Background on inferring species diversity changes based on MSA

(drawing on Faith et al 2008)

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Biodiversity Indicators
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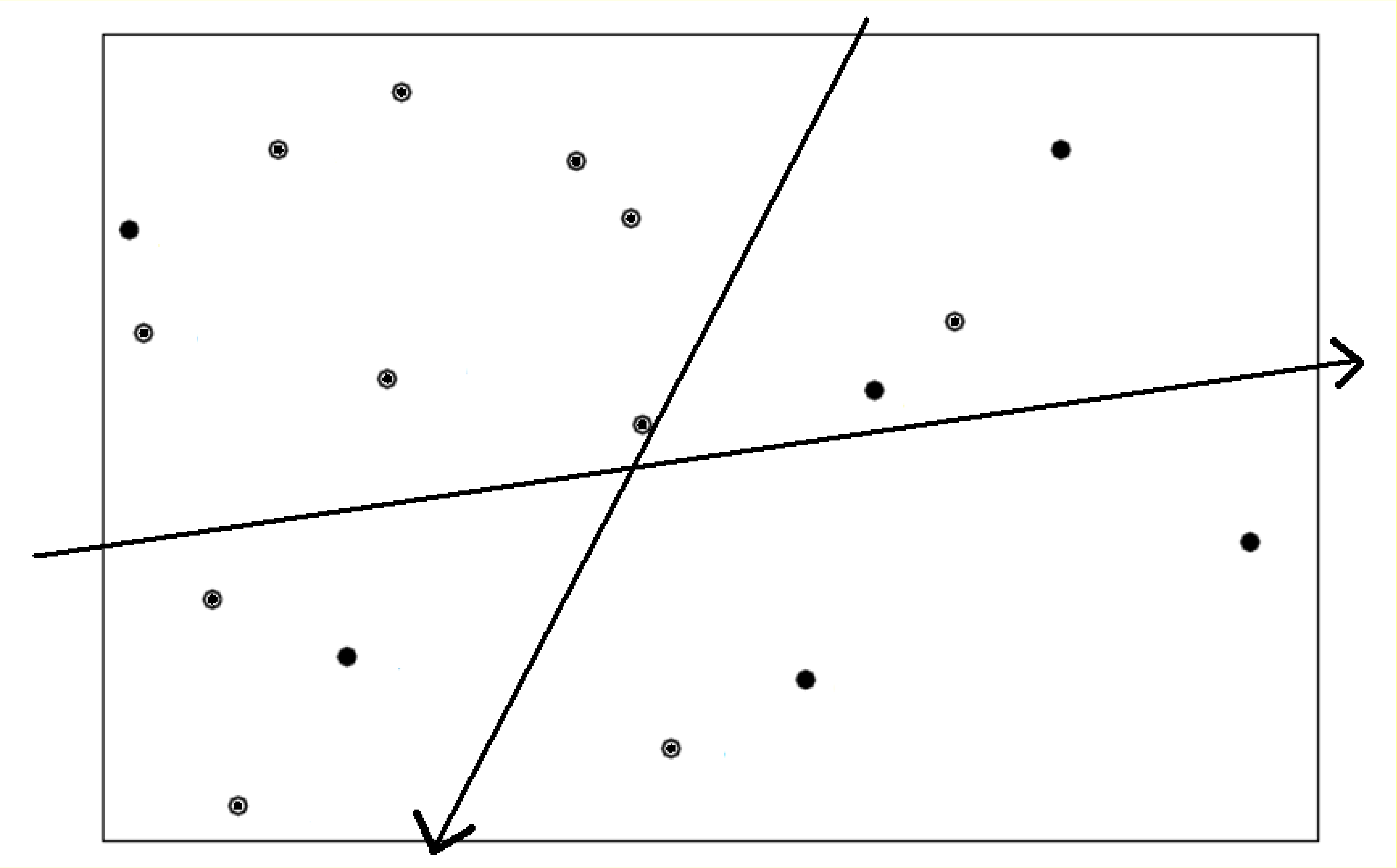
Using MSA abundance-fraction estimates

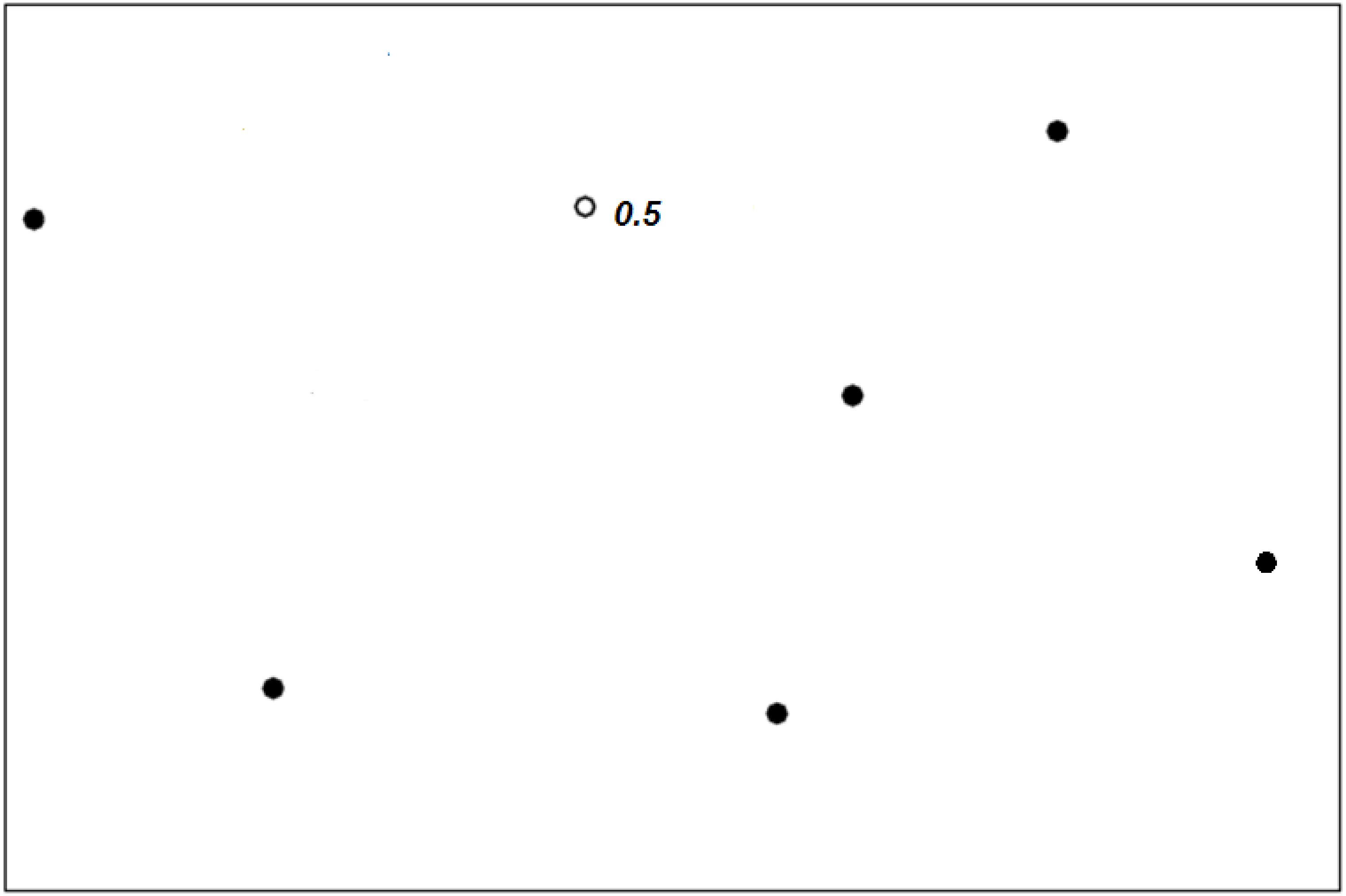
- Faith et al 2008 looked at the Biodiversity Intactness Index (BII)
  - Uses expert opinion on abundance-fractions for different land uses
  - Adds up scores over all biomes and land uses
  - **Conclude it does not measure biodiversity**
- MSA raises same issues
- Modified indices based on MSA can incorporate abundance-fraction estimates to estimate useful species richness fractions

