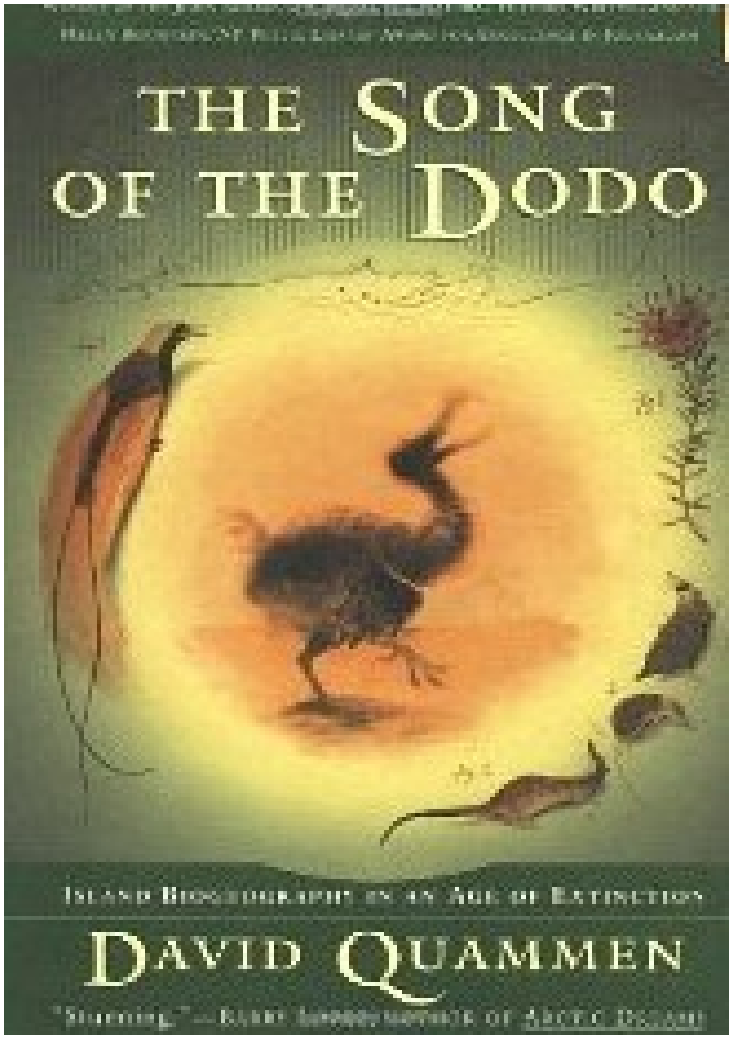
Fragmentation and the SLOSS debate

- Landscapes across the world have become increasingly fragmented as a result of human activities.
- In order to conserve wildlife decisions have to be made regarding optimal reserve design
- These decisions should take into account the nature of the entire landscape.

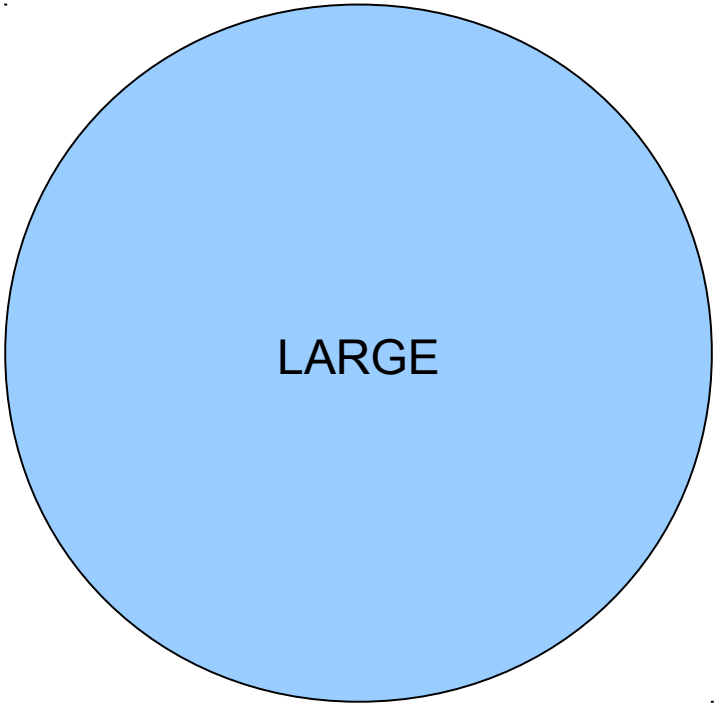
Bedtime reading

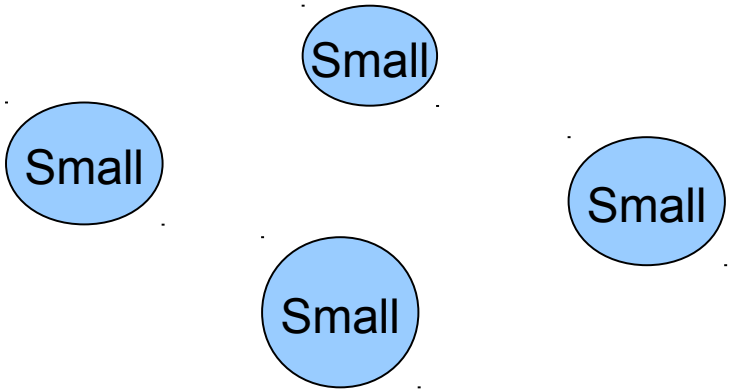


David Quammen (1997)The Song of the Dodo: Island Biogeography in an Age of Extinction,

The SLOSS debate

- **S**ingle
- **L**arge
- **O**r
- **S**everal
- **S**mall





SLOSS

- “Given the opportunity to put a fixed percentage of land into conservation use, is it better to opt for a Single Large Or Several Small reserves? ’
- At one extreme is the creation of a single large reserve;
- The alternative is to opt for several smaller reserves that amount to the same area but which are scattered across the landscape.

Single large

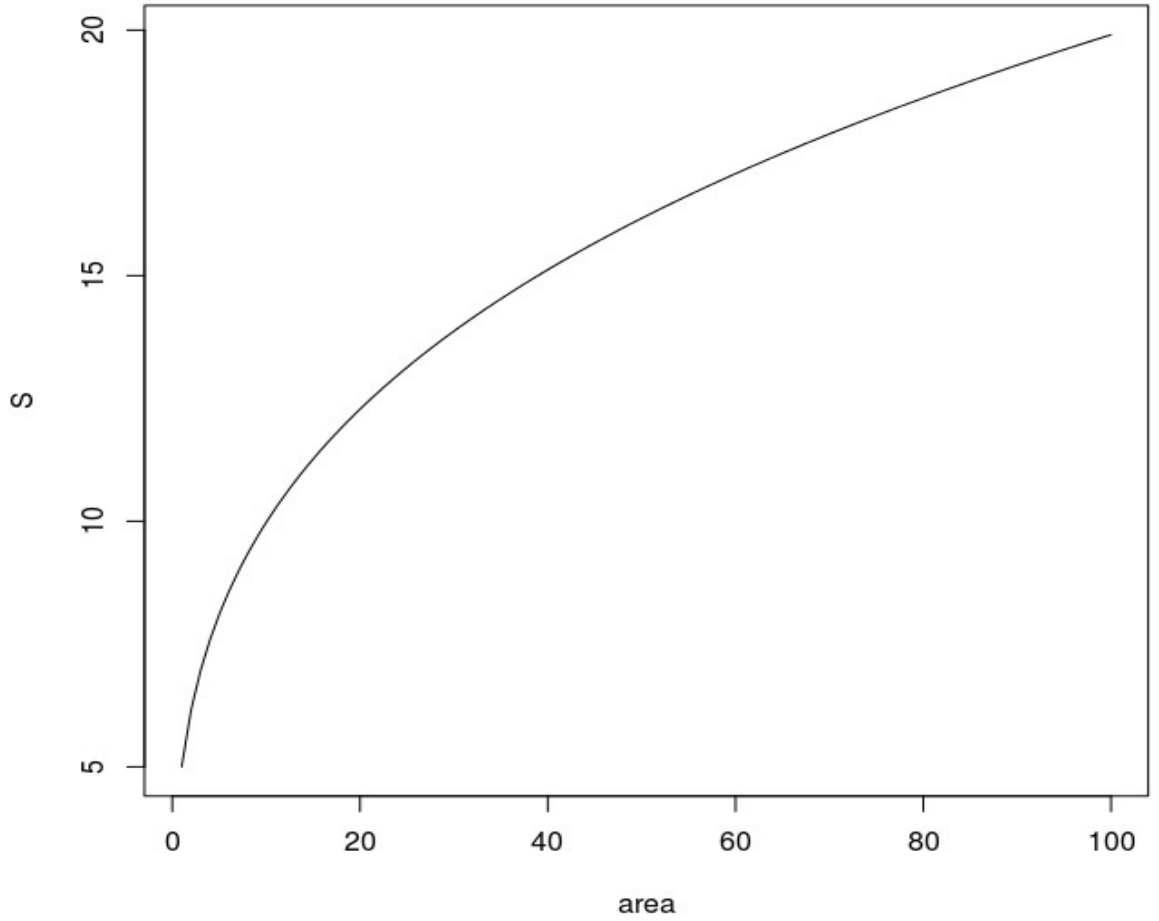
- Diamond, J.M. 1975. "The Island Dilemma: Lessons of Modern Biogeographic Studies for the Design of Natural Reserves". Biological Conservation Vol. 7, no. 2, pp. 129-146
- “A single large reserve is preferable to several smaller reserves whose total areas are equal to the larger”

Why do we need large reserves?

