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FORUM is intended for new ideas or new ways of interpreting existing information. It provides a chance for suggesting hypotheses and for challenging current thinking on ecological issues. A lighter prose, designed to attract readers, will be permitted. Formal research reports, albeit short, will not be accepted, and all contributions should be concise with a relatively short list of references. A summary is not required.

An "audience effect" for ecological terminology: use and misuse of jargon

Dean C. Adams, Mario S. Di Bitetti, Charles H. Janson, Lawrence B. Slobodkin and Nicole Valenzuela¹, Dept of Ecology and Evolution, State Univ. of New York at Stony Brook, Stony Brook, NY 11794-5245, USA.

We shall demonstrate from examination of vocabulary in several different ecological journals that the terms used by ecologists are in part dictated by the expected audience. The same terms were used in different ways in these different journals. Such linguistic differences could cause serious ambiguity.

Ecology, like any science, must explain itself to students, fellow scientists, an interested public, and to possible funding sources. Some terms used by ecologists seem to be influenced by the expected audience. Among ecologists, communication is relatively easy because of shared scientific training. With students, ecologists must simplify their discourse. In both cases, ecologists can use their scientific jargon without undue fear of miscommunication. Communication with funding agencies, politicians, and the general public is complicated by the fact that some of the jargon used by ecologists originated from everyday language, and many of these terms have different meanings for ecologists and laypeople (e.g., *community*). Particular care needs to be taken to avoid misunderstanding when talking to non-ecologists. To document this "audience effect", we selected 30 terms (see Fig. 2 legend), based on our judgment of their potential for misinterpretation. We have included terms which have "fuzzy" or multiple definitions within the ecological community (e.g., *community*, *carrying capacity*, *biome*). Other terms, such as *entropy*, *equilibrium*, and *efficiency*, have distinct meanings for different sciences. We investigated which journals used which terms and how some terms were used differently by journals aimed at distinct audiences.

We categorized 43 professional journals into five groups, representing five main audiences: ecologists, students, biologists, other scientists, and the general public, including funding agencies and politicians (see Fig. 1 legend). We have placed journals aimed at multiple audiences in the category for which we feel they are most representative. For example, we have classified *American*

Naturalist as a biological journal rather than an exclusively ecological journal. We made a database containing the number of citations present from 1982 to 1995 for 30 selected ecological terms using the Cambridge Scientific Life Sciences and Bioengineering periodicals database. This database contains citations for abstracts from over 4000 periodicals, including our selected journals. We recorded the number of articles in each journal in which each term occurred, and used these data to qualitatively compare journal groups, and to identify any general trends in word use. We then reviewed articles containing either one of a selected pair of terms to compare their use in the five journal groups.

Using analysis of covariance, we compared the number of different terms for the five journal groups, using the total number of articles per journal containing terms as a covariate. We also calculated the reciprocal of Simpson's diversity index as:

$$D = \frac{1}{\sum_{i=1}^s P_i^2}$$

where P_i is the proportional contribution of the i th ecological term to the total occurrences of ecological terms (Simpson 1949). Finally, we performed a correspondence analysis (Greenacre 1984) of citation frequency of each term in each of the 5 journal groups. Correspondence analysis is similar to principal components analysis, in that it allows one to summarize the variation of multidimensional data in a few major axes. However, correspondence analysis is more appropriate when the data are in the form of a contingency table (i.e. frequencies), as in our analysis.

Specialized audiences

Five of the 43 journals contained ten or more of the 30 selected ecological terms. Four of these journals were

¹ Authorship alphabetical.

aimed at an ecological audience, namely: *Ecological Modelling*, *Ecology*, *Oecologia*, and *Oikos*. The remaining journal, *American Naturalist*, was aimed at a biological audience. Using analysis of covariance, we found that there was a highly significant difference in the number of ecological terms used ($F_s = 5.27$, $p = 0.0018$), with journals for ecologists having the highest number of distinct terms relative to the number of articles containing terms. We also found a significant difference between journal groups for the number of articles containing terms ($F_s = 2.91$, $p = 0.034$), with journals for funding agencies, politicians, and the general public having the highest average number of articles (18.56). Thus, while journals for ecologists contained a higher number of ecological terms, the use of terms in journals for the general public was much greater.