17 sites or types in an environmental space derived using biotic and environmental data (e.g. using GDM). The space provides a surrogate strategy for biodiversity (using ED methods).



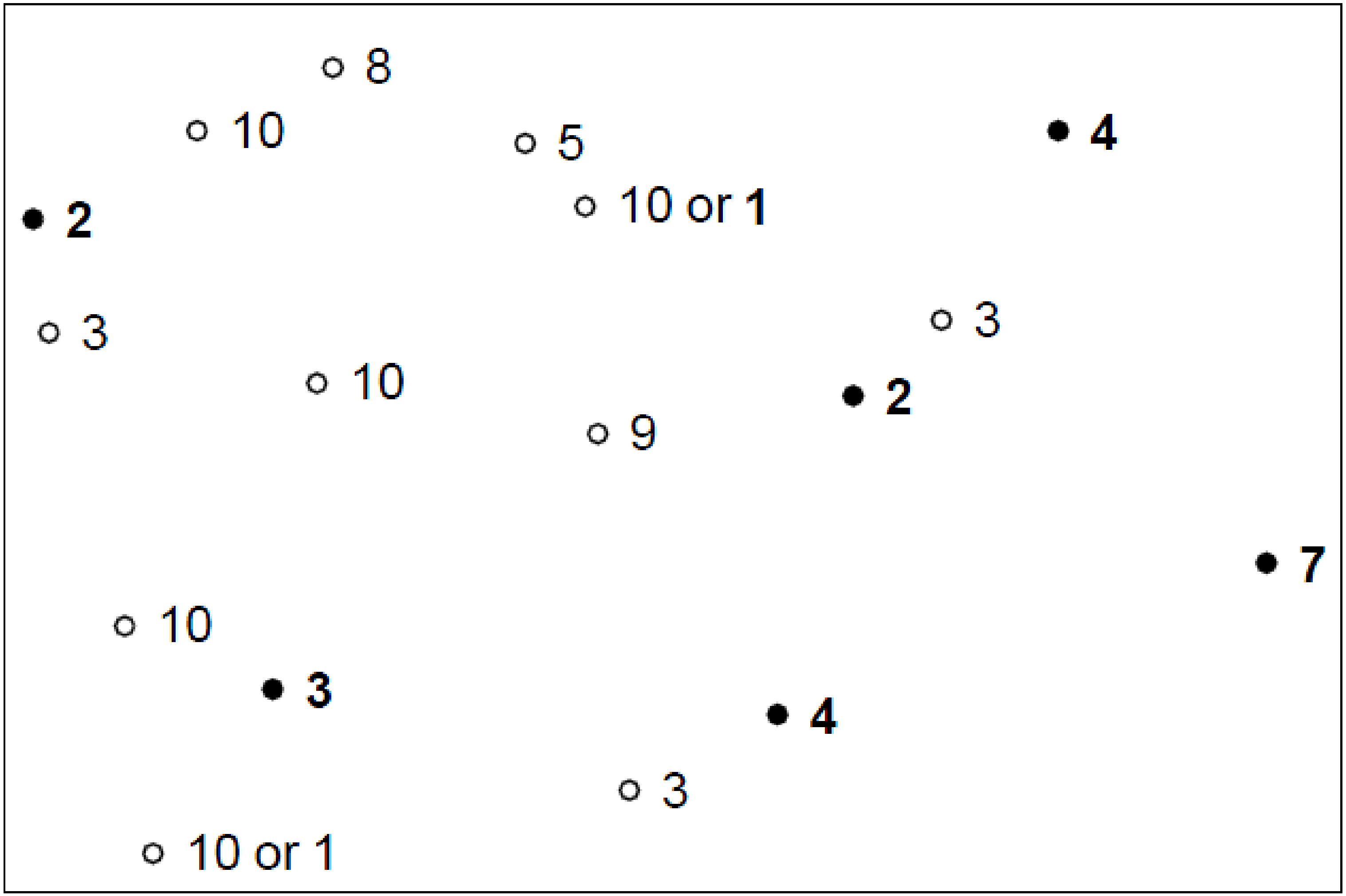
One basis for the “lens” approach in GEO BON

The sites or types offering biodiversity persistence.
1 type with **fractional species of 50%,**
for land use = biodiversity-friendly forestry



