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ANALYZING FORAGING USE VERSUS AVAILABILITY USING REGRESSION TECHNIQUES

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Abstract. Most analyses of bird foraging use versus availability of resources, such as tree species, have employed goodness-of-fit techniques. Rather than pooling observations from all birds and portions of a study area into one goodness-of-fit analysis, we recommend collecting use and availability data on a number of territories, and using the data from each territory as an independent observation in a simple, multiple, or multivariate regression analysis, with availability values as independent variables and use values as dependent variables. In a demonstration, the two methods yield slightly differing results. The advantages of the regression method are discussed with respect to biological scale, sampling considerations, analysis requirements, and interpretation. Regression methods appear superior to goodness-of-fit techniques in each respect, particularly given sufficient sample size, and provide greater promise to researchers examining use versus availability problems.

Key Words: Use versus availability; goodness-of-fit; regression; Solitary Vireo; *Vireo solitarius*; tree species preference.

Patterns of resource use and availability are commonly examined in avian ecology studies. The fit of a bird's apparent preferences to the availability of its potential resources can provide insight into a species' ability to successfully populate an area, adapt to changing conditions, and limit the populations of prey species. In this paper, we propose that regression techniques can replace other methods to analyze use versus availability data. Although we concentrate on a woodland bird's use of different tree species versus their availability, we note that these methods may be extended to other resources as well.

A variety of techniques have been applied to the analysis of use-availability data. These include the forage ratio and modifications (Williams and Marshall 1938, Chesson 1978), the index of electivity (Ivlev 1961), and goodness-of-fit. Johnson (1980) criticized these methods and proposed an alternative (PREFER), involving the use of ranks. Goodness-of-fit, however, continues to be widely used (e.g., Balda 1969; Franzreb 1978, 1983a; Holmes and Robinson 1981; Maurer and Whitmore 1981; Askins 1983; Rogers 1985), usually by the following procedure: the study area (generally a vegetationally homogeneous stand) is traversed in some regular fashion, and observations are taken on all foraging birds (Franzreb 1978, 1983a; Holmes and Robinson 1981; Askins 1983; Rogers 1985). The observations recorded may be prey attacks (e.g., Holmes and Robinson 1981, Maurer and Whitmore 1981), or simply the location of the bird during active foraging behavior (e.g., Balda 1969, Rogers 1985). Some workers have recorded the amount of time spent in each tree species or vegetation category (e.g, Askins 1983). Tree species availability is assessed by sampling throughout the study area (Balda 1969; Franzreb 1978, 1983a; Holmes and Robinson 1981; Maurer and Whitmore 1981). In the analysis, use is quantified by tallying the total number of observations in each tree species, which is multiplied by the relative availability of each tree species to obtain the availability value for that species. An $r \times 1$ (where r denotes the number of tree species being considered) table is then constructed, where the use estimate equals the observed value and the availability estimate equals the expected value in each cell. The null hypothesis of homogeneity of the two populations (use and availability) is tested using the chi-square or *G*-statistic (Franzreb 1978, 1983a; Holmes and Robinson 1981; Maurer and Whitmore 1981; Askins 1983; Rogers 1985). A significant statistic indicates that use of the suite of tree species differs from availability, but offers no information as to which tree species are responsible for the difference.

