

The ConsNet Portal 1.0

Systematic Conservation Planning Primer

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BIODIVERSITY AND BIOCULTURAL CONSERVATION LABORATORY

SCP BLOG



***Gunnera kilipiana* (Gunneraceae).** This species is endemic to wet barrancas in cloud forests of Guatemala and southern Mexico. Endemic plants are often used as biodiversity surrogates because they have to be conserved at each locality. This photo was taken in a cloud forest at Fuentes Georginas in Pico Zunil, Quetzaltenango, Guatemala. © 2006 Taylor Sultan Quedensley.

© 2006 Vanessa Lujan, Trevon Fuller, Alex Moffett, and Sahotra Sarkar. Tutorial written by Vanessa Lujan, Trevon Fuller, Alex Moffett, and Sahotra Sarkar with assistance from James Justus, Chris Kelley, Chris Margules, and Samraat Pawar.

M5: Surrogacy Identification and Analysis

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Learning Objectives: This module explains how to assess the effectiveness of surrogates within systematic conservation planning. In addition, using the Québec and Queensland data sets, this module explains the concepts of true and estimator surrogates and gives examples of the output of the Surrogacy software package.

- Surrogates must be used in conservation planning because “biodiversity” is too vague a term impossible to define, and hard to **operationalize** in the field (Sarkar 2002; Sarkar & Margules 2002).
 - If biodiversity is defined as the diversity of life at every level of structural, functional, and taxonomic organization, biodiversity becomes all of biology (Takacs 1996). It then becomes difficult to quantify biodiversity in a way that can be measured for the purpose of conservation planning.
 - Surrogates are such measurable components of different aspects of biodiversity.
 - Traditional surrogates such as charismatic, keystone, umbrella species, species of commercial importance, and conspicuous species are usually inadequate surrogates as shown in several studies, and also because of the fact that these categories ignore other species.
 - **Charismatic species:** are those species that people relate to in a positive emotional way and bring out strong protective action – and are usually able to attract political support (voters) and/or private money for protection and conservation. (e.g., redwoods, panda bears)
 - **Umbrella species:** are species that require large blocks of relatively natural or unaltered habitat to maintain a viable population and usually this habitat can encompass other species.
 - **Keystone species:** are species that have a high impact/major ecological function of the ecosystem (e.g., trophic relations, community structure, disturbance cycles) and ecological functioning can change if species is not present (e.g., otters)
 - **Commercial importance:** are species with existing or future commercial

value (e.g., for tourism, breeding new stock, pharmaceuticals, etc.)

- **Conspicuous species:** are species that are large or obvious or from which good records exist because of amateur observation preference (e.g., mammals, birds, butterflies)
- Surrogates used in conservation planning are supposed to represent biodiversity and provide a full measure of biodiversity. These types of surrogates are called true and estimator surrogates.
 - Surrogates must satisfy two criteria (Williams et al. 1994; Sarkar & Margules 2002); (i) *quantifiability* — the surrogate can be measured; and (ii) *estimability* — data about the surrogate must be obtainable, given constraints on time, expertise, costs required for data acquisition, and limited field surveys or remote sensed data. (Sarkar 2004; Margules & Sarkar 2006)
- True surrogates
 - True surrogates are supposed to represent the planning objective of general or true biodiversity in conservation planning.
 - Choice of true surrogates is partly conventional, and they are based on a general consensus on whatever “biodiversity” is – because of the problems found when defining “biodiversity” (see **M1: Introduction to Conservation Area Networks**). However, this choice is not uninformed or random.
 - Three common true surrogates are:
 - Character/trait diversity – Evolutionary mechanisms affect traits of individuals in populations. In measuring character/trait diversity, “traits” can be many things and therefore trait diversity is typically too loosely defined to quantify.
 - Species diversity – This measure of diversity is well-defined, however, the variety of species is not a sufficient surrogate for the full measure of biodiversity as there are other types of biodiversity than species types.
 - **Species assemblages**, landscape patterns, or **life zone diversity**– These terms have similar meanings although the spatial scale is different for each. The theory behind the use of these surrogates in representing biodiversity is that (i) a variety of biotic communities with associated biotic interactions is important and (ii) communities naturally include populations of species. Although many countries have classification systems for life-zones and ecoregions, these regions are defined based on relatively few species (Margules & Sarkar 2006).
- Estimator surrogates