- Diamond argued that the species/area curve and relative abundance distributions show that many species have very small populations
- These eventually become extinct if the total area is reduced
- Small reserves are of little value as many species populations will be reduced to unsustainable sizes (extinction debt)

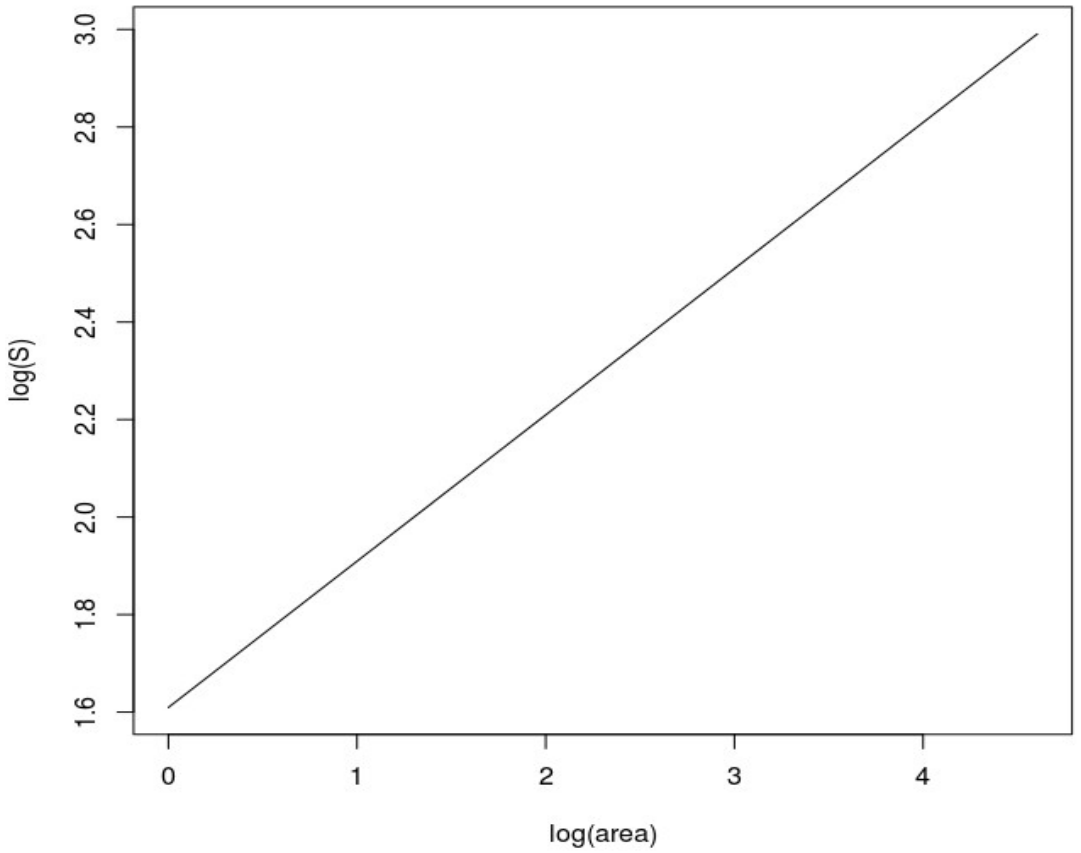
Species area relationship

$$S=cA^{z}$$



Species area relationship

log(S)=log(c)+zlog(A)



Species are relationship

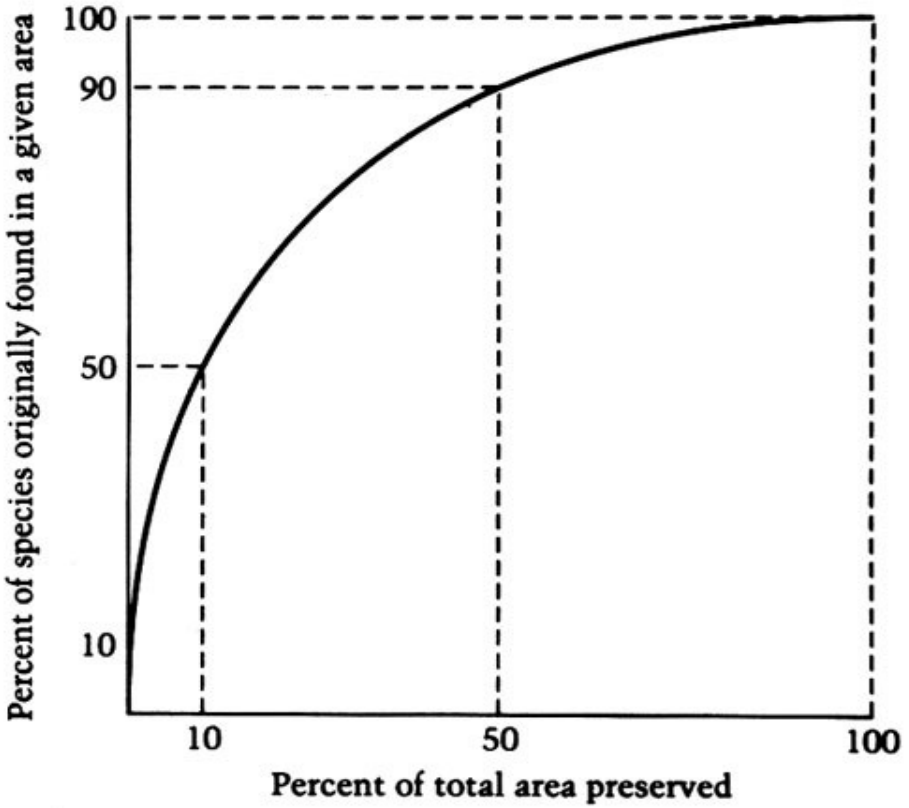
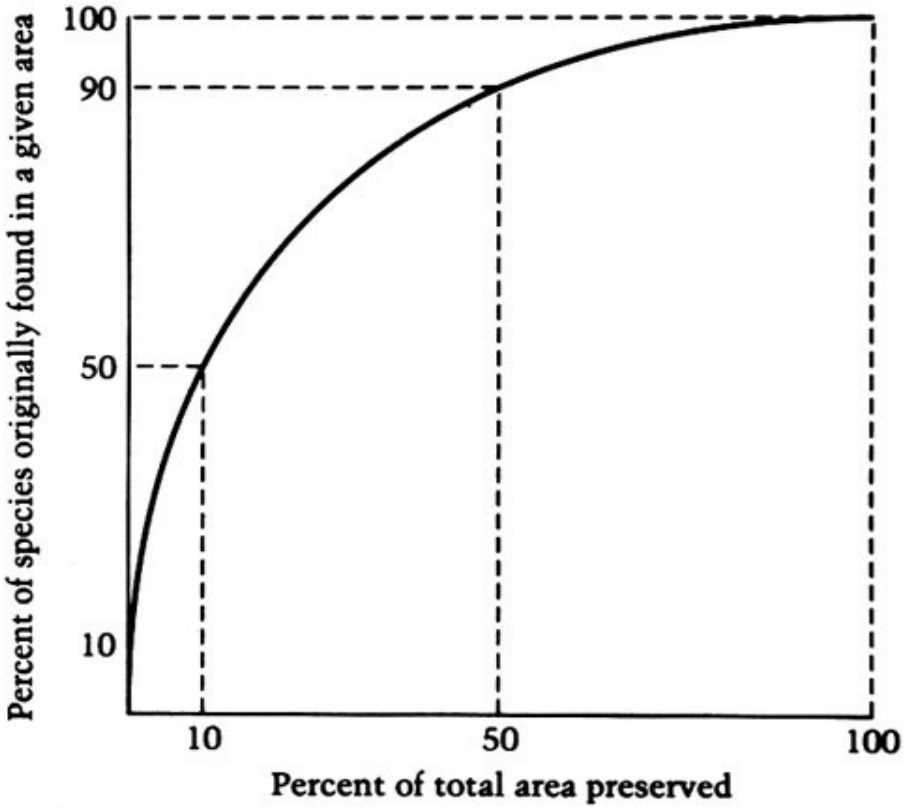


Fig. 15.2. The number of species present in an area increases asymptotically to a maximum value. As a result, if the area of habitat is reduced by 50%, the number of original endemic species going extinct may be 10%; if the habitat is reduced by 90%, the number of endemic species going extinct may be 50%. The shape of the curve is different for each region of the world and each group of species, but it gives a general indication of the impact of habitat destruction on species extinction and the persistence of species in the remaining habitat. (From Primack, 1993.)