We suggest regression procedures might be better suited to the analysis of such data. To our knowledge, regression methods have not been previously applied to this problem in the avian literature, except by Rogers (1985). In a study of Least Flycatcher (*Empidonax minimus*) foraging behavior, Rogers (1985) used the Spearman rank correlation procedure to compare relative tree species use to relative tree species frequency. However, because each observation in the analysis is composed of the use and concomitant availability of a different tree species within a bird's territory, and the analysis is limited to one territory, the design violates the assumption of independence of observations involved in regression-correlation analyses. The proper use of regression techniques appears to be a novel approach to the analysis of avian foraging use versus availability data. The sampling and analysis scenario for a study using regression is different from that used in goodness-of-fit analyses. Rather than lumping together samples from a number of different locations, individual territories are delineated, and separate data are collected on each territory. In each territory, the amount of time spent actively foraging in each specified tree species is recorded (although number of prey attacks may be used if preferred). Territories may be visited more than once through the period of interest, as long as visits are randomized to avoid diurnal and seasonal bias. At the end of the sampling period, all data for a given territory are combined by tree species. Tree species availability is also determined for each territory. Availability may be defined by a variety of measures, including basal area, foliage volume, or percent coverage. In the analysis, all data collected in each territory are combined into one statistical observation, so that the number of statistical observations in the analysis will be equal to the number of territories sampled. Hence, a number of territories must be sampled in order to provide an adequate sample size. Relative values are used in the analysis. Availability values are obtained by dividing the amount (e.g., basal area) of each tree species in each territory by the total amount (e.g., total basal area) of all tree species combined in that territory. Use values are calculated in a similar fashion by dividing the amount of seconds the bird spends in each tree species by the total number of seconds of observation collected in that territory.

Both simple and multiple regression methods may be employed to analyze the data. In all cases, the availability data constitute the independent variable(s), while the use data are used as the dependent variable(s). (Strictly, this is a correlation problem, because the independent variables are not fixed [Dowdy and Wearden 1983].) Use and availability values can be directly compared because they are expressed as relative values, and hence possess the same units of measure. The underlying reasoning for the regression approach is that, if use equals availability, there will be an approximately one-one correspondence between use and availability across all values of availability. To insure that a one-one correspondence can be tested for, the intercept value is always forced to equal 0. Theoretically, the intercept value should always equal 0 since, when availability equals 0, use has to equal 0. However, the actual distribution of data points may produce a computed regression line that deviates from a 0 intercept value. Forcing the regression line to pass through the origin eliminates this problem.

At the most elementary level, simple linear regression can be used to determine the relationship between a single tree species' use and its concomitant availability. The hypothesis that use is proportional to availability is tested by determining, using a t-test, whether or not the slope (b) is significantly different from 1. (Because the intercept is excluded from the equation, the calculation of the standard error of b in the denominator of t is somewhat altered [Afifi and Clark 1984:103]. The particular statistical package being used may or may not incorporate this change, and should be checked.) If b does not deviate significantly from 1, then the tree species is used in proportion to its availability. If b is greater than 1, use is greater than availability. If b is less than 1, availability exceeds use.

Additional information may be obtained by looking at the interaction among several tree species' availabilities in their relation to the use of one tree species (multiple regression). Such relationships can be examined by using raw partial regression coefficients. These values allow the investigator to determine the relative importance of any one availability variable to the use variable while taking the effects of the other availability variables into account by holding their effects constant (Dowdy and Wearden 1983, Afifi and Clark 1984). In this instance, the partial regression coefficient of the tree species availability variable whose use is being examined is tested (using a t-test) to determine whether or not it differs significantly from 1, and if so, in what direction.

At the highest level of complexity is multivariate regression analysis. This technique is characterized by more than one variable on each side of the equation. Multivariate regression may be particularly appropriate for examining the relationship between use and availability of all tree species simultaneously, in that response variables (use of different tree species) may be interrelated (Gnanadesikan 1977, Johnson 1981a). Partial correlation coefficients may be useful in this respect (e.g., Mountainspring and Scott 1985).