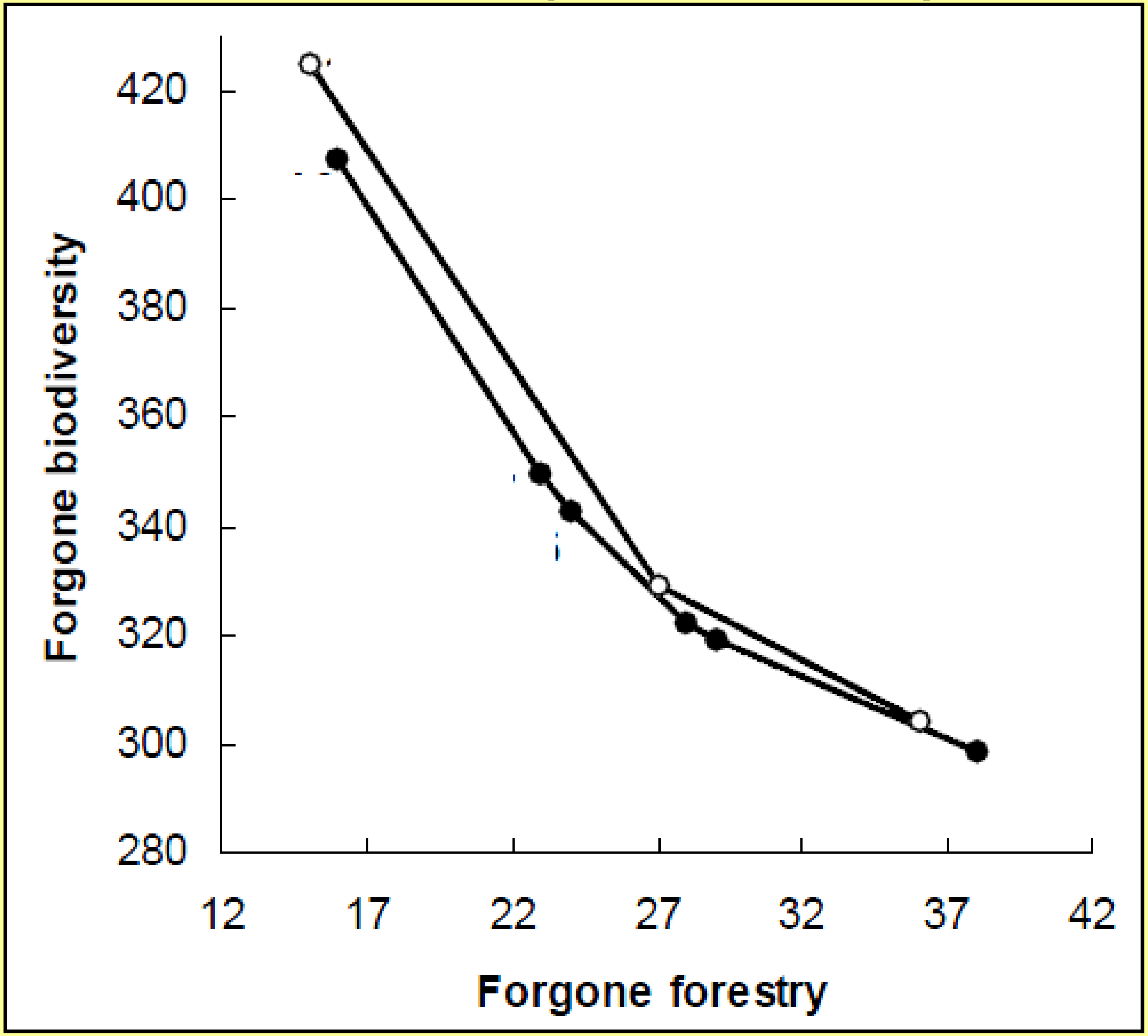
Faith (1995) Regional Sustainability Analysis. CSIRO.

17 sites or types; dark = protected. numbers are costs.
2 types offer **fractional species of 50%,** if land use = biodiversity-friendly forestry, opportunity cost is then only 1 (vs 10 if protected).



Faith (1995) Regional Sustainability Analysis. CSIRO.

Scenarios space with species fractions



Improved lower curve has greater net benefits, resulting from capacity to allocate land-use = biodiversity-friendly forestry with 50% species fraction and opportunity cost = only 1 (vs 10 if protected).

Faith (1995) Regional Sustainability Analysis. CSIRO.

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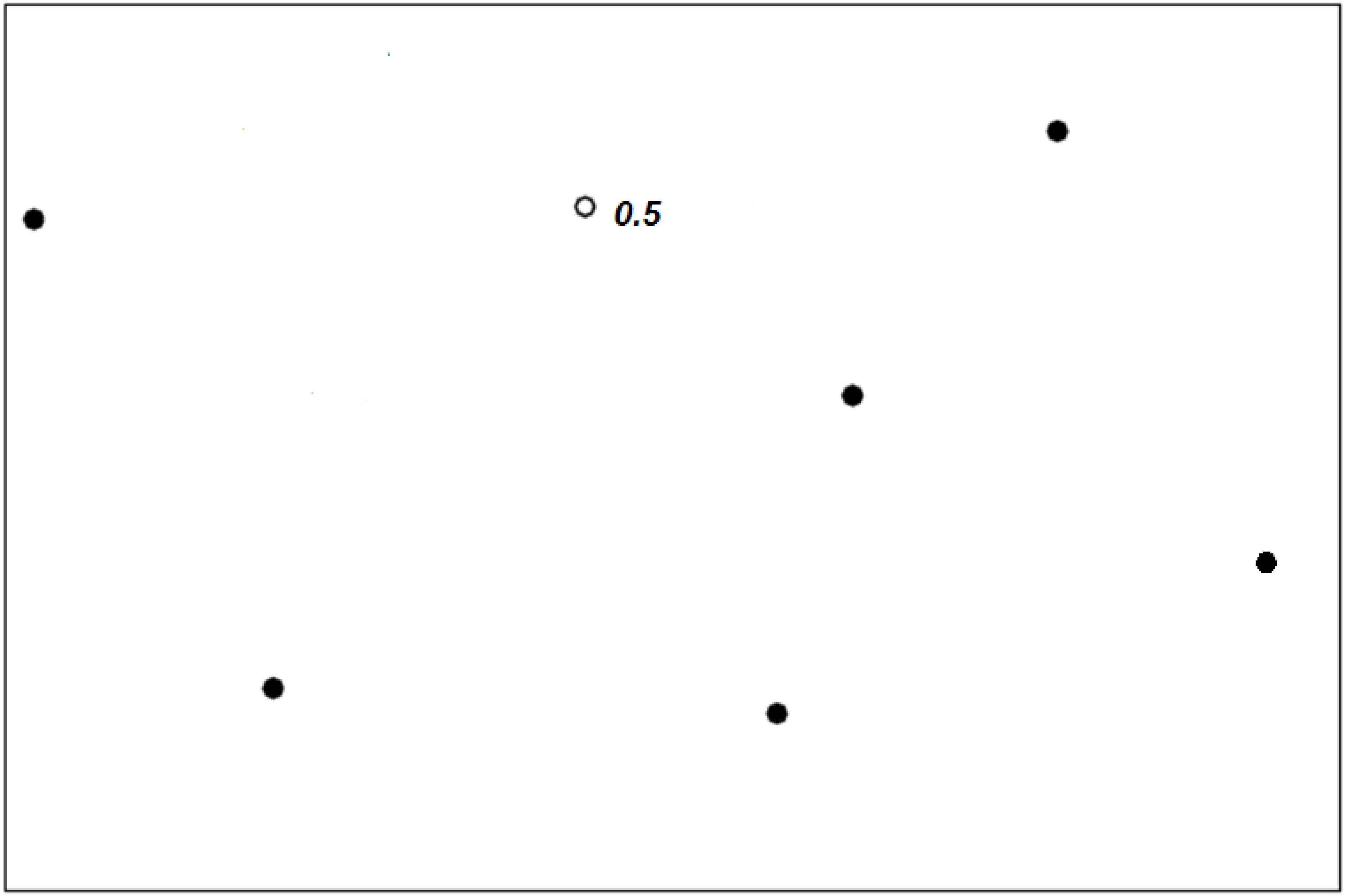

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Species area relationship

SAR has been utilized in the past for the estimation of species loss in response to regional habitat loss (e.g. May *et al.*, 1995; May & Stumpf, 2000; Ney-Nifle & Mangel, 2000; Pimm & Raven, 2000; Desmet & Cowling, 2004; Ferrier *et al.*, 2004; Millennium Ecosystem Assessment, 2005). The estimation of fractional losses in species numbers is clear when SAR is expressed as

$$\frac{S_1}{S_0} = \left(\frac{A_1}{A_0}\right)^z, \qquad (2)$$

where S is species number, A is area, subscript 1 (0) indicates the new (old) value.

