will always be important. For species such as New Zealand pigeons *(Hemiphaga novaeseelandiae),* which feed only on fruit and leaves, fruit and foliage biomass may be a more appropriate measure of availability. The surface area (and hence biomass) of fruit can be measured if surveys are made when plants are fruiting. Otherwise, it is likely that large, old, trees with a large surface area will produce more fruit, contain more cavities, and have a larger biomass than smaller, younger, trees of the same species. As a result of these considerations, we recommend the use of vegetation surface area as a more appropriate measure of plant species availability than standard forest inventory measurements for both insectivorous and frugivorous birds in New Zealand forests.

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