METHODS

To demonstrate the use of regression techniques in analyzing foraging use versus availability, and to compare the results of regression analyses with those of the goodness-of-fit technique, Solitary Vireo (*Vireo solitarius*) foraging data were subjected to analysis. Because these data were not collected in independent territories, they are presented solely for illustrative purposes. Unless one is willing to assume that Solitary Vireos do not exhibit individual-specific foraging behavior, the results of these analyses should not be used to develop conclusions regarding this species. The data were collected on a 58 ha study area located in Sleepy Creek Public Hunting and Fishing Area, Berkeley Co., in eastern West Virginia. The study area is situated on the western slope of Third Hill Mountain, in a forest dominated by scarlet oak (*Quercus coccinea*), chestnut

TABLE 1. RESULTS OF SIMPLE REGRESSION ANALYSES OF SOLITARY VIREO FORAGING USE VERSUS AVAILABILITY OF NINE TREE SPECIES OR GROUPS. EACH SPECIES OR GROUP LISTED REPRESENTS A SEPARATE ANALYSIS INVOLVING THE USE OF THAT SPECIES OR GROUP AS THE DEPENDENT VARIABLE, AND THE AVAILABILITY OF THAT SPECIES OR GROUP AS THE INDEPENDENT VARIABLE. LISTED FOR EACH SPECIES OR GROUP IS THE SLOPE (*b*), STANDARD ERROR OF THE SLOPE, T-VALUE FOR TESTING H_0: $B = 1$ (* = $P < 0.05$; ** = $P < 0.01$), COEFFICIENT OF DETERMINATION (r^2), AND WHETHER USE (U) EQUALS OR IS LESS OR GREATER THAN AVAILABILITY (A)

Tree species or group	*b* (slope)	Standard error of slope	*t* (H_0:$b = 1$)	Coefficient of determination	Conclusion
Chestnut oak	0.485	0.111	−4.621**	0.373	U < A
Pines	0.373	0.075	−8.379**	0.437	U < A
Red Maple	0.070	0.146	−6.353**	0.007	U < A
White oak	0.391	0.488	−1.246	0.020	U = A
Scarlet oak	1.577	0.209	2.767**	0.641	U > A
Snags	0.551	0.163	−2.747**	0.262	U < A
Other red oaks	0.408	0.201	−2.952**	0.115	U < A
Hickories	0.882	0.240	−0.494	0.297	U = A
Black gum	0.303	0.140	−4.983**	0.128	U < A

oak (*Q. prinus*), and pitch pine (*Pinus rigida*) in the canopy, and red maple (*Acer rubrum*) and black gum (*Nyssa sylvatica*) in the understory. Lesser amounts of white oak (*Q. alba*), northern red oak (*Q. rubra*), black oak (*Q. velutina*), table mountain pine (*P. pungens*), and several species of hickory (*Carya* spp.) occur. Mountain laurel (*Kalmia latifolia*) and blueberries (*Vaccinium* spp.) compose the majority of the shrub layer. The herbaceous layer is sparse. The area was divided into 50 m × 50 m blocks. From mid-June to late July 1985 the study area was repeatedly traversed from 06:00–13:00 EDT. All vireos encountered were followed for up to approximately 1 hr. The amount of time spent actively foraging in each tree species visited, including snags, was recorded on a cassette recorder and assigned to the block in which the bird was located. Observations were transcribed from cassettes and timed using a stopwatch, and constitute use data. The basal area of each tree species, including snags, was also measured on 0.04 ha circular plots located in the center of each block to characterize tree species availability in that block.