Species are relationship



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Advantages of several small

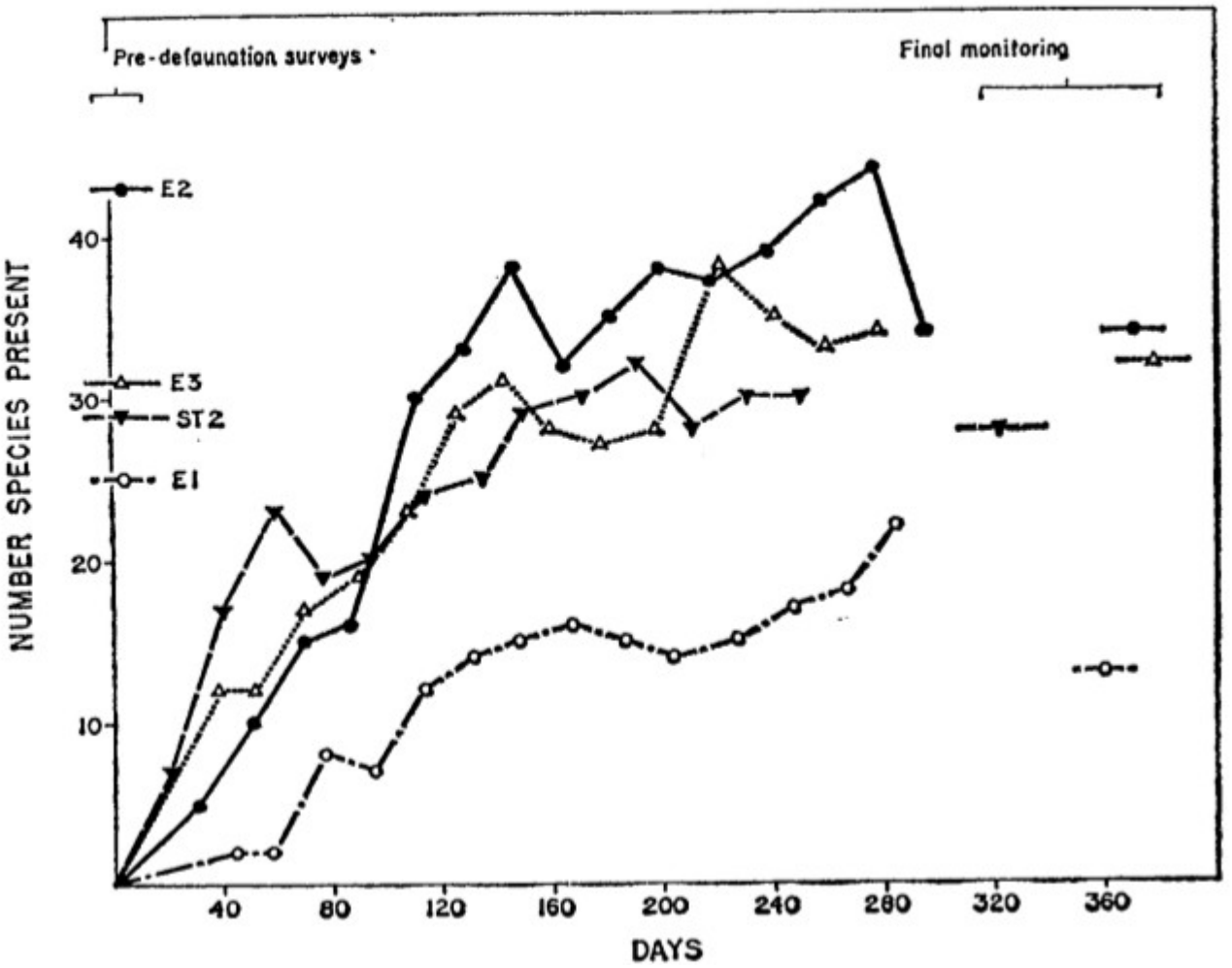
- Compensating advantages:
  - Greater overall representation of rare habitats;
  - More effective representation of differing biogeographical elements across a region;
  - Competitive effects involving different ‘ winners ’ in different patches;
  - Less effective spread of disease and exotic species
  - More habitat for edge species

Simberloff's big experiment

Simberloff's big experiment

- Simberloff and Wilson fumigated mangrove “islands” removing insects and arachnids
- Followed the dynamics of recolonization in order to test IBG theory.
- Results were ambiguous and unclear.

Simberloff's big experiment



Simberloff's experiment

- Did not provide evidence either way for SLOSS
- Simberloff found that species turnover was esoteric and unpredictable
- Consistent patterns were hard to find
- Simberloff lost faith in predictive power of simple theories
- Chance effects responsible for many “patterns”

Simberloff's problem

KGBT-TV / ValleyCentral.Com

What do you see in this tortilla? A family in Texas says a brown spot on a flour tortilla (left) is actually an image of the Virgin Mary and Baby Jesus -- similar to this Byzantine depiction of the Christian figures (right).

Simberloff's problem

- Scientists interested in a theory such as ETIBG could “cherry pick” the evidence.
- Corroborating “evidence” might be published while lack of evidence would be ignored
- Simberloff began to look for more rigorous tests of theory
- Became interested in testing “null models”

Simberloff and Abele

Simberloff, D.S., and L.G. Abele. 1982. Refuge design and island biogeographic theory: effects of fragmentation. Am. Nat. 120:41-50.

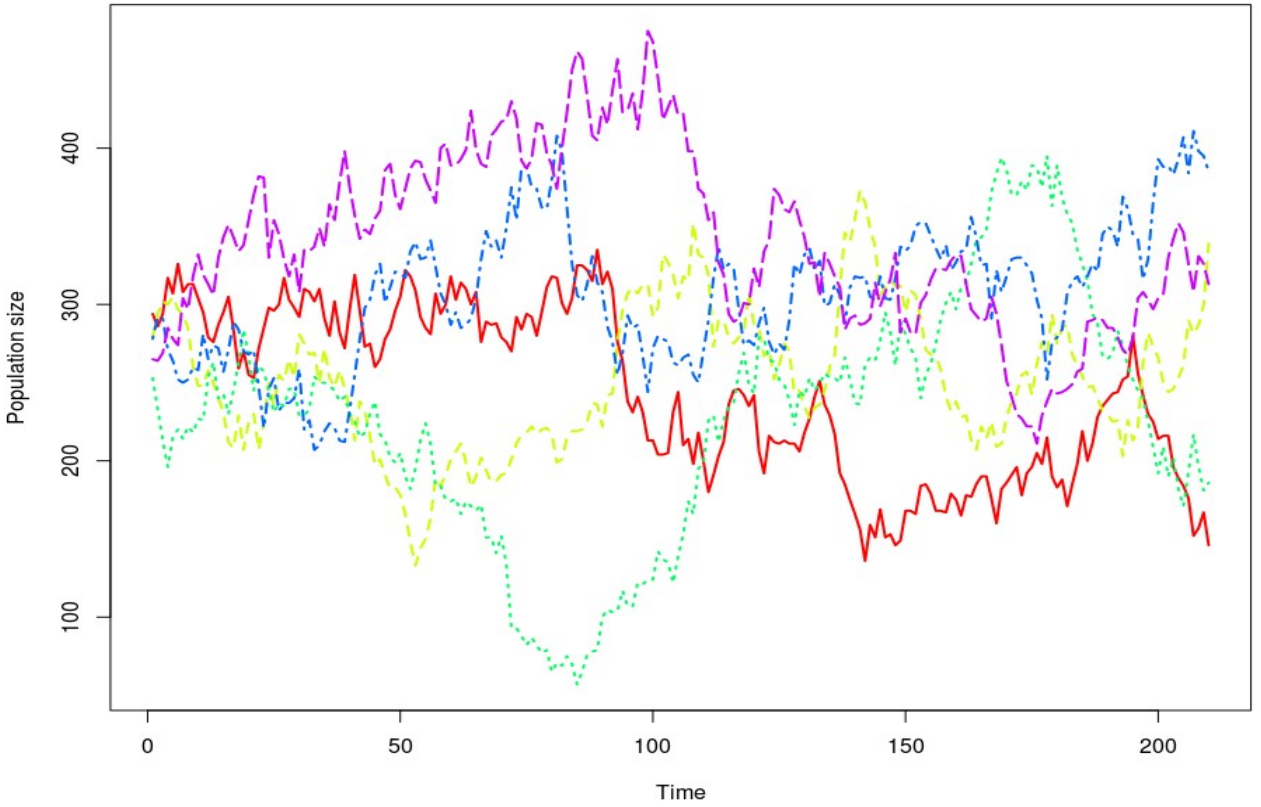
“The number of species on an archipelago as opposed to one large island is an idiosyncratic matter that does not admit of general laws”