To investigate further any differences in term usage among journal groups we calculated the reciprocal of Simpson's diversity index (D) for each journal (Simpson 1949) to assess their heterogeneity, which ranged from 1.0 to 9.61. The three highest Simpson's D values (9.61, 9.31, and 8.91) were associated with three of the four journals with the highest number of ecological terms: *Oecologia*, *Ecology*, and *American Naturalist*, respectively. Regression analysis of Simpson's D on number of terms indicated that general public journals were low in their use of terms, and that these terms were not evenly distributed (Fig. 1). In these journals, a few terms were used a higher amount of the time than was expected by chance (sign test; probability = 0.0019). For example, *Ecological Economics* contained five different ecological terms and a total of nineteen citations. However, the term *sustainability* accounted for thirteen of these citations; hence a lower diversity index. Although not a general public journal, *Ecological Modelling* was found to be a statistical outlier, with a total of 15 ecological terms, but a diversity index of only 5.05 (Fig. 1). Of the 49 citations in this journal, 20 were for the term *ecosystem*.

To visualize the relationships between the 30 ecological terms and the five journal groups, we performed a correspondence analysis (Fig. 2). The first two axes of the analysis explained 89% of the variation in ecological terms (63.5% and 25% respectively). Based on the positions of the journal groups, the first axis represents a specificity axis, where negative deviations along this axis correspond to journals for more general audiences, and positive deviations along this axis correspond to journals of a more specialized nature. In addition, we noticed specific clumping of ecological terms along this axis, as well as around the different journal groups (Fig. 2). In particular, *diversity*, *tragedy of the commons*, *biodiversity*, *sustainability*, and *alien species* are tightly grouped around the general public journal group. Other terms, such as *stability*, *ecosystem*, *trophic level*, *equilibrium*, and *complexity*, are tightly grouped around

journals for ecologists; whereas *niche*, *pioneer*, *stress*, *dominance*, and *altruism*, are grouped around journals for biologists.

Audience-specific usage

Five terms were present in all five journal groups: *carrying capacity*, *diversity*, *ecosystem*, *population*, and *biodiversity*. Two of these, *ecosystem* and *biodiversity*, were found in a disproportionate amount in only one journal group. In particular, we found 82% (27 of 33) of the citations for *ecosystem* were located in the ecological journals, and 70% (92 of 131) of the citations for *biodiversity* were found in the general public journals. Another example of specialized usage was *sustainability*, for which 93% of the 41 citations were located in the general public journals.