These data were subjected to two different analyses. The nine most abundant tree species (or tree species groups), including snags, were selected for inclusion. All pines were lumped into one variable, as were all hickories, and northern red oak and black oak were combined into "other red oaks." Only those blocks where at least 3 min of foraging observations were recorded were included in the analyses to simulate territories, yielding a sample size of 33 blocks. Although 3 min may seem a minimal amount of time to adequately describe a bird's foraging behavior at a particular location, it is realistic for such a study, considering the difficulty of collecting such data (e.g., Robinson and Holmes 1982). For each block, the number of seconds spent foraging in each tree species or group relative to the total number of seconds of observation in that block was calculated, as was the basal area of each species or group relative to the total basal area of all species in that block combined. Hence, the relative values ranged from 0 to 1. Due to the small sample size, only simple regression analyses were run in the manner described previously. For the comparative goodness-of-fit analysis, foraging observations collected across all the blocks incorporated in the regression analysis were combined for each tree species or group to yield use data (i.e., the total number of seconds spent in each tree species or group across all 33 blocks was calculated). Similarly, tree species availability was determined by combining basal area values for each tree species or group across all 33 blocks, dividing by the total basal area of all tree species, and multiplying by the total number of seconds of foraging observations collected. Any tree species or group not included in the regression analysis was placed in the "other species" category. These data constituted observed and expected values, respectively, as described above. The two values for each tree species or group were then compared, and the chi-square value was calculated across all tree species and groups and checked against the table value for 9 df. To determine the contribution of each tree species or group to the overall results, an analysis of residuals (Everitt 1977:46–48) was performed. Because only one column exists in the table of data, adjusted residuals could not be calculated, so unadjusted values were used for interpretation. Adjusted values are always higher than unadjusted values, so the unadjusted values represent conservative estimates (Everitt 1977:46–48).

RESULTS

Regression

Simple regression analyses indicated that six tree species or groups were underused relative to their availability (chestnut oak, pines, red maple, snags, other red oaks, and black gum), one was used more frequently than expected based on its availability (scarlet oak), and two were used in proportion to their availability (white oak and hickories) (Table 1). Note the fairly inconsistent relationships between use and availability for

TABLE 2. RESULTS OF GOODNESS-OF-FIT ANALYSIS OF SOLITARY VIREO FORAGING USE VERSUS AVAILABILITY OF 10 TREE SPECIES OR GROUPS. EACH SPECIES OR GROUP REPRESENTS ONE ROW OF A 10 × 1 TABLE. LISTED FOR EACH SPECIES OR GROUP ARE THE OBSERVED (USE) AND EXPECTED (AVAILABILITY) VALUES (IN SECONDS), DEVIATION USED IN THE CALCULATION OF THE CHI-SQUARE VALUE, THE PERCENT DEVIATION OF USE FROM AVAILABILITY, THE UNADJUSTED RESIDUAL VALUE (SEE TEXT), AND RESULTS OF Z-TEST OF H_0: RESIDUAL = 0 (* = P < 0.05; ** = P < 0.01), AND WHETHER USE (U) EQUALS OR IS LESS OR GREATER THAN AVAILABILITY (A). CHI-SQUARE = 8397 (P < 0.01)

Tree species or group	Observed (*O*) (use)	Expected (*E*) (availability)	$\frac{(O-E)^2}{E}$	% deviation	Unadjusted residual	Conclusion
Chestnut oak	3091	4554	470	−32	−21.68**	U < A
Pines	639	1609	585	−60	−24.18**	U < A
Red maple	254	635	229	−60	−15.12**	U < A
White oak	500	353	61	42	7.82**	U > A
Scarlet oak	8854	3961	6044	124	77.75**	U > A
Snags	1772	3122	584	−43	−24.16**	U < A
Other red oaks	883	1456	226	−39	−15.02**	U < A
Hickories	14	26	6	−46	−2.35*	U < A
Black gum	190	392	104	−52	−10.20**	U < A
Other species	1	90	88	−99	−9.38**	U < A

most species, as exhibited by the relatively low coefficients of determination (r^2 values).

Goodness-of-fit

The goodness-of-fit analysis produced a highly significant chi-square value (Table 2). This indicates that, overall, use of the tree species was different from availability. The analysis of residuals (Everitt 1977) demonstrates that every tree species or group was used disproportionately. Specifically, white oak and scarlet oak were used more than available, while the other species were underused. Percent deviations of use from availability reflect these results. For instance, scarlet oak, according to this analysis, was used 124% more than it was available, while several other species were used at least 50% less than expected.