- Estimator surrogates are intended to represent true surrogates.
- The goal of surrogacy analysis is to determine how well the estimator surrogates represent the true surrogates.
- In selecting conservation areas, proper use of the estimator surrogate should be that it “adequately” represents the true surrogate. This is accomplished by sampling uniformly across geographical and environmental space to determine whether the estimator surrogate represents the true surrogate.
 - Examples of potential estimator surrogates are:
 - Environmental classes – This term refers to land classifications based on physical and climatic variables, which may or may not include biotic variables. Different kinds of environments most likely support different sets of species. Environmental surrogates and distributions can be obtained using remote-sensed data models (e.g. satellite imagery) –see **Example 5.4**.
 - Vegetation classes – Vegetation types interact with and represent other organisms, and can be inferred from remote-sensed data. (e.g., vascular plants were used as estimator surrogates –see **Example 5.2**).
 - Subsets of species compositions – Species subsets (e.g., mammals, birds, plants, butterflies, etc, and combinations of these) are the most widely used estimator surrogate sets. Data on their distributions can be compiled from surveys, or museums and **herbaria**.
 - Subsets of genus or other higher taxon composition – These types of estimator surrogates are defined similar to subsets of species and their data compilations.
 - Estimator surrogate distributions are usually compiled from presence-absence data. (see **M4: Data Compilation, Assessment, and Treatment**)
- Techniques for assessing estimator-surrogate performance in representing true surrogates:
 - One technique is the use of different species accumulation curves (Ferrier & Watson 1997; Margules & Sarkar 2006)
 - The estimator curve: In the estimator curve, as sites are added into a potential conservation area network (using

estimator surrogates), the cumulative representation of the true surrogates (with each true surrogate represented at least once) is graphed. (The B curve in figure 5.1.)

- The “optimum reference curve”: is the curve that would be obtained when the true surrogates are used to represent themselves (thus the term “optimum”). (The A curve in figure 5.1.)
- The “mean random reference curve”: is the curve obtained when sites are selected randomly and the resulting representation of true surrogates is graphed. (The C curve in figure 5.1.)

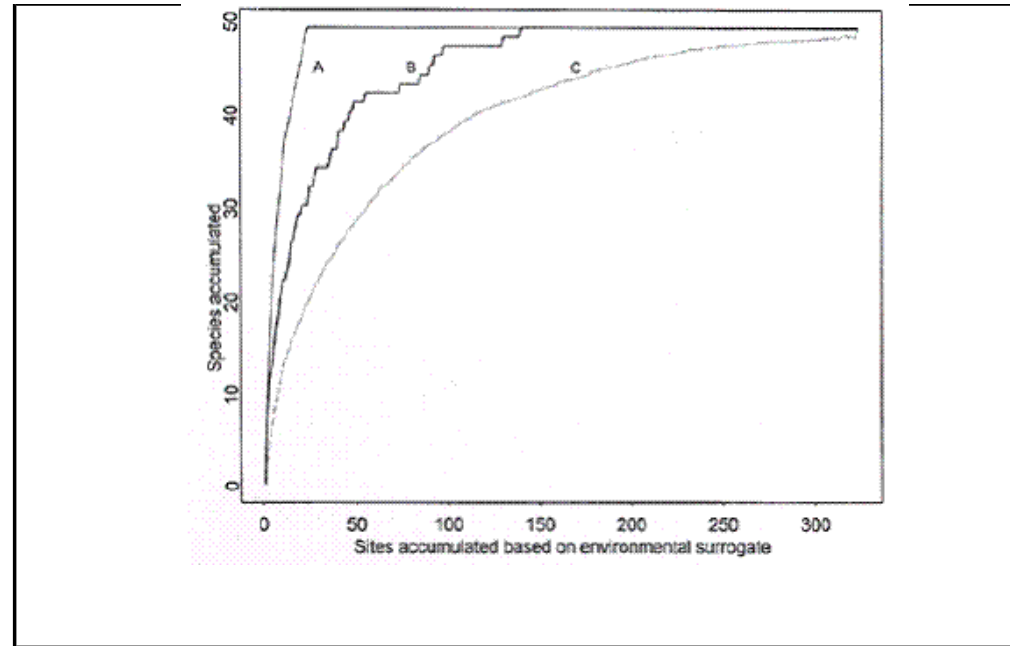
Example 5.1

Species Accumulation Curve for New South Wales

(Ferrier & Watson 1997; Margules & Sarkar 2006)

In this example species are the true surrogates and environmental features are the estimator surrogates. *A*: the “optimum reference curve” that would be obtained if the planning units were selected using the true surrogates; *B*: the estimator surrogate curve; *C*: the “mean random reference curve” which results from the random selection of planning units. The data were from New South Wales; 429 invertebrate, 280 vertebrate, and 2828 plant species were used as true surrogates. (From Ferrier and Watson (1997), 3.4.2.)