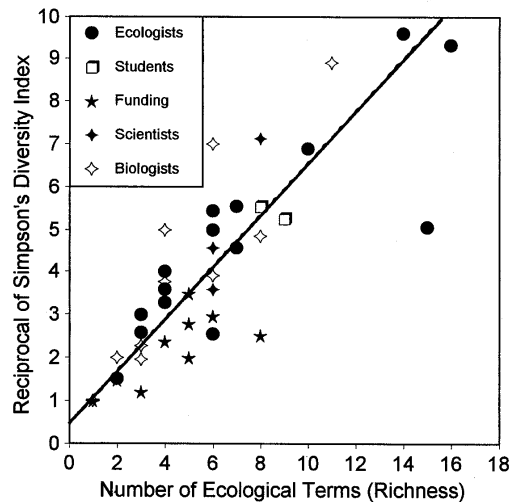


Fig. 1. Regression of Simpson's reciprocal index to the number of ecological terms for each of 43 journals. Symbols represent the five different journal groups, based on ecological audience. Journals used are: Ecologists: *Acta Oecologica*, *Biodiversity Letters*, *Ecological Modelling*, *Ecological Monographs*, *Ecology*, *Evolutionary Ecology*, *Functional Ecology*, *Journal of Applied Ecology*, *Journal of Ecology*, *Journal of Tropical Ecology*, *Oecologia*, *Oikos*, *Plant and Soil*, *Tropical Ecology*, *Vegetation*; Students: *BioScience*, *Trends in Ecology and Evolution*; Funding Agencies, Government, and the General Public: *Ambio*, *Biodiversity and Conservation*, *Biological Conservation*, *Conservation Biology*, *Ecological Applications*, *Ecological Economics*, *Environmental Conservation*, *Journal of Forestry*, *Landscape and Urban Planning*; Scientists: *Nature*, *Proceedings of the National Academy of Sciences*, *Science*; Biologists: *American Journal of Botany*, *American Midland Naturalist*, *American Naturalist*, *Annual Review of Ecology and Systematics*, *Auk*, *Biological Journal of the Linnean Society*, *Biotropica*, *Canadian Journal of Botany*, *Canadian Journal of Zoology*, *Copeia*, *Evolution*, *Journal of Biogeography*, *Journal of Biosciences*, *Journal of Zoology*.

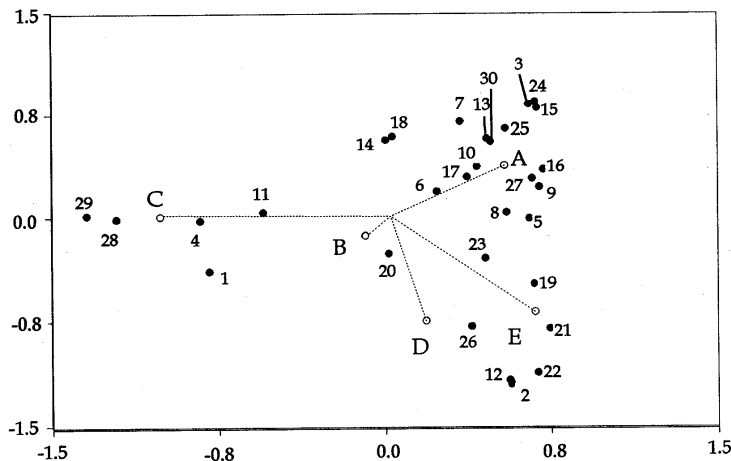


Fig. 2. Correspondence analysis of ecological terms and journal groups. Journal groups are: A = ecologists, B = students, C = funding agencies, politicians, and the general public, D = scientists, E = biologists. Terms are labeled numerically as follows: 1) alien species, 2) altruism, 3) balance of nature, 4) biodiversity, 5) biome, 6) carrying capacity, 7) climax, 8) community, 9) competition, 10) complexity, 11) diversity, 12) dominance, 13) ecosystem, 14) efficiency, 15) entropy, 16) equilibrium, 17) exotic species, 18) invasive species, 19) limiting resources, 20) limits on growth, 21) niche, 22) pioneer, 23) population, 24) sensitivity, 25) stability, 26) stress, 27) succession, 28) sustainability, 29) tragedy of commons, 30) trophic level.

For the most widely used terms, *carrying capacity* and *diversity*, we reviewed articles to determine if these were used consistently. *Carrying capacity* was found in titles, keywords, and abstracts from over 110 articles in the 43 selected journals. Only articles found in journals for students (i.e. *Trends in Ecology and Evolution*, and *BioScience*) explicitly defined *carrying capacity* (e.g., Catton 1987, Fearnside 1990). References to *carrying capacity* in the general public journal group use *carrying capacity* to mean sustainability (Reid et al. 1989), whereas references to *carrying capacity* in the ecological journal group were more variable, including debates on the specifics of 'K' (e.g., Abrams and Roth 1994). When cross-referenced with *ecology*, we found *diversity* in titles, abstracts, and keywords from over 265 articles in the selected journals. In journals for the general public, *diversity* was usually synonymous with "a large number of species". Therefore, 'loss of diversity' in such journals implied fewer species. In the scientific journal group however, *diversity* referred to either the number, or relative abundance, of diverse entities; i.e., genotypic, behavioral, resource, or trophic entities. In these journals, *diversity* was usually clearly defined (e.g., Watve and Sukuman 1995), whereas in the general public journal group, *diversity* was not often explicitly defined, nor was its near synonym, *biodiversity*.