SAR provides one immediate alternative to BII, using the same regional data. Area-amounts corresponding to the different land uses can be incorporated into SAR models. For taxonomic group, i, and any land use, j, covering area A_j, we simply set $X_{ij} = 1$ (else 0) if the I_{ij} estimate used in BII was greater than some nominated threshold, t. For a given biome or vegetation type, one simple SAR-based intactness index is

$$\mathrm{SARII} = \sum_i R_i \left[\frac{\sum_j X_{ij} A_j}{T} \right]^z, \tag{3}$$

where R_i is the richness of species group i in that biome/type, A_j the total area of land use j in that biome/type, and X_{ij} the 0–1 threshold-based version

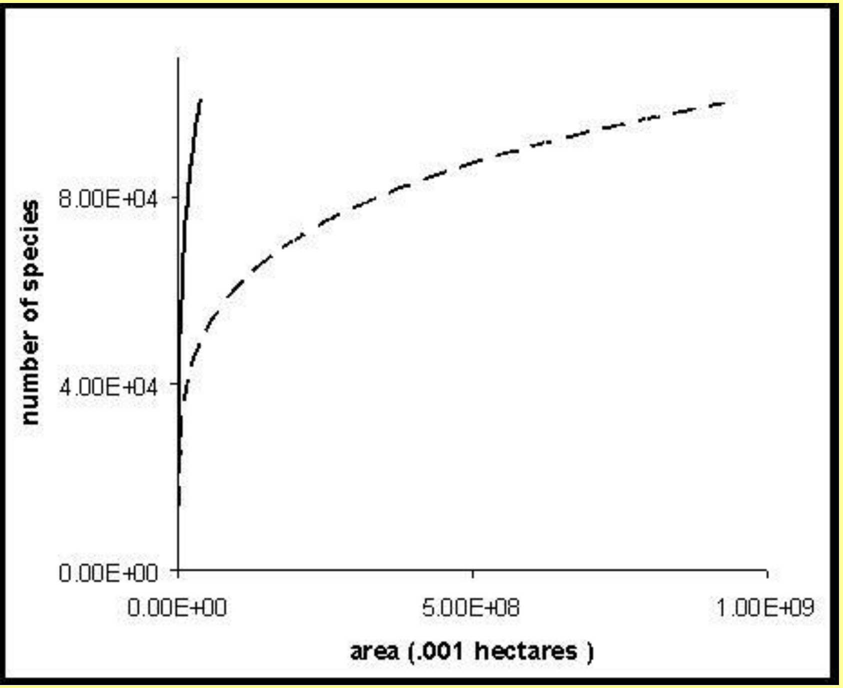
Given estimated abundance fractions, we will work backwards, via range sizes, to infer fractional area. Harte *et al.* (2001) derived a power-law relationship between abundance, a, and range size, r, among species in a given taxonomic group (Fig. 1b; 1 = new; 0 = original):

$$\frac{r_1}{r_0} = \left(\frac{a_1}{a_0}\right)^y, \tag{4}$$

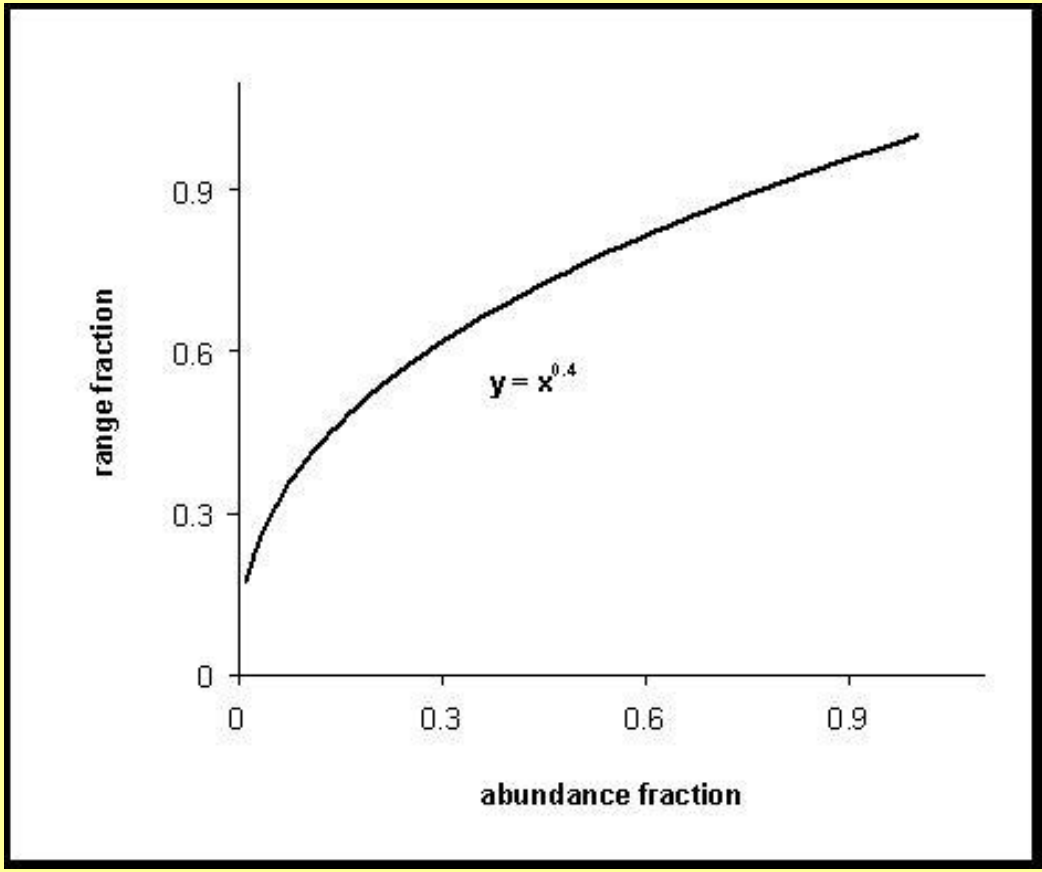
where y is the nominated power term. This abundance fraction corresponds to an I value (for some taxonomic group and land use). The corresponding range fraction might form the X value in (3) – the fractional effective area simply equated with the fractional range. Alternatively, a simple model (Harte & Kinzig, 1997; formula 27) implies that the SAR effective area is approximately the square of the average range size, so that

$$\frac{A_1}{A_0} = \left(\frac{a_1}{a_0}\right)^{2y}. \tag{5}$$

Species area curves



Range size – abundance curves



Inferring species-diversity-fractions from abundance-fractions

Focusing on a single taxonomic group and one I value, and combining Eqns (5) and (2), we have a new *species-diversity abundance-fraction curve* (SAC)

$$\text{SAC}: \frac{S_1}{S_0} = \left(\left(\frac{a_1}{a_0}\right)^w\right)^z = ((I)^w)^z = I^{wz}, \qquad (6)$$

