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FORUM

On the existence of ecological communities

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Introduction

Wilson (1991) raised the question of whether plant communities exist. He included the existence of assembly rules, niche limitation, discreteness, discontinuity, and integratedness as potential criteria for the existence of communities. In response, Keddy (1993) argued that though it may be possible to draft a list of criteria for the existence of communities, the debate over existence of communities is an ontological and epistemological game which is peripheral (and, Keddy argued, even harmful) to scientific progress. We suggest that community ecologists define community operationally, with as little conceptual baggage as possible, so that we can put the debate about their existence behind us.

An operational view of the community

Definitions

Lindeman (1942) defined the ecosystem as "the system composed of physical-chemical-biological processes active within a space-time unit of any magnitude". As such, it is a perfect operational definition. We begin by considering the 'space-time unit'. The space aspect of this space-time unit could be completely arbitrary, such as a 0.1 hectare quadrat, a cubic meter of lake water, or a political district such as a province or nation, or it could be somewhat less arbitrary, such as a lake, a watershed, or an island. The time aspect of the unit could be measured arbitrarily as seconds or decades, or somewhat less arbitrarily as days or years.

Whatever space and time units are chosen, physical-chemical-biological processes will be present – with the uncontroversial assumption that living organisms are present – because organisms live, consume, reproduce, and die; nutrients arrive by various means, and nutrients leave by various means. Lindeman therefore defined the ecosystem into existence. Although he certainly believed that some processes regulated ecosystem structure, his ideas of regulation did not impinge upon the definition of ecosystem. Ecosystems are not defined as integrated, discrete entities.

We suggest that community should be defined in a parallel manner as "the living organisms present within a space-time unit of any magnitude". The statement "communities exist" is no longer a fruitless ontological problem (as Keddy 1993 suggested) but a tautology. By using an operational definition, we can now ask questions concerning the properties of communities, and the forces underlying variation in communities.

Wilson (1991) asked whether "plant communities exist in a more meaningful sense, as integrated, discrete entities". Keddy (1993) argued that this question is unscientific. Our operational definition transforms Wilson's question to "Are there any communities which are integrated and discrete?" This reformulation should be scientifically valid by Keddy's standards, as long as procedures for defining and detecting integration and discreteness can be identified.

Wilson implies that the general usage of the term community connotes a strong degree of integration. Keddy believes that it is possible (but scientifically vacuous) to list criteria which distinguish whether a system exists as a community; these criteria are not listed, but presumably involve some sort of integration between species/and or environment. Some ecologists do indeed believe that integration is the key to definitions of community. In attempting to establish an epistemology of ecology, Scheiner (1993) considered communities as natural entities which are defined by 'linking processes such as interactions among populations. Allen & Hoekstra (1990) recognized that there is much

arbitrariness in defining communities (and mapping them to physical space), but they do stress that "communities are the integration of the complex behavior of the biota so as to produce a cohesive whole".

However, we find little evidence that such integration and discreteness are important parts of the prevailing definitions of community. An informal survey of biology and ecology texts reveals only one text which stresses that communities should be defined as organized wholes (Giller 1984), 13 texts which include interaction, but require neither integration nor discreteness as part of the definition (e.g. Krebs 1972; Ricklefs 1979; Brewer 1988; Smith 1990), and 12 texts (e.g. McNaughton & Wolf 1979; Barbour et al. 1987; Ehrlich & Roughgarden 1987; Odum 1989; Begon et al. 1990) use purely operational definitions similar to Lindeman's definition of ecosystem. It is intriguing that two texts at opposite ends of the reductionist-holist spectrum (Odum 1989; Begon et al. 1990) adopt almost identical definitions. We believe that both Wilson and Keddy would unequivocally agree that communities exist, if they accepted any textbook definition of community – except that of Giller (1984).

The community and homogeneity

Species composition varies through space, sometimes continuously, sometimes abruptly. An operational definition of communities forces us to accept regions with spatial (and temporal) changes (no matter how rapid or gradual) as communities.

In the tallgrass prairie region of Oklahoma, physiognomy (physical structure of vegetation) grades from grassland to woodland in many ways - there can be an abrupt edge, a gradation from short to tall trees, a gradation from open savannah to closed forest, a gradation in the importance of shrubs, a gradation in overall woody stem density, etc. These gradations are frequently, but not always accompanied by a change in tree species composition. In this system, it would be impossible to capture the rich diversity of transitional physiognomies if we required quadrats to be internally homogeneous: any quadrats of more than a few square metres would possess noticeable spatial trends. If we ignored transitional physiognomies, we have almost no woodlands left to study, and we cannot claim to have a vegetation analysis which truly represents the landscape.