Simberloff's theoretical alternative to single large

- Single large is only better if smaller reserves have a nested species composition
  - In other words, the larger reserve has all the species present in the set of smaller reserve.
- If the smaller reserves have unshared species, then it is possible that two smaller reserves can have more species than a single large reserve.

Stochastic population model

- Simberloff also used a model to show that if population sizes are greater than 20 extinction may take a long time.



Wilcox and Murphy

- Four causes of population extinction
  - Demographic stochasticity
  - Environmental variation
  - Genetic stochasticity
  - Natural catastrophes
- Simberloff had modelled the first
- Claimed that by adding in the effects of other forms of extinction a “network” could be the most stable solution

Fragmentation effects

- Wilcox and Murphy argued that fragmentation and habitat loss act in a complex manner on many populations at once.
  - Demographic units destroyed outright, reduced in size or subdivided
  - Potential sources of immigration lost
  - Immigration impeded by conversion of habitats between fragment

Fragmentation effects

- Wilcove (1987)
  - Stage 1. Initial exclusion. Some species will be lost from the landscape simply because their original ranges did not include any of the remnant patches.
  - Stage 2. Extirpation due to lack of essential resources. Species vary greatly in their resource requirements and many require very large areas and/ or very rare resources.
  - Stage 3. Perils associated with small populations. Small populations are much more susceptible to genetic, demographical, and stochastic problems.
  - Stage 4. Deleterious effects of isolation. Some populations may be rescued from extinction by migration and recruitment of individuals from other populations. The likelihood of such rescue effects decreases as isolation increases.
  - Stage 5. Ecological imbalance. Most species are strongly influenced by interactions with other species. Loss of one species may result in the subsequent loss of its predators, parasites, mutualists, or commensalss In addition, habitat disturbance and reductions in community diversity may facilitate the establishment of introduced species, triggering a cascade of subsequent extirpations.

Lovejoy's experiment

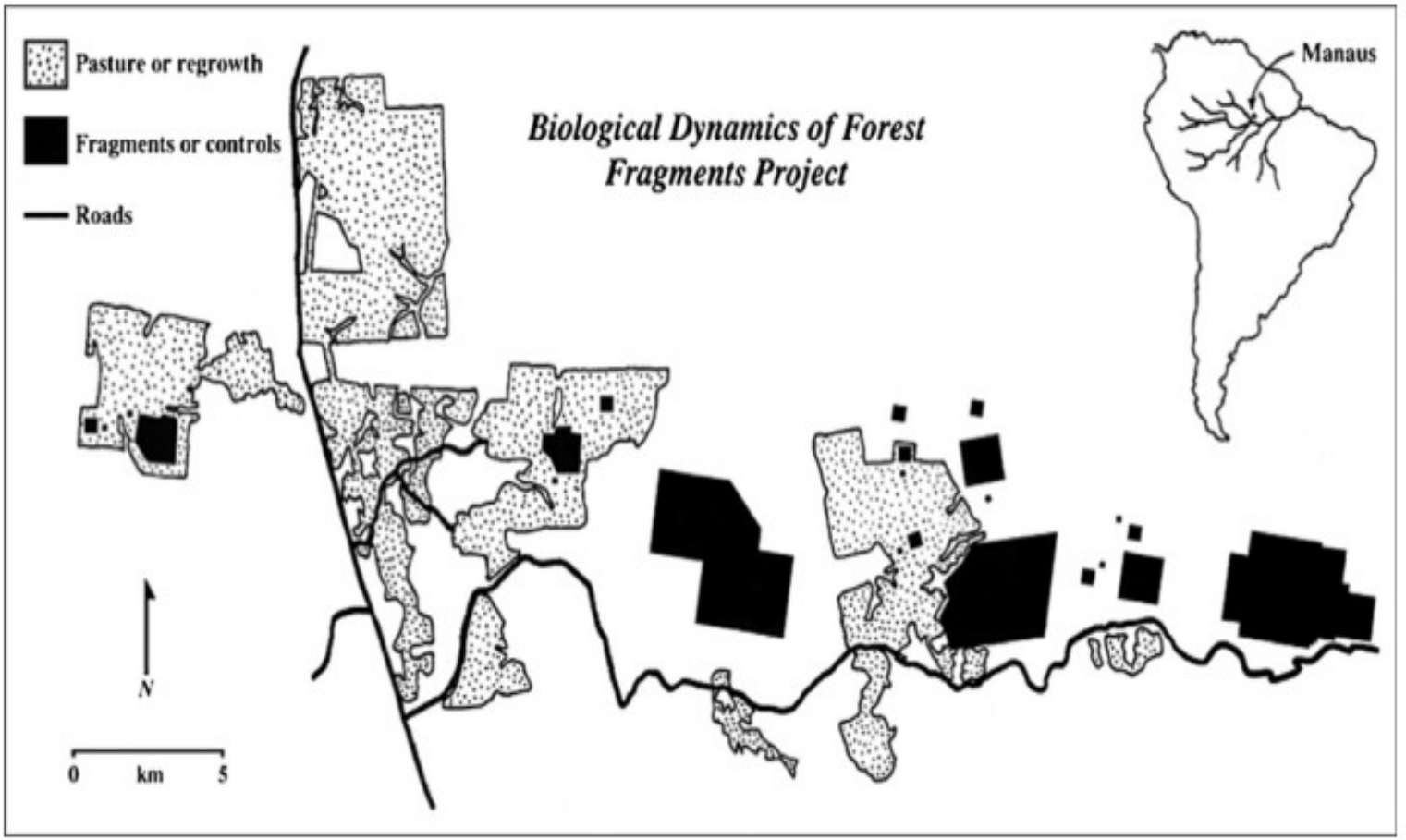


Fig. 1. Map of the BDFFP study area in central Amazonia. Unshaded areas are mostly intact forest.

BDFF project

- Biological dynamics of forest fragments
- Minimum Critical Size of Ecosystems Project
- Created forest fragments of sizes 1 hectare (2 acres), 10 hectares (25 acres), and 100 hectares (247 acres).
- Data were collected prior to the creation of the fragments
- Studies of the effects of fragmentation now exceed 25 years.

BDFF

- Many species may be absent from fragments not because their populations have vanished, but because they were simply not present at the time of fragment creation (sampling effect)
- The species richness of many organisms declines with fragment area even with constant sampling effort across all fragments.
  - Leaf bryophytes
  - Palms
  - Tree seedlings
  - Understory insectivorous birds
  - Primates
  - Larger herbivorous mammals