Evidence for distinct audiences

From the preceding analyses, several conclusions can be drawn. First, certain ecological terms are somewhat specialized with respect to publication citations. This is the case for terms such as *biodiversity*, *ecosystem*, and

sustainability, where 70%, 82%, and 93% of their citations respectively were restricted to one journal group. In addition, certain journals use a relatively small number of ecological terms, as is the case with *Ecological Economics* and its use of the term *sustainability*. We found that some ecological terms (e.g., *carrying capacity* and *diversity*) were used differently in journals for different groups. Fearnside (1990) gives an example with *carrying capacity*, and states that much of the difference originates from the use of two different definitions of the term. Another case of an ecological term being used differently for different audiences is found with *diversity*. Redford and Stearman (1993) noticed that, to Amazonian indigenous people, preserving biological diversity equated to preventing large-scale habitat destruction, while to conservationists, preserving biological diversity meant preserving the number of species and their genetic variation.

We found differences in the number of terms used by the journal groups. This could indicate that ecologists are most comfortable using specific terms when speaking to other ecologists and students, or that ecologists are purposely not using problematic words when speaking to audiences unfamiliar with such terminology. Another possibility is that some terms are not of interest to the general public, but are only of specialized ecological interest. Finally, it is possible that the meanings of ecological terms are currently active areas of debate, which is why their occurrence in the ecological literature is higher. Specialized terms and their meanings may flow not only from academic ecologists to their intended audiences, but in reverse as well. There are groups that are not focused on science per se, such as Green political parties, "Deep Ecologists", and bird

watchers. Each of these may develop their own set of meanings for terms that may have originated in ecological science, which then influences the use of those terms by ecologists (e.g., the use of *ecosystem* in Shepard and McKinley 1969).

Consequences of terminological confusion

When speaking to ecologists, the importance of being accurate in the definition of commonly used terms has been pointed out for a variety of particular cases (e.g., *stability*: Pimm 1984; *community*, *assemblages*, *guilds*: Fauth et al. 1996). Much confusion and pointless argument has been caused by different scientists adopting distinct definitions of a particular piece of 'jargon'. Whereas jargon can serve a useful function as shorthand for a complex idea, all too often the complexity of the original idea becomes forgotten, and scientists gradually change the definition of the term without realizing it. Many ecologists have defined what they mean by a *niche*. In many cases, however, when ecologists refer to a species' niche casually, they do not specify which of the 4–6 standard definitions (e.g., Grinnell 1917, Elton 1927, Hutchinson 1957, MacArthur and Levins 1967, Grubb 1977) they are using. This problem is made worse because many of the terms used in ecology are borrowed from common speech, and thus have pre-existing definitions which do not conform in detail to their technical definitions.

Many jargon words used in ecology sound appealingly like everyday words. While it is unlikely that an ecologist would use *endotherm* in speaking to a layperson without defining it, there is a much greater temptation to use words like *stability*, *productivity*, *pioneer*, and *exploitation* without further explanation. The stakes for misunderstanding of terms and metaphors are large, as these errors may impact directly upon the creation of laws and policies that affect the future of ecosystems. As shown by the recent debate between those who advocate natural limits to human population growth versus those that do not (Vitousek et al. 1986, Ehrlich 1994, Sagoff 1995), the application of metaphors like *carrying capacity* may be simplistic when applied to humans.

The clarification of the various uses of the word *stability* in ecology (Pimm 1984) has led to more precise investigations of the natural history and community properties associated with these distinct aspects of stability (e.g., Yodzis 1989, Ginzburg and Akçakaya 1992, Akçakaya et al. 1995), rather than the simple dichotomy of previous stability/complexity debates (e.g., May 1973). Ecologists must try to use precise and clear words. We should not deliberately use ambiguous language for the sake of our hope to increase possible funding (cf. Ghilarov 1996). To the extent that public policy demands educated answers about problems in

real ecosystems or that ecologists wish to learn more about disturbed ecosystems before they become irrevocably altered in the next century, we will not be able to afford the luxury of imprecise use of jargon.

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