The dilemma described above does not pertain only to situations with a pronounced change in physiognomy. Distance decay (i.e. the situation where nearby objects are on average more similar to each other than distant objects) characterizes many, if not most communities, both with respect to species composition (Palmer 1988) and environmental variables (Burrough 1981; Robertson 1987). Strong distance decay in the environment can even occur in sites selected on the basis of visual homogeneity (Palmer 1990; Lechowicz & Bell 1991). If distance decay is very strong, it would be a great challenge to locate a homogeneous study site anywhere in a region.

If distance decay proves to be universal (we believe it is), then every spot on earth is unique, and can be considered a 'transitional zone' between community types. It is not surprising, then, that many national parks, biological stations, etc. claim to be in or near the meeting place of several biomes, or to contain many eastern, western, southern, and northern species. If all communities are transitional, then the meaning of terms such as ecotone, ecocline, zonal, and edge become ambiguous. Instead of seeking the right terms for communities with different degrees of transitionality, it may be more profitable to pose testable questions about how we might expect community dynamics to vary as a function of some 'transitionality index'.

Even if homogeneous communities could be identified, it does not necessarily follow that we should preferentially study such communities. If we follow a region selected on the basis of homogeneity through time, it will tend to increase in heterogeneity through the statistical artifact known as the 'regression effect' (Palmer 1993).

An operational definition of community, by liberating us from assumptions of interaction, integration, and discreteness, allows us to consider all regions on earth, not merely homogeneous regions, as valid systems for community ecologists to study. Indeed, the liberation allows us to study interaction, integration, and discreteness in a more objective manner.

The community and scale

Since communities can be defined at 'any magnitude', the idea of the 'size' or 'area' of a community is nonsensical: it is as large as you define it to be. The observation that ecological processes have fractal properties (Phillips 1985; Culling 1986; Palmer 1988; Johnson et al. 1992; Milne et al. 1992) means that there is detail at all spatial scales, and it is not possible to assign one 'correct' scale of observation (Levin 1987). The terms patch, community, landscape, formation, and biome may loosely coincide with some preconceived notion of scale, but it is unlikely that a non-arbitrary distinction can be made between them. Since the species-area curve is an increasing function at all spatial scales (Williams 1964; Williamson 1988), it is artificial to define a spatial scale which identifies a community, landscape, etc.

Several authors promote a hierarchical view of communities (e.g. Ricklefs 1987; Allen & Hoekstra 1990;

Kotliar & Wiens 1990; O'Neill et al. 1991; Holling 1992). However, few studies present evidence which identifies the spatial scales of the hierarchy. As a result, hierarchy is often an assumption rather than an observation. By liberating the concept of community from assumptions of scale, we can treat scale as an independent variable and propose experiments to determine whether communities are indeed hierarchically arranged.

Reification

If we fail to define our terms operationally, we run the risk of reification: i.e. of converting a theoretical concept into a concrete object. A prime example of this is the biome concept. Few would deny that biomes are useful ways to categorize large regions by the physiognomy and composition of vegetation. However, continental-scale maps of biomes or 'vegetation types' compiled by different authors at best only loosely correspondence with each other. In particular, boundaries between different biomes are rarely identical in different treatments (with the exception of the water/land interface). According to Begon et al. (1990, p. 26), "the number of biomes that are recognized differs between biogeographers, and it is rather a matter of taste how many should be recognized. They certainly grade into one another, and sharp boundaries are a convenience for cartographers rather than a reality of nature".

On the other hand, several authors (e.g. Gosz & Sharpe 1989; Neilson et al. 1992; Scheiner 1993) believe that biomes are real entities, with their own set of properties. Transitions zones between biomes are viewed as having completely different processes than regions in the interiors of biomes (Gosz & Sharpe 1989; Neilson 1991).

We feel that 'biome' should be an operational concept which describes the physiognomy in an arbitrarily defined region. Therefore, concepts such as 'transition zones' are meaningless - they may merely be artifacts of the reification of biomes.