DISCUSSION

Comparison of methods

Two methods, simple regression and goodness-of-fit analysis, were used to analyze the same data set of foraging use and availability values. The conclusions are the same for seven of nine tree species or groups. Two species, however, yielded different results. Regression showed use to be equal to availability for white oak and hickories, while the goodness-of-fit analysis indicated usage greater and less than availability, respectively. For these two species, variability in use among individual "territories" (blocks) inflated the denominator of the t-test in the regression analysis, making any trend difficult to determine. Because the goodness-of-fit analysis does not incorporate any measure of variability, but rather sums use across individuals, the results appear more definite, but are misleading. If the techniques produce conflicting conclusions, which is better, if not more legitimate? We think the regression method is superior on the basis of four criteria: biological scale, sampling considerations, analysis requirements, and interpretation. We discuss each criterion below (summarized in Table 3).

Biological scale

Wiens (1981) has discussed the importance of selecting the proper scale for examining various ecological questions, and insuring that the same scale is considered for all portions of a particular analysis. Goodness-of-fit studies customarily involve sampling availability randomly throughout the study area. However, birds have already selected certain regions of the area for use. Use and availability are therefore measured at two different scales, in that availability may be determined at points not used by any one individual. Availability must be sampled only at locations possessing potential for use (i.e., within territories). Otherwise, comparisons are invalid. If availability data are collected within areas of known use, the goodness-of-fit method is still invalid if all individuals are lumped together (as is commonly done), because each individual does not possess an equal opportunity to use all areas where availability is measured. The alternative is to run a separate analysis for each individual, but this defeats the purpose of the method, in that general conclusions cannot be readily drawn across all individuals. Regression procedures measure both use and availability at the same

TABLE 3. SUMMARY OF THE ADVANTAGES OF REGRESSION METHODS OVER GOODNESS-OF-FIT TECHNIQUES. THE TWO METHODS ARE COMPARED ON THE BASIS OF BIOLOGICAL SCALE, SAMPLING CONSIDERATIONS, ANALYSIS REQUIREMENTS, AND INTERPRETATION

	Regression	Goodness-of-fit
Biological scale	Use of resources by each individual bird is compared only to the availability of resources within that bird's territory, so that use and availability are measured at the same scale.	Use of resources by each individual bird is compared in part to the availability of some resources to which that bird does not have access (outside its territory), hence use and availability are measured at different scales.
Sampling considerations	For each individual bird, sequential foraging data may be collected, as they will be combined into 1 statistical observation for that individual. This enhances sampling efficiency.	Sequential foraging data may not be collected, as each datum will constitute a statistical observation, and these observations must be independent to satisfy analysis requirements. This reduces sampling efficiency.
Analysis requirements	Though requirements are more rigid (e.g., independent observations, normality, equality of variances, linearity, minimal effect of outliers, and low multicollinearity in multiple regression), they can be met or circumvented with a well-designed study and an adequate sample size.	Few requirements exist, but the effect of nonindependent observations and small expected values can be difficult to overcome.
Interpretation	Use versus availability of different tree species, and deviations of individual birds from the population as a whole, may be readily determined.	Use versus availability of different tree species, and especially the deviation of individual birds from the population as a whole, may be difficult to ascertain.

level. Availability data for a given territory are related only to the individual(s) occurring in that territory. Availability data are collected in some manner throughout each territory because all trees in that territory are potentially accessible.

Sampling considerations

A requirement of goodness-of-fit significance tests is that observations be independent (Everitt 1977, Dowdy and Wearden 1983). Strictly, only one observation can be collected per individual (Peters and Grubb 1983), but workers have employed various strategies in an attempt to sidestep this problem, including separating observations by a specified time interval (the "metronome method") (Wiens et al. 1970, Rusterholz 1981, Morrison 1984a). However, unless the interval between observations in a sequence is sufficiently large, the observations may still be correlated (Hejl et al., this volume). A problem with using only a subset of observations per sampling bout is that a large amount of effort is required to procure a sufficient sample size for analysis (Wagner 1981a). Field time, often limited, is inefficiently used when such a sampling strategy is employed.