Understory birds

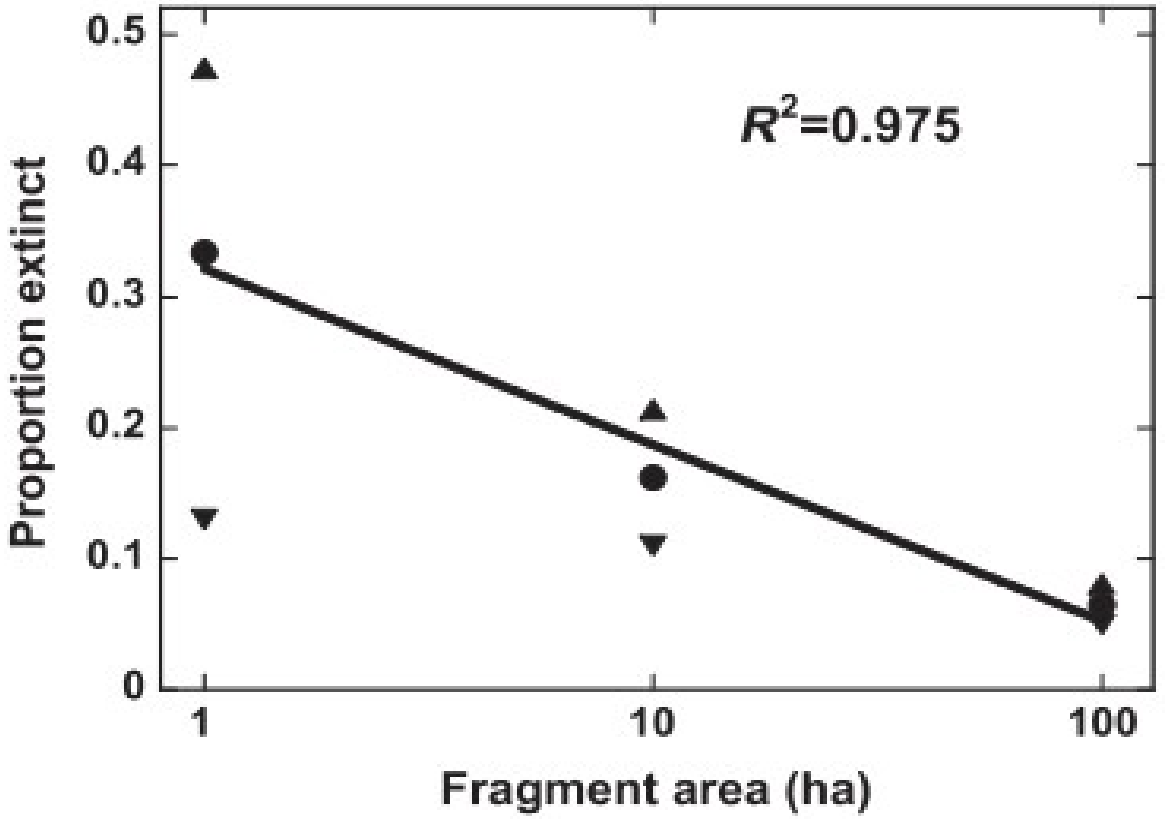
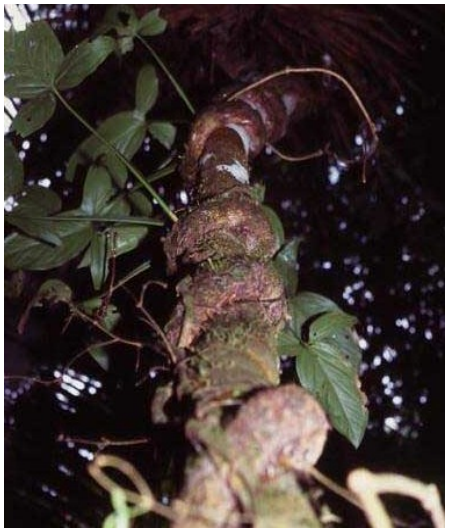


Fig. 2. Fragment-size dependent extinction of understory birds. Shown are the mean, minimum, and maximum proportion of bird species captured in each fragment in 1992 that were locally extinct in the same fragment in 2001 (after Stouffer et al., 2008).

Species favoured by edge effects

- Hummingbirds,
- Butterflies
- Lianas.



Edge effects may be more important than fragmentation

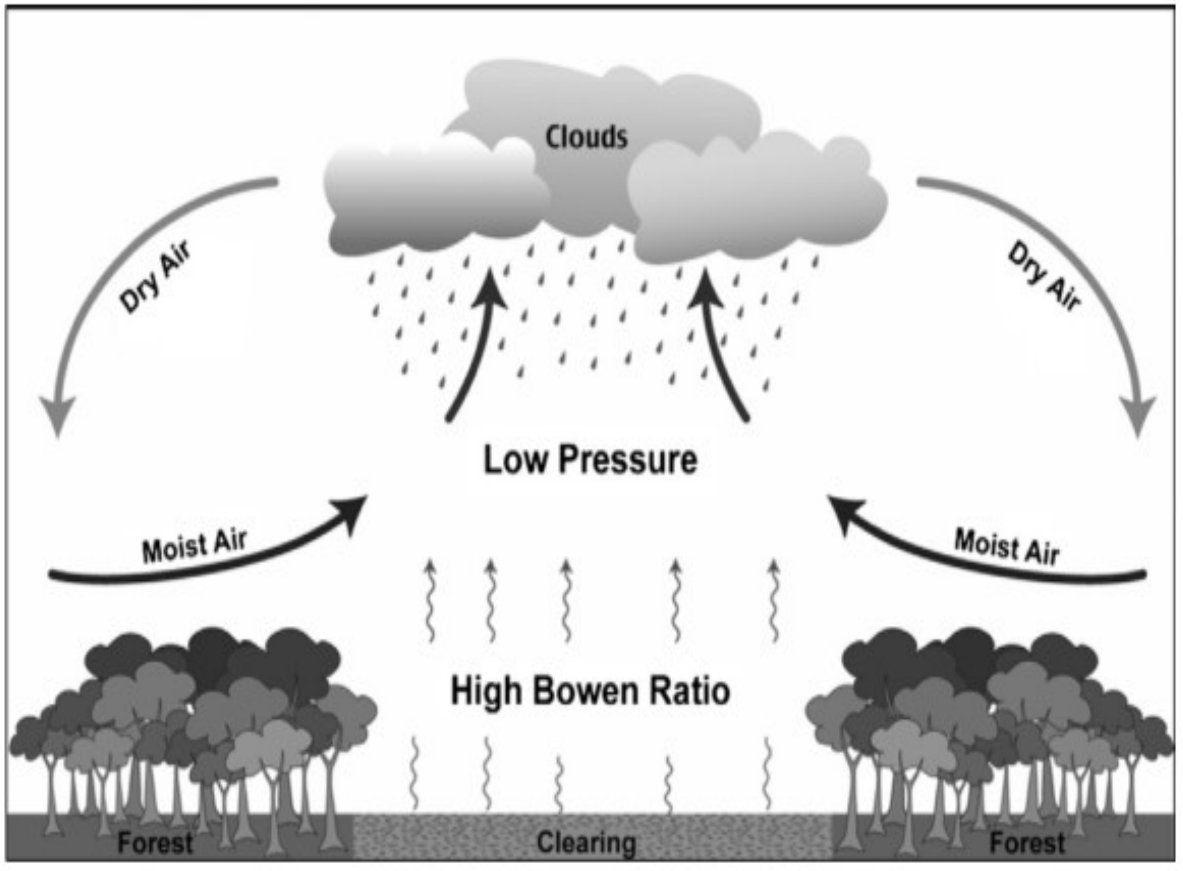


Fig. 3. In fragmented tropical landscapes, clearings can create localized atmospheric circulations that rob nearby forests of moisture (after Laurance and Peres, 2006).

Forest birds

- 164 bird species: mostly flycatchers, antbirds, tanagers, woodcreepers, and foliage-gleaners.
- More than one half (95) of the species belongs to one of the four families: Tyrannidae (32), Thamnophilidae (21), Furnariidae (22), and Emberizidae (20).
- The remaining species are distributed among 24 different families. The sample includes 40% of the regional bird species list
- Species from open fields, inundated areas, and the high canopy are the most consistent absences. The families Icteridae, Hirundinidae, Apodidae, Psittacidae, and Cracidae are regionally well represented but do not appear in the data set.