Students of the community must avoid the pitfalls of reification. Wilson (1991) likened the study of communities to the study of Yetis (the probably-mythical giant apes of the Himalayas). Reification would have us chasing such Yetis. If we recognize communities as arbitrary structures, however, we neither have need to assume the existence of possibly-mythical unifying forces in communities, nor to identify interactions among communities at their possibly-mythical borders. Indeed, we may be more likely to find such forces and borders if we do not assume their existence *a priori.*

Allen & Hoekstra (1990) stated that communities possess self-assertiveness, but the need for identifying mechanisms of self-assertiveness disappears as soon as one realizes that communities have no 'selfness' other than that we have called into existence.

Perhaps the root cause of reification is the structure of the human brain – we seem to want a yes/no or in/out or inside-a-definition/outside-a-definition structure to our world. We yearn for a homogeneous patch to define and study. We create discrete words. We create hierarchies of discrete definitions. We would like to think that what is signified by our definitions has an objective existence independent of our definition. However, our job as scientists is arguably not to map the world onto our mental structures, but to re-wire our mental structures to reflect the world.

Triviality

Wilson (1991) stated that "we can describe vegetation, and vegetation processes in the hope that general and non-trivial patterns will emerge, but they never seem to." But what is trivial? We think unraveling the amino acid sequence of yet another enzyme is trivial, yet a protein biochemist would probably find a well-implemented gradient analysis to be quite trivial. Still, both studies could have important implications for theory and application. We believe that the long-recognized patterns of species richness (e.g. Crawley 1986) are general and non-trivial, and results of studies on these patterns will be useful for conservation biology as well as ecological theory.

Triviality should not be confused with simplicity. If we can summarize patterns in communities by very simple processes such as immigration, extinction, disturbance, resource use, and environmental variability, and fail to find evidence for an overarching integrative force in communities, we will have scored a major triumph. The principle of parsimony, which argues that we should prefer simple over complex explanations for phenomena, is a cornerstone of scientific progress (Jefferys & Berger 1992). Whether the discovery of simple explanations for complex phenomena is elegant or trivial is a matter of perspective.

Conclusions

Keddy (1993) states that "the term community is probably no more or less useful (or real) than other terms like electron, self, city, or car". Except for community, however, all these terms have an integrative process or structure. An electron is an indivisible quantum of electrical (what else?) charge. Self can be defined with reference to consciousness, or perhaps even to soul. A city is an entity with a defined jurisdiction and political structure. A car is a device designed to carry

out a particular function – though the planet would be much better off if this function was implemented out by other devices.

Although Keddy's ontological *reductio ad absurdum* can wipe any of these items out of existence, they can all be easily defined non-operationally on the basis of function or discreteness. Communities, on the other hand, have no universally recognized integrative, circumscribing force. Communities therefore must be defined and studied operationally. If, as Wilson suggests, an integrative, circumscribing force is a necessary precondition for the existence of Vegetation Science, then Vegetation Science has no hope of discovering such a force.

References

Allen, T.F.H. & Hoekstra, T.W. 1990. The confusion between scale-defined levels and conventional levels of organization in ecology. *J. Veg. Sci.* 1: 5-12.

Barbour, M.G., Burk, J.H. & Pitts, W.D. 1987. *Terrestrial Plant Ecology*. 2nd ed. Benjamin Cummings, Menlo Park, CA.

Begon, M., Harper, J.L. & Townsend, C.R. 1990. *Ecology: Individuals, Populations, and Communities*. 2nd ed. Blackwell Scientific, Boston, MA.

Brewer, R. 1988. *The Science of Ecology*. Saunders College Publications, Philadelphia, PA.

Burrough, P.A. 1981. Fractal dimensions of landscapes and other environmental data. *Nature* 294: 240-242.

Crawley, M.J. 1986. The structure of plant communities. In: Crawley, M.J. (ed.). *Plant Ecology*, pp. 1-50. Blackwell, Oxford.

Culling, W.E.H. 1986. Highly erratic spatial variability of soil-pH on Iping Common, West Sussex. *Catena* 13: 81-98.

Ehrlich, P.R. & Roughgarden, J. 1987. *The science of ecology*. Macmillan, New York, NY.

Giller, P.S. 1984. *Community Structure and the Niche*. Chapman and Hall, London.

Gosz, J.R. & Sharpe, P.J.H. 1989. Broad-scale concepts for interactions of climate, topography, and biota at biome transitions. *Landscape Ecol*. 3: 229-244.