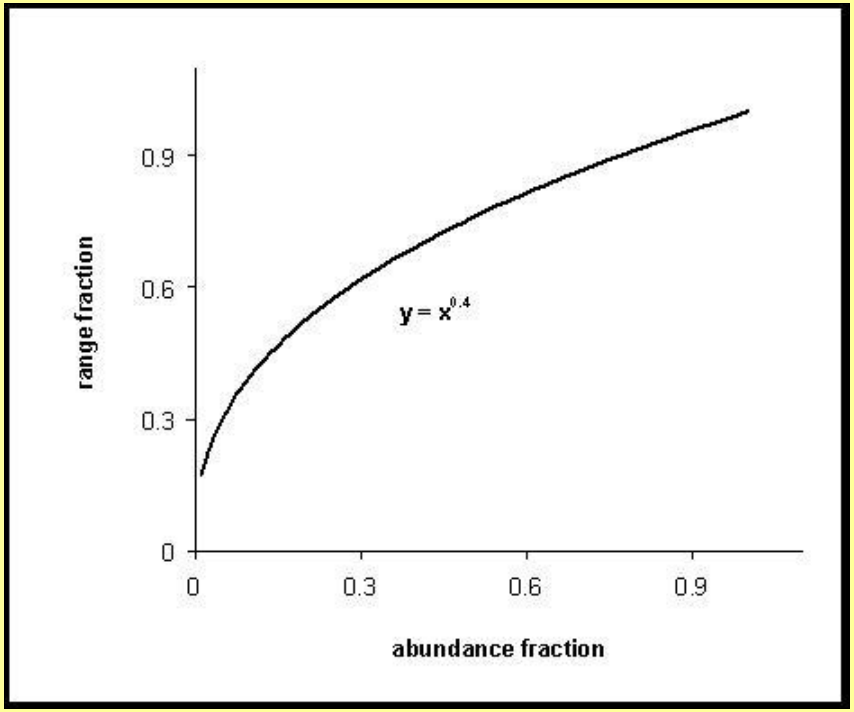
where $w = 2y$, for effective area equated with average range size squared. This combined power curve means that initial reductions in abundance fraction do not imply much change in fraction of species represented (Fig. 1c). Also, w approximates 1 when $y = 0.4$, providing some theoretical justification for a simple option assuming that the area fraction is roughly equal to the abundance fraction.

species-diversity abundance-fraction curve (SAC)

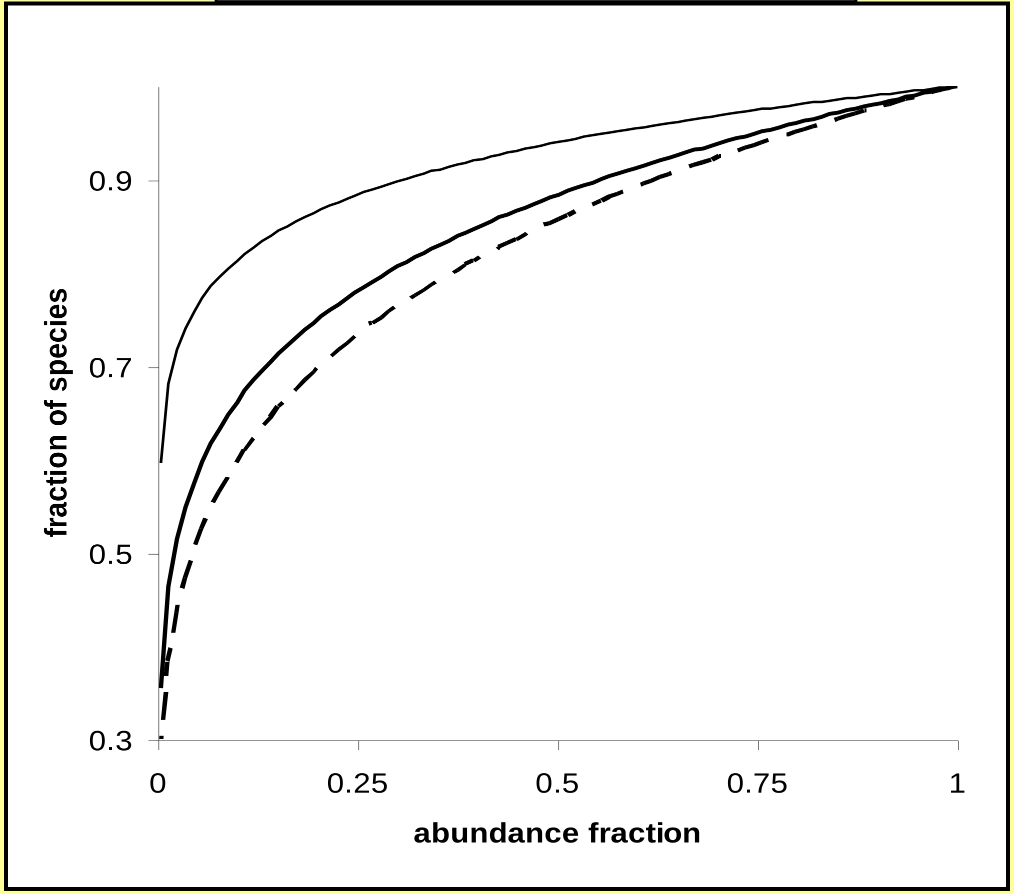
$$\text{SAC}: \frac{S_1}{S_0} = \left(\left(\frac{a_1}{a_0}\right)^w\right)^z = ((I)^w)^z = I^{wz}, \qquad (6)$$

- This power-law relationship depends on 3 assumptions –
  - – Abundance fraction to range fraction
  - – Range fraction to area fraction
  - – Area fraction to species fraction