Amphibians

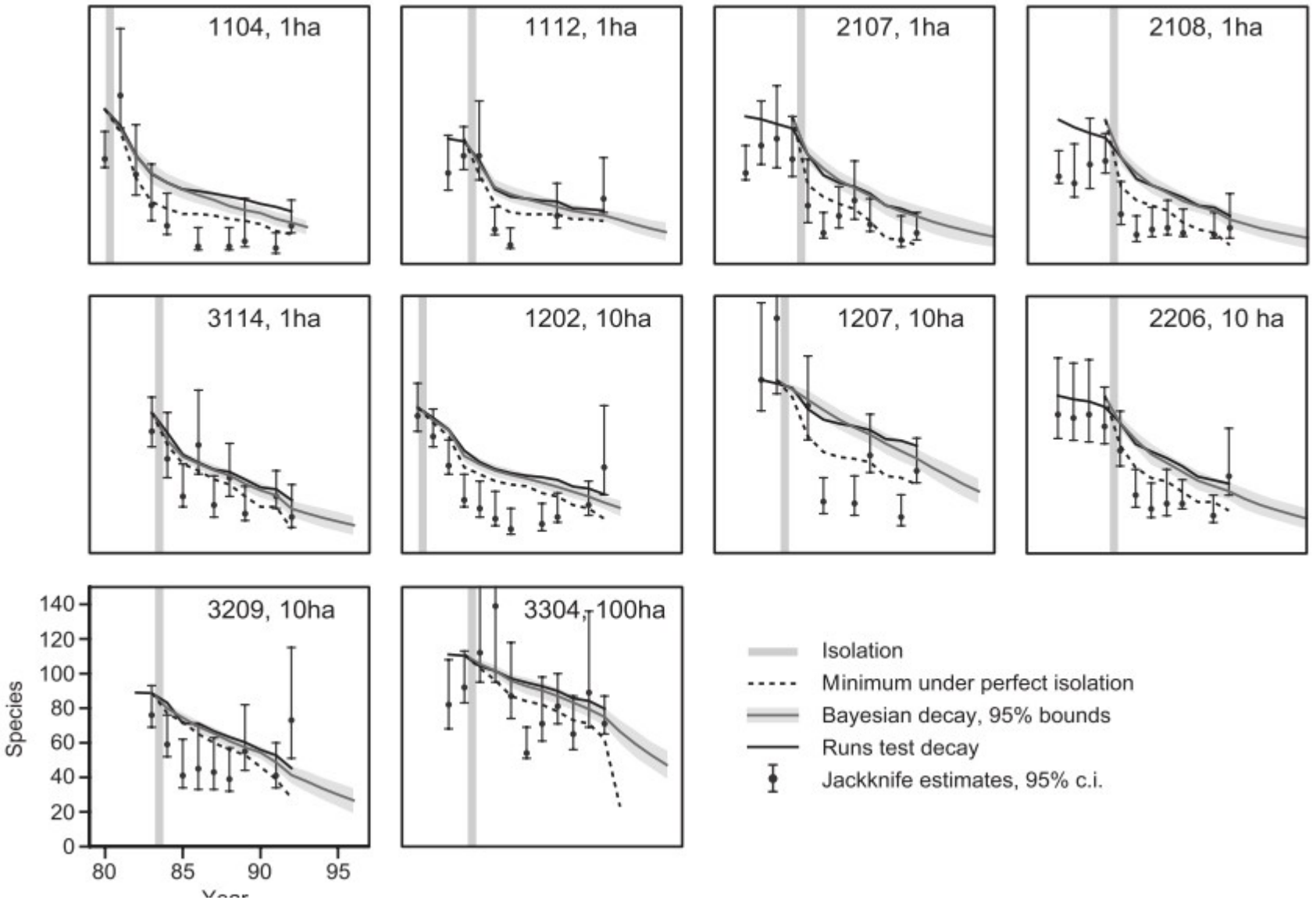
Zimmerman and Bierregard (1986) used data from the fragments to argue against single large in the SLOSS debate.

They found that habitat quality (type of water bodies in the fragment for amphibian breeding) was a critical factor determining species presence

Argued for better understanding of autecology

Zimmerman BL, Bierregaard RO. Relevance of the equilibrium theory of island biogeography and species-area relations to conservation with a case from Amazonia. Journal of Biogeography 1986;13(2):133–43.

Changes in total species richness



Results of BDFF

- Very ambiguous
- Project focussed on patch size
- Connectivity between patches not well typified
- Matrix changed during the course of the experiment (regrowth, originally of *Vismia* and *Cecropia*)
- Major conclusion uncontroversial but inconclusive. “The nature of the landscape within which the fragments are embedded plays a crucial role in determining species composition and richness”

setup

draw-island

draw-sea

go

draw-continent

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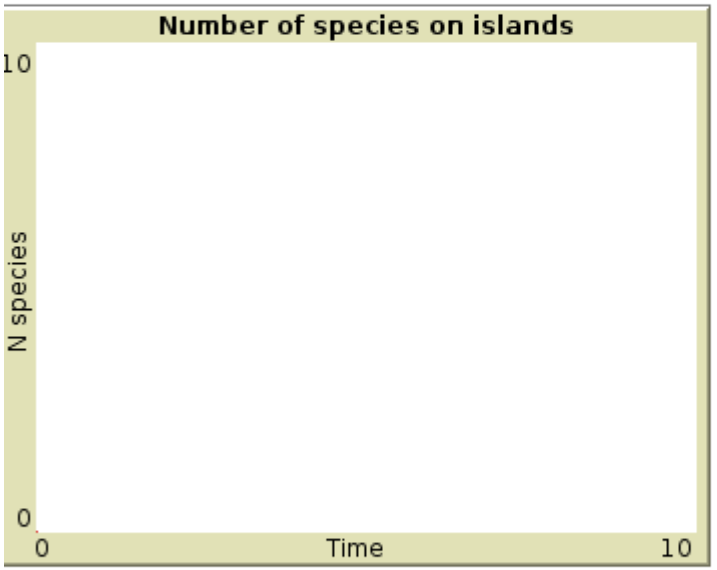
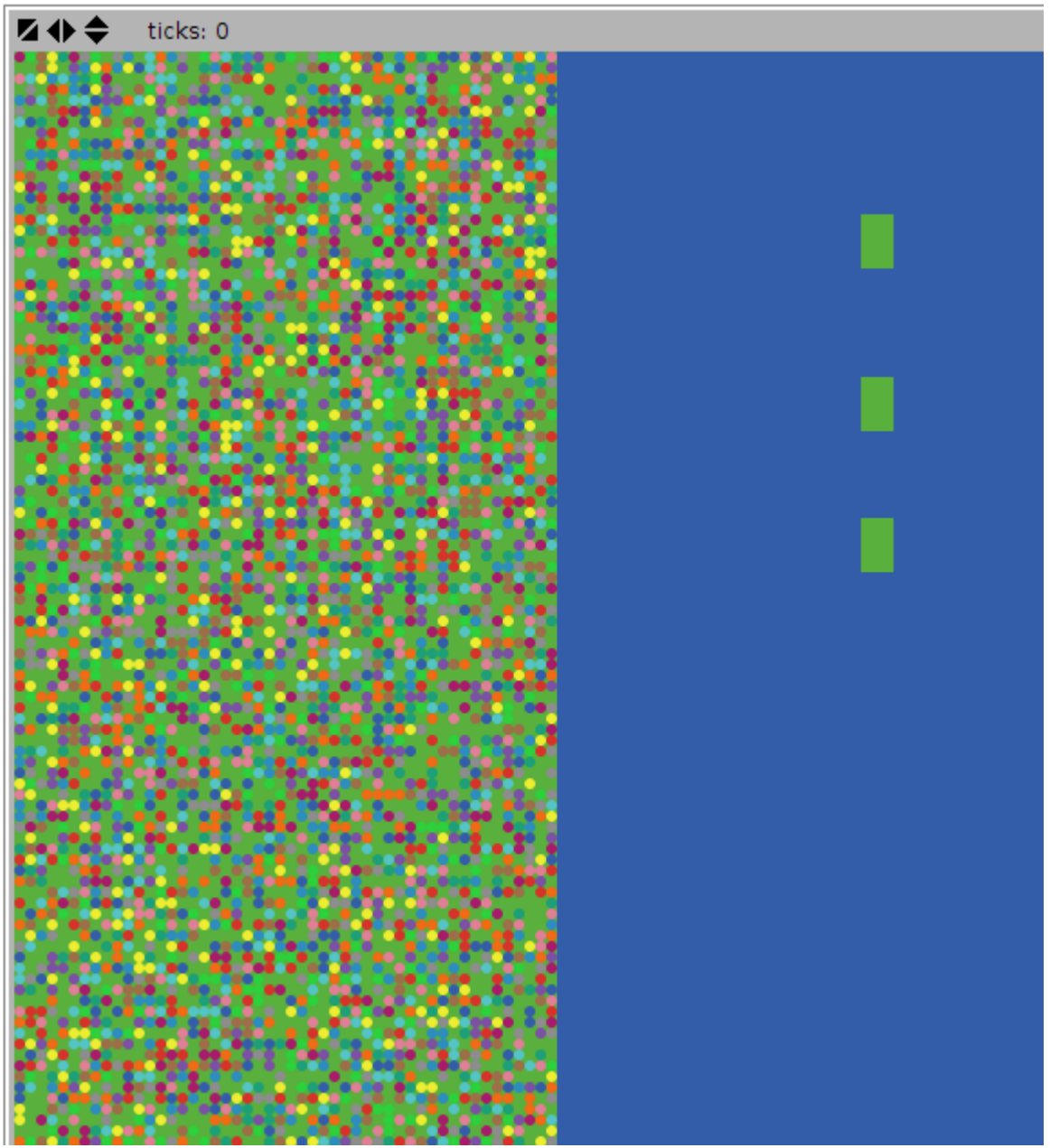
sp_on_continent
14





