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Effects of Insularisation on Plant Species Richness in the Prairie-Forest Ecotone

Daniel Simberloff & Nicholas Gotelli

Department of Biological Science, Florida State University,
Tallahassee, Florida 32306, USA

ABSTRACT

Data on plants from five groups of remnant prairies and forests in the prairie-forest ecotone of the midwestern United States show that: (1) Archipelagos of small sites tend to contain more species than do single

large ones of equal total area. (2) No species are excluded from small sites. (3) Small sites tend to have surprisingly many species, and large

to conserve the most herb and shrub species. Specifically, we ask two questions. First, is species richness greater in a single large refuge or in an archipelago of small ones, where total area of the archipelago equals area of the large refuge? Second, how are individual species distributed among remnants of different sizes? To this end we examine five data sets:

(1) [redacted] species of 56 prairie remnants in Iowa and Minnesota (Glass, 1981).

(2) The 152 herb and shrub species of 15 prairie remnants in Illinois (R. Clinebell, pers. comm.).

(3) The 102 understorey herb species of 12 natural forest remnants in [redacted]

TABLE 1
Species–Area Statistics and Minimum Site Size (ha) for Two Data Sets discussed in Text. All Probabilities are less than 0·01.

Data set	R^2	F	*Smallest site (ha)*
(1) Total species	0·864	$343_{1,54}$	0·000 6
(1) Goldenrods	0·646	$98_{1,54}$	0·002 1
(1) Milkweeds	0·615	$86_{1,54}$	0·002 1
(1) Legumes	0·789	$206_{1,54}$	0·000 6
(2)	0·535	$17_{1,13}$	0·025

[redacted]

[redacted]

[redacted]

[redacted]

a significant relationship between species richness and area (Table 1).

[redacted]

ng Log
bles are

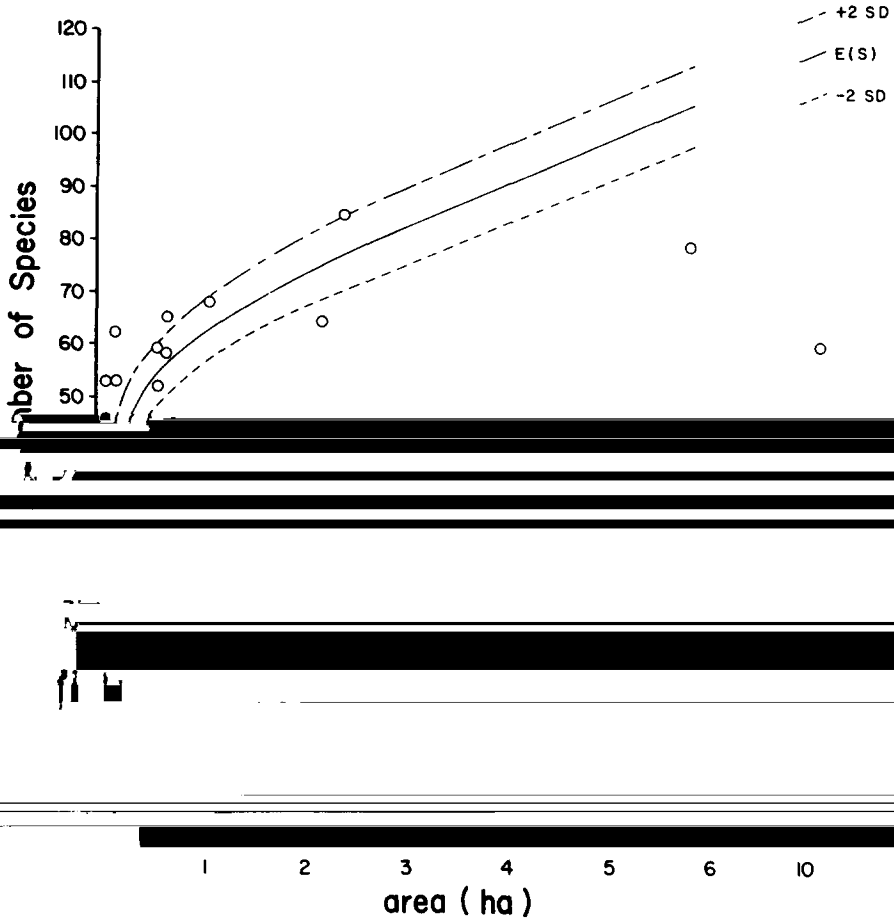
Pr
0·01
0·96
0·42
0·05
0·39

randomly lumped together samples of pairs, trios, quartets, etc., of small remnants and compiled species lists of all species in each such random 'archipelago' (Table 2). Appendix 1 details the procedure. None of these random archipelagos was larger in area than the largest remnant. We then performed a multiple regression of number of species on area as first independent variable, number of remnants (including the single

To test whether the distribution of observed minimum areas shows them to be surprisingly large even given the species–area relationship, we used a simulation. For each species i we rained simulated propagules down one at a time onto a set of S simulated buckets, with the size of each [redacted]

stopped when N_i of the buckets were occupied (contained at least one propagule). This simulation was run ten times for each data set, and for each species the distribution of observed sizes of occupied remnants was compared by a Kolmogorov–Smirnov test to the simulated expected distribution. Numbers of species that differ from expected at $Pr \leq 0.05$ are given in Table 4. For data sets (1)–(4) there are substantially fewer species than one would have expected for which the distribution of sizes of occupied remnants differs from that produced by a random model. There [redacted]

[redacted]



[redacted]

remnants of data set (2).