Holling, C.S. 1992. Cross-scale morphology, geometry, and dynamics of ecosystems. *Ecol. Monogr*. 62: 447-502.

Jefferys, W.H. & Berger, J.O. 1992. Ockham's Razor and Bayesian Analysis. *Am. Sci*. 80: 64-72.

Johnson, A.R., Milne, B.T. & Wiens, J. A. 1992. Diffusion in fractal landscapes: simulations and experimental studies of tenebrionid beetle movements. *Ecology* 73: 1968-1983.

Keddy, P. 1993. Do ecological communities exist? A reply to Bastow Wilson. *J. Veg. Sci.* 4: 135-136.

Kotliar, N.B. & Wiens, J.A. 1990. Multiple scales of patchiness and patch structure: a hierarchical framework for the study of heterogeneity. *Oikos* 59: 253-260.

Krebs, C.J. 1972. *Ecology: The experimental analysis of distribution and abundance*. Harper & Row, New York. NY.

Lechowicz, M. & Bell, G. 1991. The ecology and genetics of fitness in forest plants. II. Microspatial heterogeneity of the edaphic environment. *J. Ecol.* 79: 687-696.

Levin, S.A. 1987. Scale and Predictability in ecological modeling. In: Vincent, T.L., Cohen, Y., Grantham, M.J., Kirkwood, G.P. & Skowronski, J.M. (eds.) *Modeling and management of resources under uncertainty*, pp. 2-8. Springer-Verlag, Berlin.

Lindeman, R.L. 1942. The trophic-dynamic aspect of ecology. *Ecology* 23: 399-418.

McNaughton, S.J. & Wolf, L.L. 1979. *General Ecology*. 2nd ed. Holt, Rinehart and Winston, New York, NY.

Milne, B.T., Turner, M.G, Wiens, J.A. & Johnson, A. R. 1992. Interactions between the fractal geometry of landscapes and allometric herbivory. *Theor. Popul. Biol*. 41: 337-353.

Neilson, R.P. 1991. Climatic constraints and issues of scale controlling regional biomes. In: Holland, M.M., Risser, P.G. & Naiman, R.J. (eds.) *The role of landscape boundaries in the management and restoration of changing environments*, pp. 31-51. Chapman and Hall, New York, NY.

Neilson, R.P., King, G.A. & Koerper, G. 1992. Toward a rule-based biome model. *Landscape Ecol*. 7: 27-43.

Odum, E.P. 1989. *Ecology and our endangered life-support systems*. Sinauer, Sunderland, MA.

O'Neill, R.V., Gardner, R.H., Milne, B.T., Turner, M.G. & Jackson, B. 1991. Heterogeneity and spatial hierarchies. In: Kolasa, J. & Pickett, S.T.A. (eds.) *Ecological Heterogeneity*, pp. 85-96. Springer-Verlag, Berlin.

Palmer, M.W. 1988. Fractal Geometry: a tool for describing spatial patterns of plant communities. *Vegetatio* 75: 91-102.

Palmer, M.W. 1990. Spatial scale and patterns of species-environment relationships in hardwood forests of the North Carolina piedmont. *Coenoses* 5: 79-87.

Palmer, M.W. 1993. Potential biases in site and species selection for ecological monitoring. *Environ. Monit. Assessm*. 26: 277-282.

Phillips, J.D. 1985. Measuring complexity of environmental gradients. *Vegetatio* 64: 95-102.

Ricklefs, R.E. 1979. *Ecology*. 2nd ed. Chiron Press, New York, NY.

Ricklefs, R.E. 1987. Community diversity: relative roles of local and regional processes. *Science* 235: 167-171.

Robertson, G.P. 1987. Geostatistics in ecology: interpolating with known variance. *Ecology* 68: 744-748.

Scheiner, S.M. 1993. An epistemology for ecology. *Bull. Ecol. Soc. Am*. 74: 17-21.

Smith, R.L. 1990. *Ecology and Field Biology*. 4th ed. Harper & Row, New York, NY.

Williams, C.B. 1964. *Patterns in the Balance of Nature*. Academic Press, New York, NY.

Williamson, M. 1988. Relationship of species number to area, distance and other variables. In: Myers, A.A. & Giller, P.S. (eds.) *Analytical Biogeography*, pp. 91-115. Chapman and Hall, New York, NY.

Wilson, J.B. 1991. Does vegetation science exist? *J. Veg. Sci.* 2: 289-290.