setup

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sp_on_island
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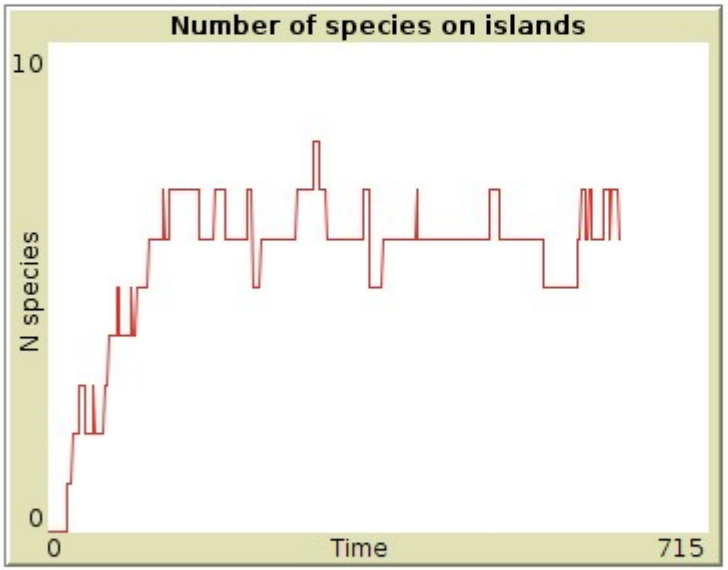

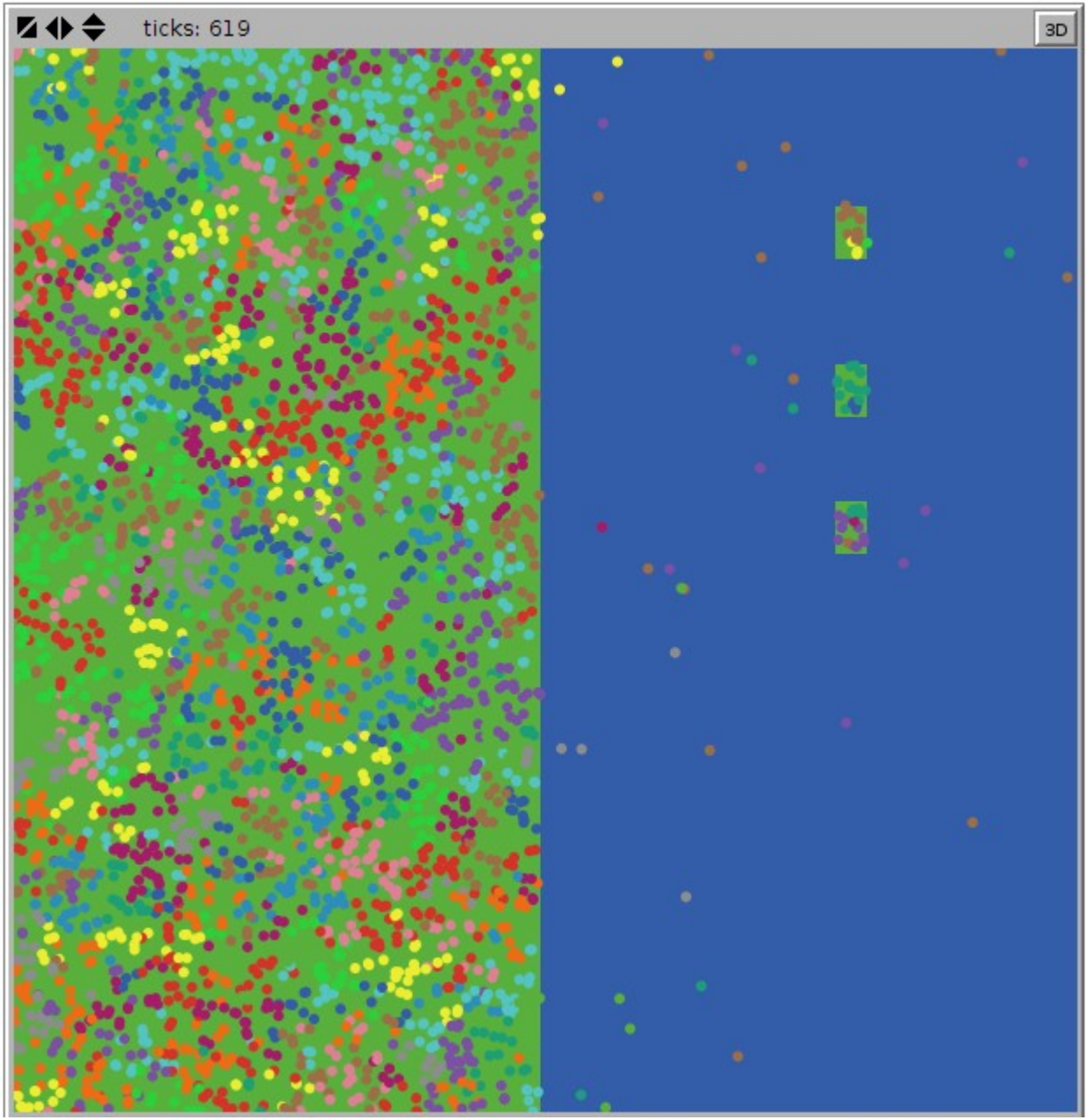

setup

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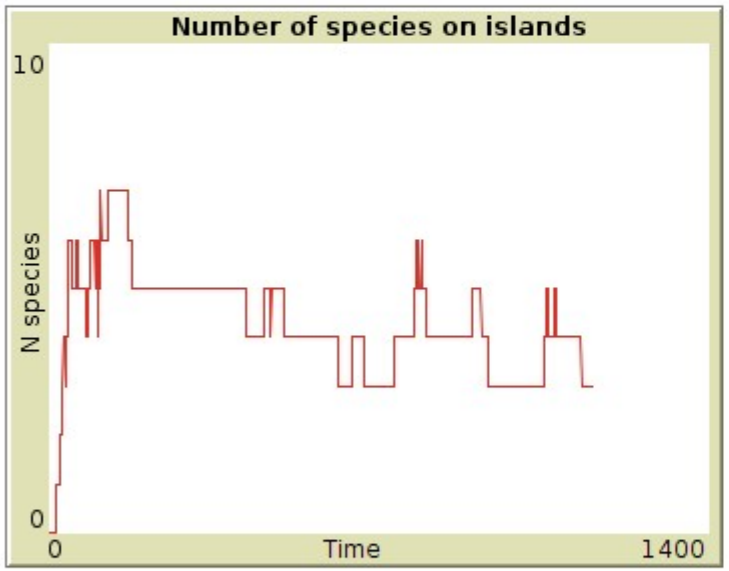