Range size – abundance curve



Species-fraction abundance-fraction curves



Combined with

species-area curve -

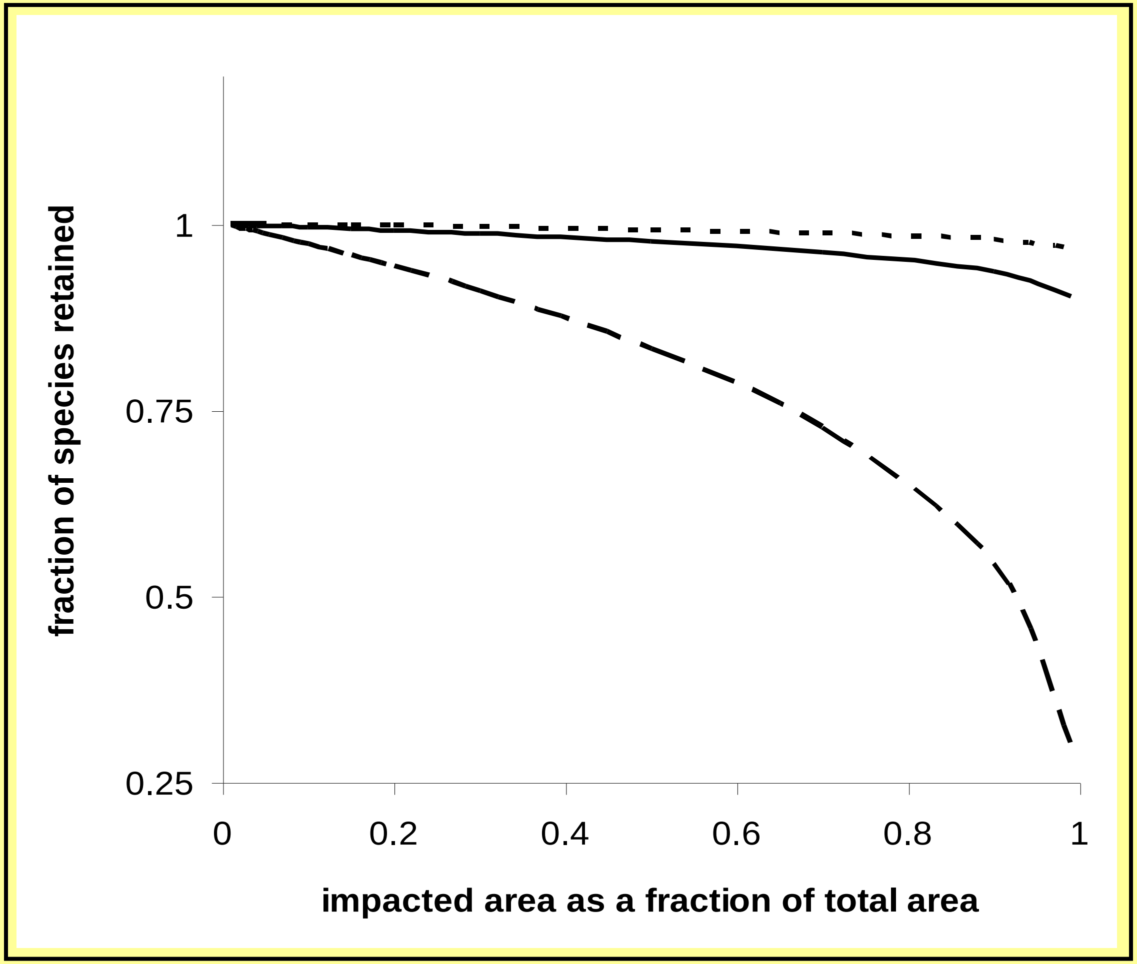
Faith et al, *Global Change Biology*

Biome area can be a mix of pristine and "impacted" by a land use, with some abundance fraction

Dashed curve – only pristine offers any species

Solid curve – land use credited with abundance fraction of 0.5

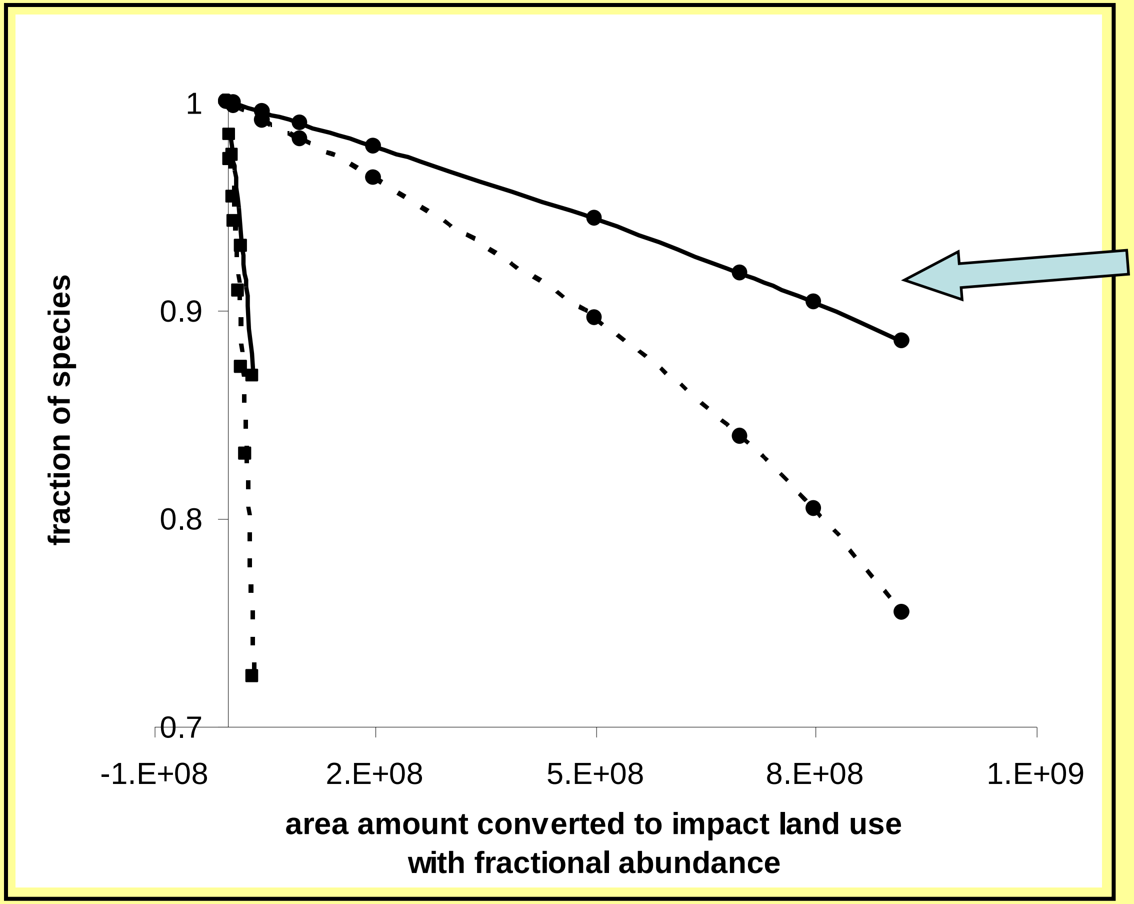
Dotted curve – land use credited with abundance fraction of 0.8



Global Change Biology

Solid curves reflect amounts of area converted to land-use with abundance fraction of 0.5