The only difficulty with sampling for the regression method is that a relatively large number of territories must be monitored to insure an adequate sample size. The number of samples needed depends on, among other things, the number of variables included in the analysis, and the amount of variability in the data (Johnson 1981b). This hampers the utility of the regression method for less abundant species. Further, sufficient observations must be collected in each territory so that the data are representative of the behavior exhibited by that individual. Otherwise, the regression procedure possesses distinct advantages with respect to sampling. Data are independent, because all foraging observations collected within a territory are incorporated into the same statistical observation. Because territories are separate from one another, these statistical observations are independent. The investigator is therefore free to incorporate all the data recorded for each territory, and time data (time spent in each tree species) may be used. Recording a sequential stream of data, such as time data, lessens the effect of discovery bias, and provides a more complete representation of a species' full range of behaviors (Hertz et al.

1979, Morrison 1984a). By recording all the activity displayed by a bird, rather than single observations, field efficiency is maximized (Wagner 1981a).

Analysis requirements

Goodness-of-fit analysis requirements are less stringent than those for regression methods, but more difficult to satisfy with foraging data. Goodness-of-fit significance tests assume independence of observations, a problem discussed previously. A second problem is small expected values, which will result from including uncommon tree species in the analysis, and may negatively affect the results of both chi-square and *G* statistic significance tests (Sokal and Rohlf 1969). Some workers have attempted to circumvent this problem by lumping certain categories together following data collection (e.g., Maurer and Whitmore 1981), but this may result in a loss of useful information and affect the randomness of the samples, violating the assumption of random and independent observations (Everitt 1977:40).

Though the assumptions for regression-correlation methods are more rigid, they can be met or circumvented, particularly with larger sample sizes (Green 1979). Normal distributions of variables are required to conduct hypothesis tests and make other inferences (Dowdy and Wearden 1983, Afifi and Clark 1984). Though transformations are available to improve many non-normal distributions prior to analysis, transformations are frequently undesirable, particularly for dependent variables (Johnson 1981a, Afifi and Clark 1984). In general, deviations from normality tend to make statistical tests conservative (Hollander and Wolfe 1973), so that significant results are likely to be truly significant. Variables are also assumed to possess equal variances (homoscedasticity). This assumption is not critical unless differences between variances are large (Afifi and Clark 1984). While the regression procedures discussed here assume a linear relationship between independent and dependent variables, curvilinear relationships are possible. Analysis of such relationships is likely to indicate that use deviates from availability, which should generally be the correct conclusion if substantial curvilinearity exists. Outliers can greatly affect both univariate and multivariate analyses (McDonald 1981, Afifi and Clark 1984); these may be identified before or after the analysis is undertaken. Outlying observations may be removed from the analysis, but such observations often possess important information (Neter et al. 1983, Afifi and Clark 1984). It may be wisest to incorporate all but those observations that are obvious blunders, and investigate the effect, if any, of including any outlying observations after the analysis is conducted.

An additional condition can affect multiple regression analyses. Multicollinearity, or interdependence of variables, can cause regression coefficients to be unstable, hindering interpretation of the results (Afifi and Clark 1984). Techniques are available to locate highly correlated variables, both prior and subsequent to analysis, so that the problem can be minimized (McDonald 1981, Afifi and Clark 1984). Careful variable selection may help this problem, and simple regression analyses may be used to back up multiple regression conclusions.

Interpretation

It is not enough to conclude that a bird does or does not use tree species in relation to their availability. One desires to know just which tree species are preferred or avoided, and which tree species most influence use patterns. In this respect, regression procedures are superior. Although residuals (Everitt 1977:46–48) may be useful in determining which tree species contribute most to a significant chi-square value, goodness-of-fit methods do not allow the investigator to assess the influence of the availability of one tree species on the use of another, or the interaction of different tree species availabilities in determining use trends. Partial regression coefficients may be examined for this purpose in regression analysis.