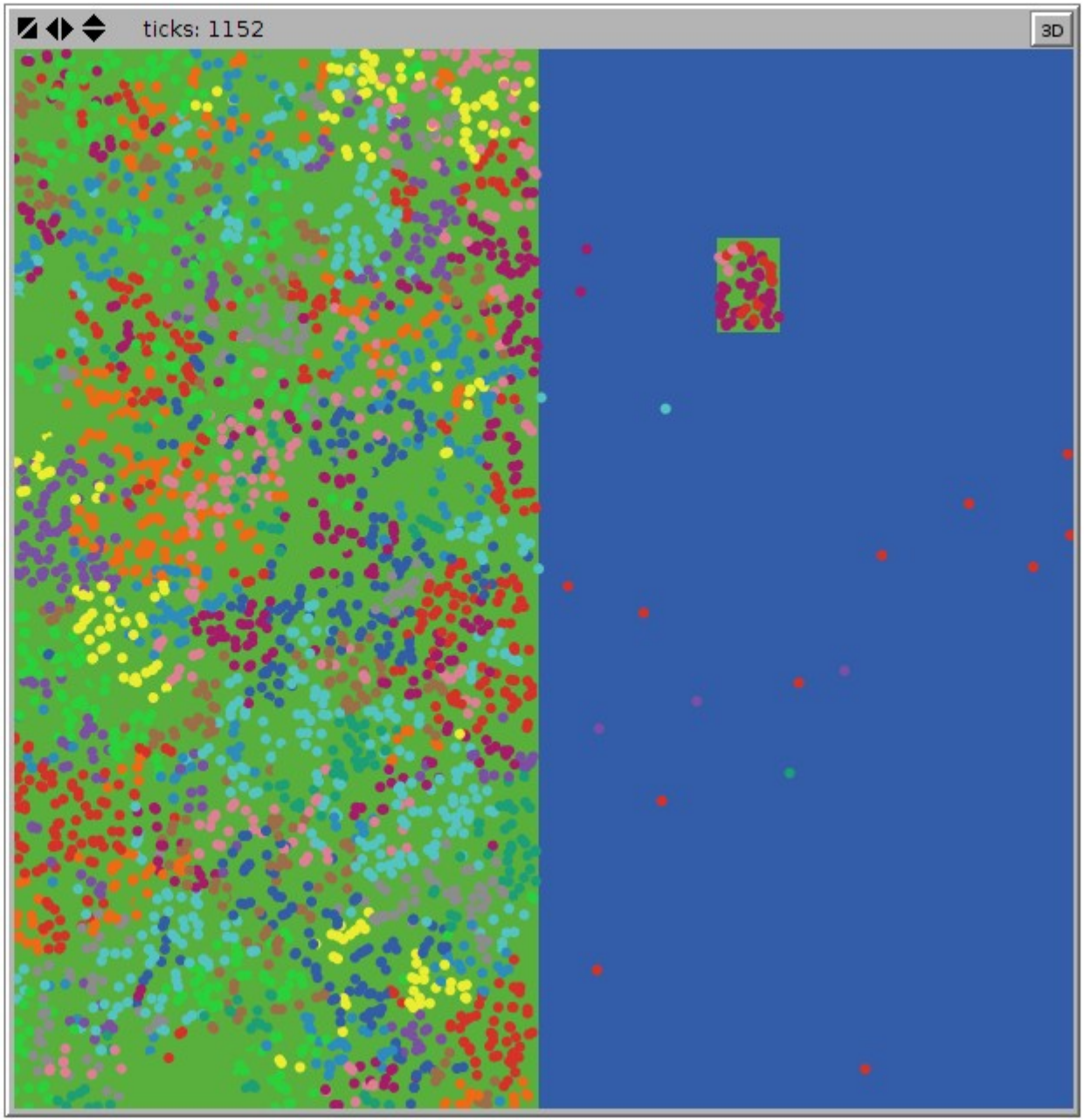

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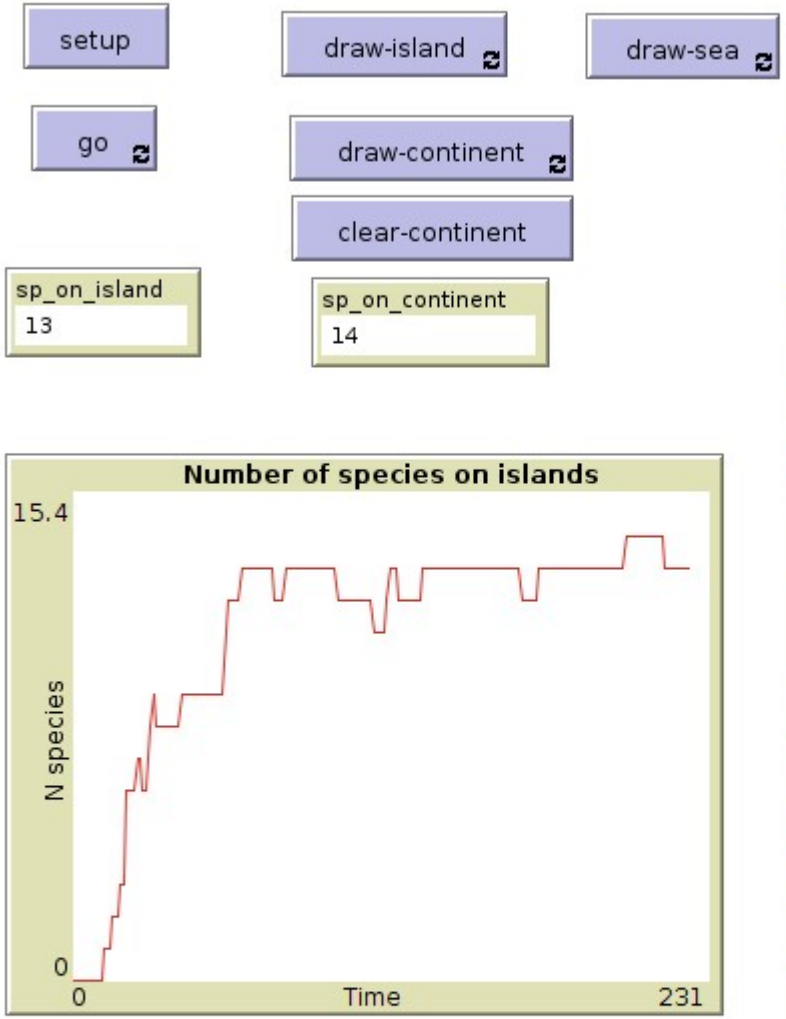

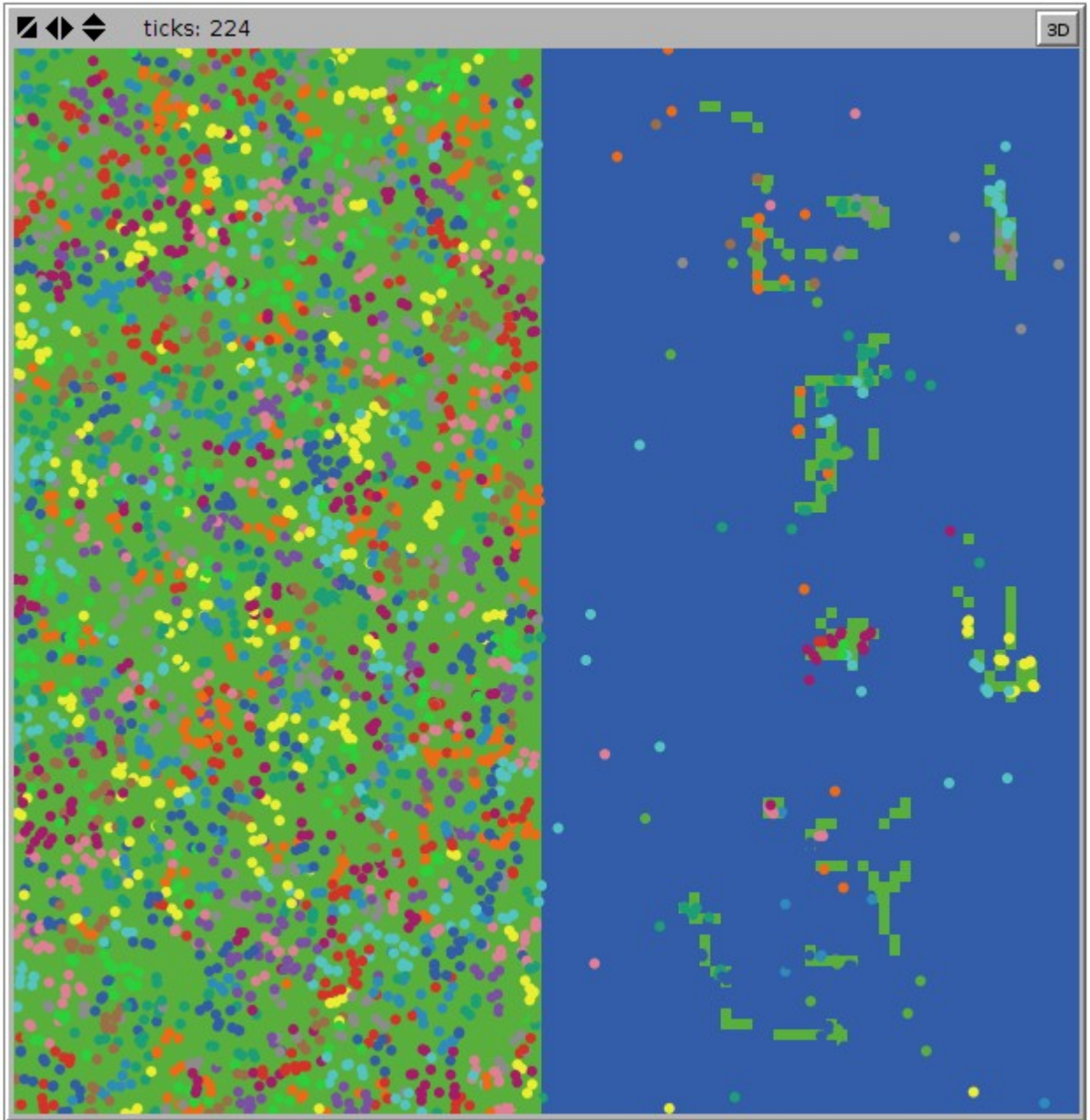

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