Dashed curves – abundance fraction of only 0.2

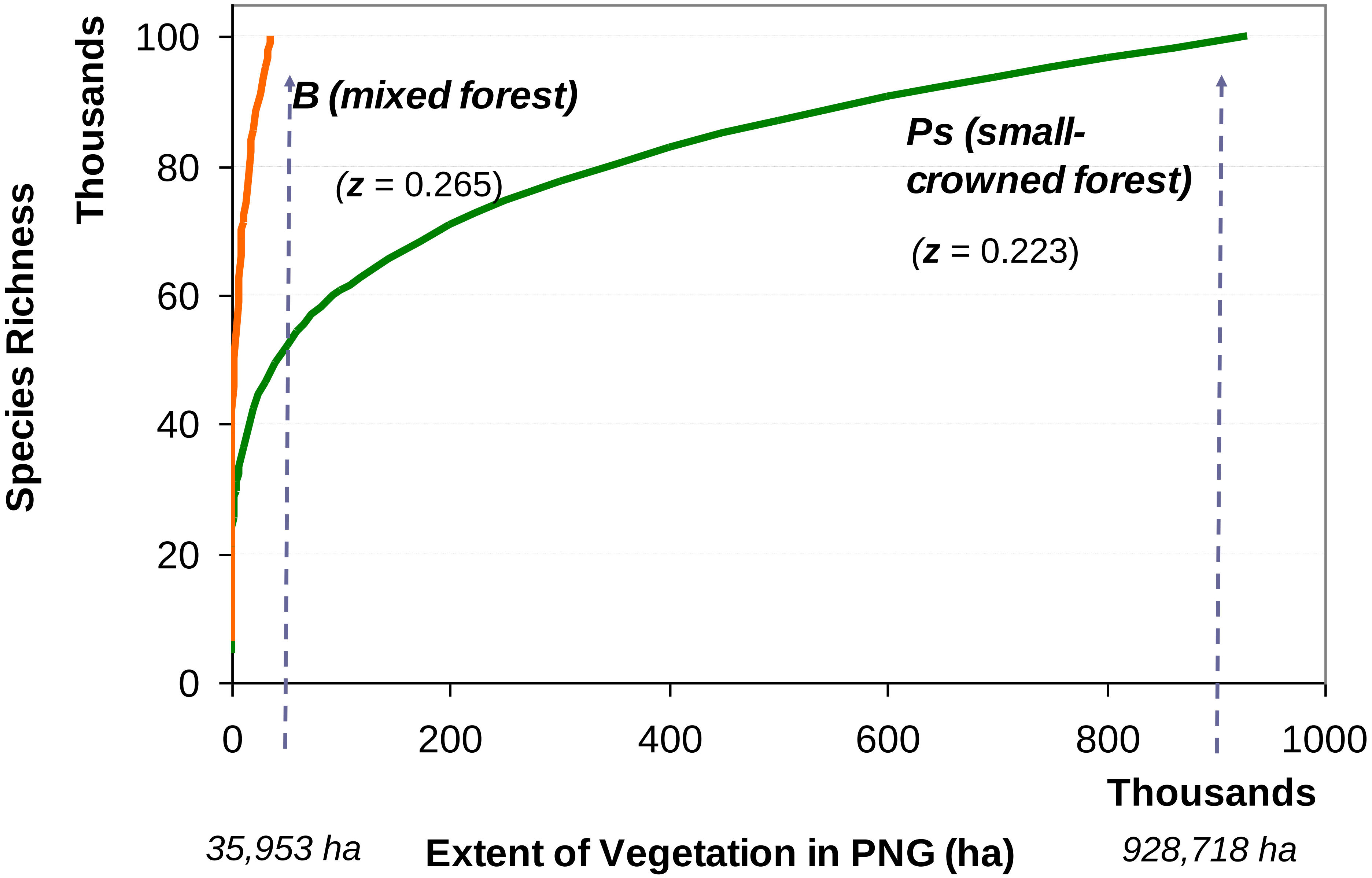


Rate of species loss less for higher abundance fraction value

Left – the rarer forest type   Right – extensive forest type

Global Change Biology

PNG vegetation types - SAR

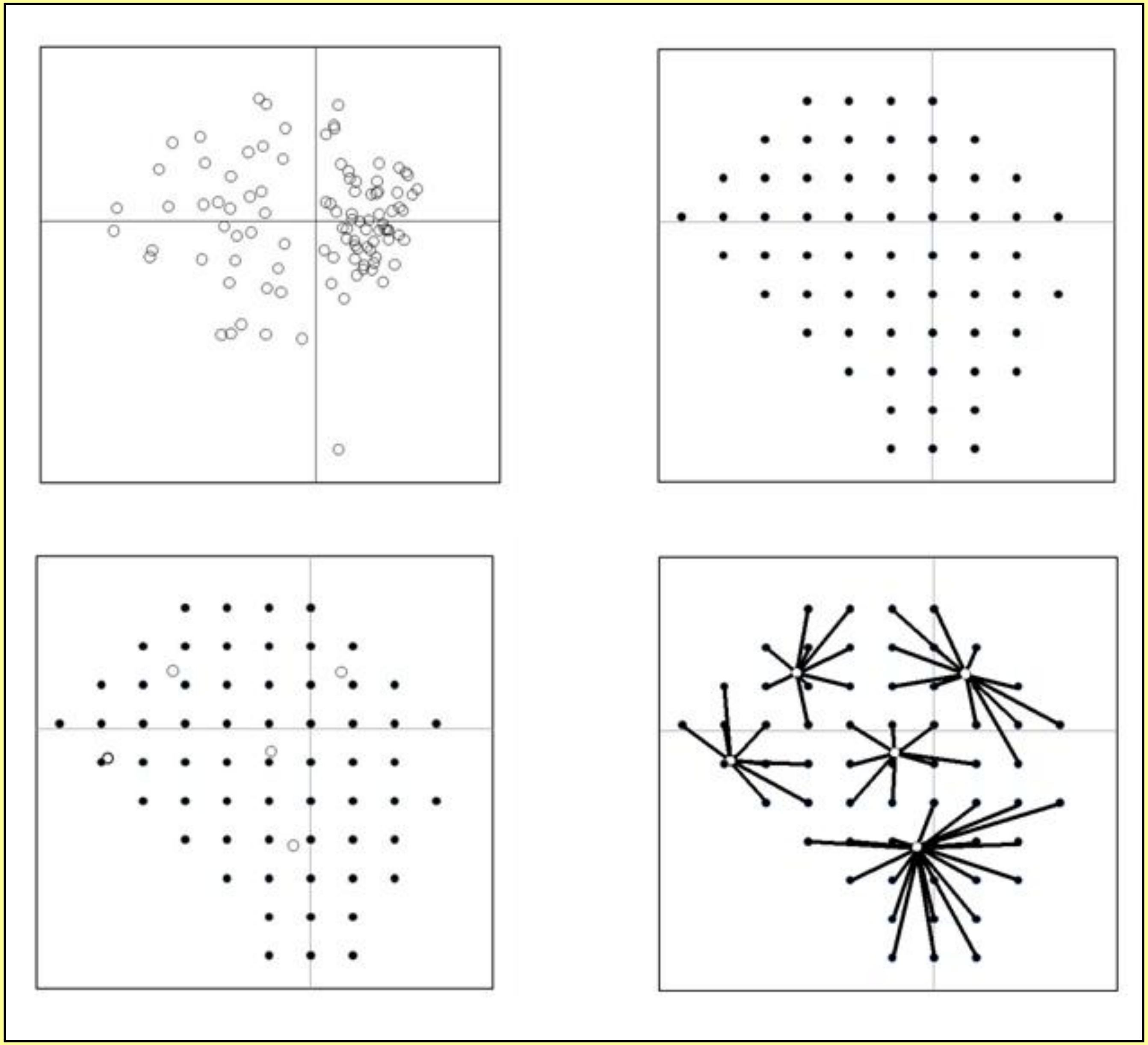


Williams et al

Taking overlap among types into account using ED

- For discussion of ED method applied to types, see Faith and Walker 1996 etc
- For GLOBIO, MSA, have species fractions, inferred from abundance fractions, for individual types/classes