Another important consideration is whether some individuals provide data divergent from the analysis as a whole, and how such individuals have influenced the analysis. Only by constructing a different table for each territory can individual observations be examined separately using goodness-of-fit techniques. It is possible to examine tables separately, then subsequently combine them for additional analysis, but this approach is relatively awkward (Everitt 1977: 51). Regression methods are more informative and easier to execute and understand in this respect. Various plots and residuals can be examined to identify unusual or outlying observations (Afifi and Clark 1984). A battery of measures (e.g., Cook's distance) are available to ascertain the effect of each observation on the analysis (Afifi and Clark 1984, SAS Institute Inc. 1985). It requires little extra effort to obtain this information using many statistical computer packages (Afifi and Clark 1984).

Extensions

Regression methods may prove useful for other types of food exploitation studies, such as analysis of food use versus availability. The food brought to nestlings might be monitored and related to the prey available on the territory. Nest boxes (e.g., Dahlsten and Copper 1979) would be particularly useful for such a study. Another possible design involves the determination of adult bird diets through emetics or collection and subsequent gut content analysis. Food availability in this case would be ascertained by observing the bird prior to capture or collection and sampling immediately afterward the prey resource in locations in which the bird foraged. The ability of regression techniques to examine territory-territory or bird-bird variation in prey use versus availability makes these methods particularly attractive.

Examination of tree species use versus availability may lead to other investigations. For instance, the prey availability in each tree species might be determined. The amount of prey found in each tree species might be used to weight the abundance of that species, and the analysis rerun. If use approximates availability, it might be concluded that the primary reason some tree species are preferred or avoided is due to the prey they harbor. Tree species use versus availability characteristics may also help explain habitat distribution patterns. The correlation of the presence or abundance of a bird species with the abundance of a particular tree species may be found to be due to the bird's foraging preference for that tree species. The application of information obtained at one scale to phenomena observed at another scale would be valuable.

CONCLUSIONS

Several compelling arguments point to the superiority of the regression technique over the goodness-of-fit method in analyzing use versus availability data. In terms of sampling design, regression procedures are theoretically more appealing. Foraging data are easier to obtain per bird using the regression sampling scheme, and little additional work is demanded to assess availability on each territory. Regression analyses are at least as easy and straightforward to perform as goodness-of-fit methods. Though the statistical assumptions of regression techniques are more rigid, they can be met given careful attention to study design and an adequate sample size. Finally, regression results may be interpreted with greater facility than goodness-of-fit output, and provide more information.

Two additional methods, discussed in this symposium, have recently been applied to the analysis of use versus availability data. Markov chains can be used to produce independent data from sequential observations that are suitable for analysis (Raphael, this volume; Hejl et al., this volume). Although Raphael presents a goodness-of-fit analysis of data pooled across territories, he suggested methods for analyzing data on a territory-by-territory basis. Despite the generation of independent data, the limitations of goodness-of-fit analyses discussed above, particularly in terms of interpretation, still exist. McDonald et al. (this volume) discuss a means of analyzing use versus availability data using selection functions. Success is based in part on the proper choice of a model to fit the distribution of used and available resources, a choice that may not always be easy to make. This method appears to be in the developmental stages, and its applicability and effectiveness remain to be determined.

Of all the techniques, the regression approach appears to us to be the most sound. It makes sense to collect data on a number of territories due to the possibility of individual-specific behavior. Data may be collected in an efficient manner, a variety of statistical packages for analysis are readily available, and the methods and interpretation are straightforward. Conclusions may be drawn across the entire population; yet, the ability to examine the pecularities of individual territory owners is not lost. We encourage researchers to use the regression method to analyze suitable, presently available data sets, design future studies to accommodate the regression approach, and improve the methodology.

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