TABLE 6

Kolmogorov-Smirnov Statistics and Associated Probabilities for Distribution of 'Rare' Species among Sites of Different Area and among Sites with Different Numbers of Non-rare Species.

Data set	Number of species	Number of rare species	D_{mn} [a]	Pr	D_{mn} [b]	Pr
2	152	45	0·313	<0·01	0·165	>0·10
3	102	36	0·301	<0·01	0·203	>0·10
4	116	31	0·395	<0·01	0·104	>0·10
5	84	36	0·267	<0·01	0·104	>0·10

[a] Kolmogorov-Smirnov test statistic; sites ranked by area.
[b] Kolmogorov-Smirnov test statistic; sites ranked by number of non-rare species.

were proportional to site areas. For all four data sets, these two distributions differed significantly (Table 6), and always in the same [illegible]

(MacArthur & Wilson, 1967) provides theoretical justification for such a choice. This strategy is suspect because:

(1) The [illegible]

logical and statistical difficulties (Abele & Connor, 1979; Faeth & Conner, 1979).

Finally, a surprising result common to all four data sets that included

[illegible]

'gom' (uniquely occurring) species was that such species tend to be found

[illegible]

in small remnants more frequently than a random colonisation model would have predicted, and in large remnants correspondingly less frequently than expected. Järvinen (1982) found a similar result for vascular plant species of the Åland Islands. He noted that, on average, more endangered plant species occur in groups of small islands than on single large ones.

Several possible explanations for this result come to mind; these are not

[illegible]

surprisingly often found in small sites is to be found in the answer to a more general question: Why do small sites tend to have surprisingly many

species?

CONCLUSION

We conclude, then, that for these forest herb and prairie plant communities, over the size ranges of these remnants, the data clearly imply no justification for preserving single large sites rather than an archipelago of small ones, if such a choice is required. On average a greater species total and more rare species will occur in the archipelago, no species appear to be excluded from the archipelago, and there is no evidence that there will be a short- or long-term decline in species number in the archipelago, particularly if the total area and number of component 'islands' are large. We emphasise three important limitations to our

MacArthur, R. H. & Wilson, E. O. (1967). *The theory of island biogeography*. Princeton, NJ, Princeton University Press.
Malyshev, L. I. (1980). Isolated reservation areas as pseudo-insular biotas. *J. gen. Biol. (Moscow)*, **41**, 338–49.
Odum, E. P. (1971). *Fundamentals of ecology*, 3rd edn. Philadelphia, Saunders.
Pickett, S. T. A. & Thompson, J. N. (1978). Patch dynamics and the design of nature reserves. *Biol. Conserv.*, **13**, 27–37.
Rabinowitz, D. (1981). Seven forms of rarity. In *The biological aspects of rare*

[redacted]

Scanlan, M. J. (1975). *The geography of forest plants across the prairie-forest border in western Minnesota*. PhD thesis, University of Minnesota, St. Paul.
Scanlan, M. J. (1981). Biogeography of forest plants in the prairie-forest ecotone of western Minnesota. In *Forest island dynamics in man-dominated landscapes*, ed. by R. L. Burgess and D. M. Sharpe, 97–124. New York, Springer-Verlag.
Shaffer, M. L. (1981). Minimum population sizes for species conservation.

[redacted]

Simberloff, D. (1976). Experimental zoogeography of islands: Effects of island size. *Ecology*, **57**, 629–48.

[redacted]

TABLE A-1

: Simulated Archipelagos of Several Remnants. Variables were Forced in a Stepwise Multiple ler: Area, Number of Remnants, Interaction Term. Transformations were Selected by Examining Residual Plots.

gression formation	*Intercept*	*log_{10}(area) coefficient* (Δr^2)	*log_{10}(number of remnants) coefficient* (Δr^2)	*Interaction coefficient* (Δr^2)
$\sqrt{S}$	0·867	0·789, $p < 0·01$ (0·865)	2·378, $p < 0·01$ (0·020)	−0·374, $p < 0·01$ (0·016)
g$_{10}$ S	1·72	0·142, $p < 0·01$ (0·714)	0·200, $p < 0·01$ (0·091)	−0·006, $p = 0·96$ (0·000)
g$_{10}$ S	1·33	0·184, $p < 0·01$ (0·436)	0·750, $p < 0·01$ (0·282)	−0·302, $p = 0·42$ (0·008)
g$_{10}$ S	1·26	0·194, $p < 0·01$ (0·615)	0·815, $p < 0·01$ (0·106)	−0·266, $p = 0·05$ (0·014)
$\sqrt{S}$	3·30	0·952, $p < 0·01$ (0·346)	1·133, $p < 0·01$ (0·112)	2·041, $p = 0·39$ (0·006)

is the critical area above which there will be diminishing returns for adding remnants. For data set 1, the coefficients yield $X_1 = 228{\cdot}19$ ha and $X_2 = 128$ remnants. For data set 4, $X_1 = 5{\cdot}36$ ha and $X_2 = 1158$ remnants. This critical size for data set 4 is smaller than 68 % of the single remnants. Above a total area of 5·36 ha, there will be a smaller increase in species richness for each remnant that is added. However, these numerical coefficients must not be interpreted literally, because the results depend on the simulation structure.