- But a report card on species diversity losses needs to summarise over all types, and the problem is that these types have overlap (share species)

Use estimated dissimilarities among types and apply ED to gradients space

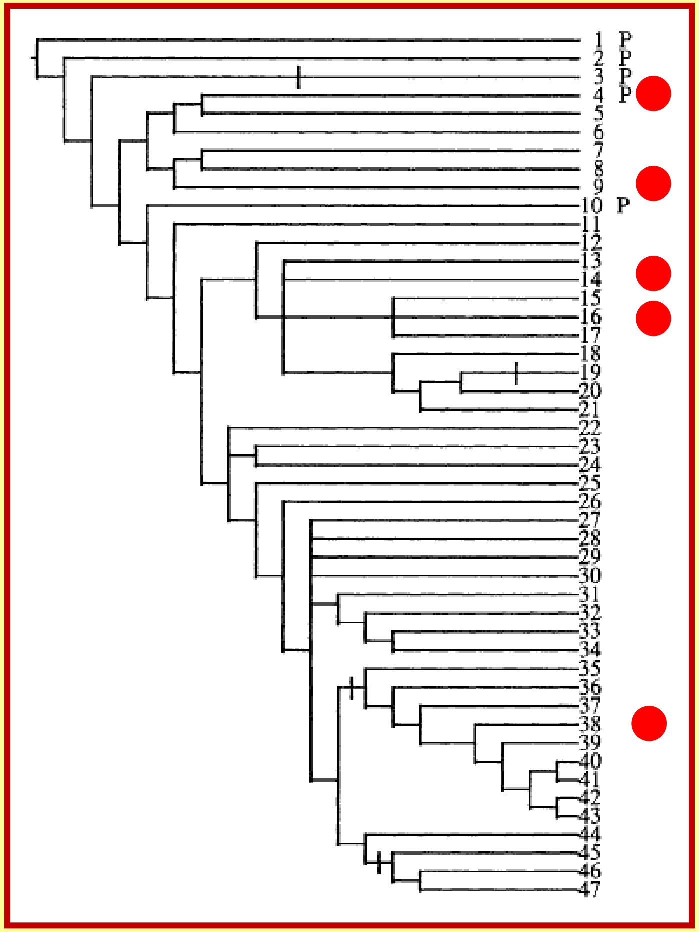


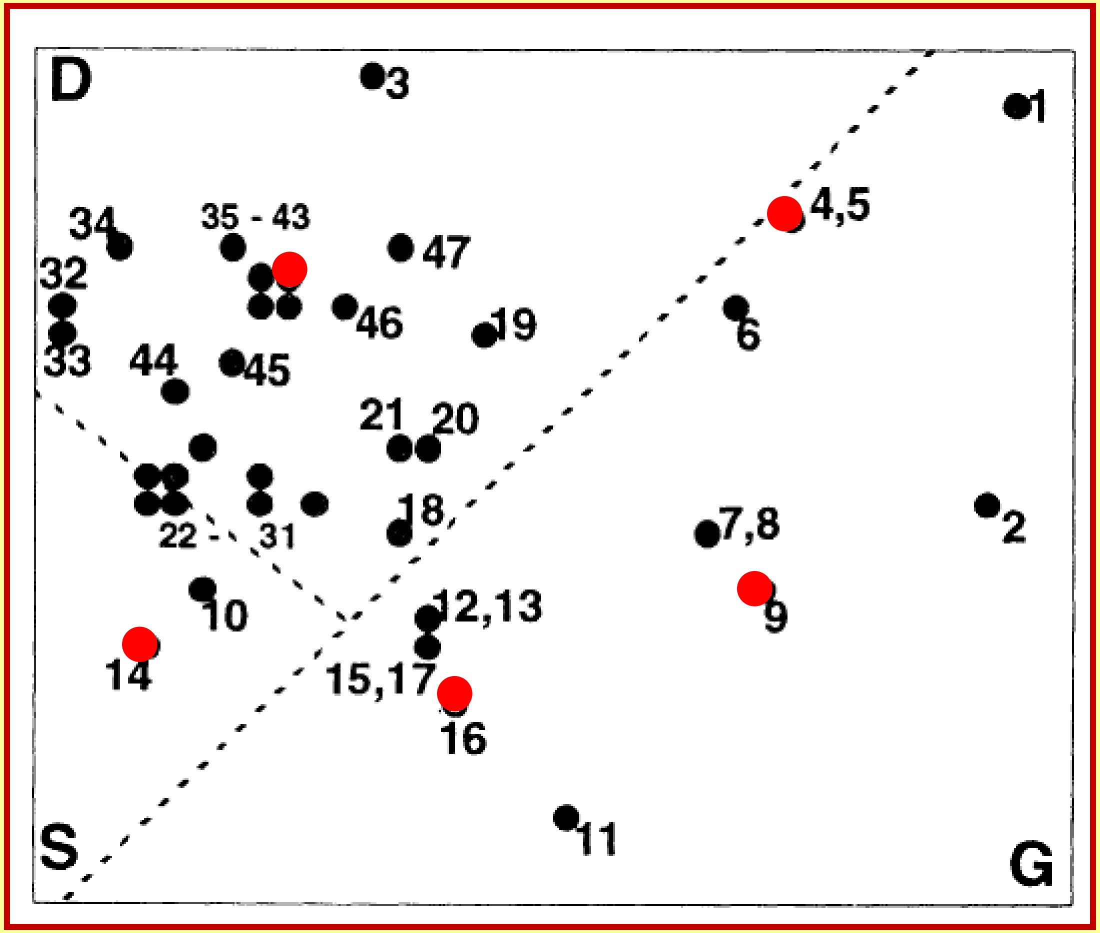
ED figure from Williams et al in press

Functional diversity

An index of functional diversity based on ED

Can track loss in functional diversity, look at resilience, see if communities are clumped or dispersed in functional space





Faith DP (1996) *Conservation Biology*, Vol. 10, No. 4 pp. 1286-1289