Figure 5.1

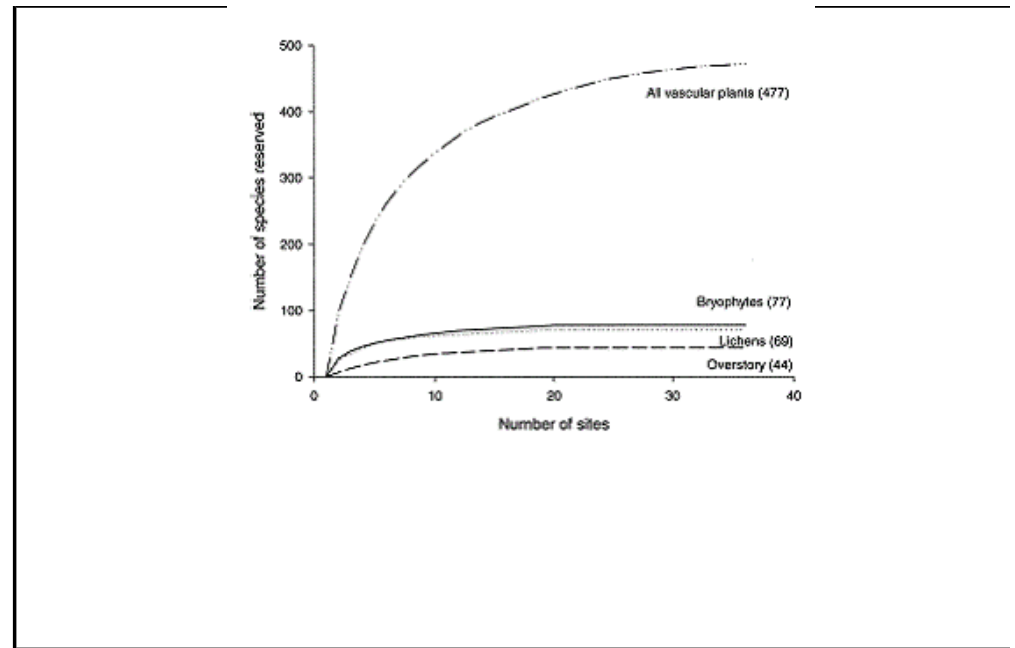


Example 5.2

Species Accumulation Curves for New South Wales Data (Pharo et al. 2000)

Uniformly covering a taxonomically related class will represent other ecologically linked taxa. In this case, the true surrogates were bryophyte and lichen species. Lichen species are often difficult to identify at the species level. As seen in the species accumulation curve, vascular plants are a sufficient estimator surrogate.

Figure 5.2



- Surrogacy graphs are also used as techniques for assessing estimator-surrogate performance in representing true surrogates– surrogacy graphs are graphs that are generalizations of species accumulation curves.
 - They are different from species accumulation curves because the targets of representation for surrogates can vary (e.g., more than one representation) – unlike species accumulation curves that have a single representation target which is part of a network of selected areas.
 - There are two types of surrogacy graphs:
 - A) A graph produced when the fraction of estimator surrogates have met their specified targets.
 - B) A graph when the fraction of the total area is selected. These “fractions” are to be defined by the conservation planners.
 - “The success of representation of true surrogates achieved in a surrogacy graph measures the

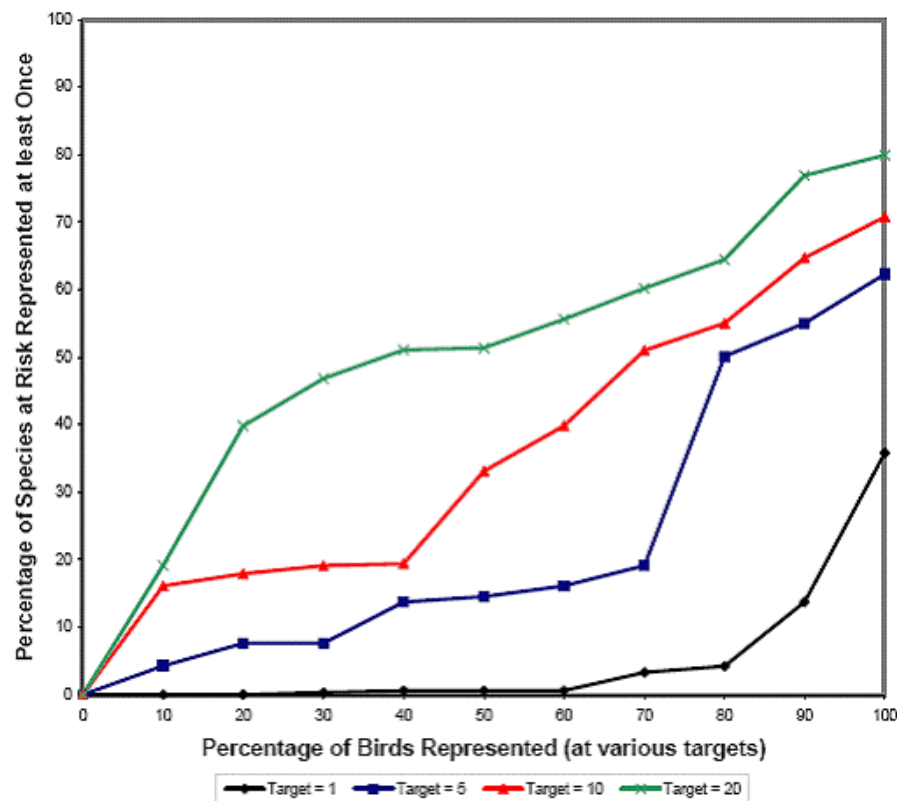
performance of an estimator surrogate set.” (Margules & Sarkar 2006)

Example 5.3

Surrogacy Graphs for Southern Québec
(Garson et al. 2002a; Margules & Sarkar 2006)

The estimator surrogates were 242 breeding bird species. The true surrogates were 402 animal and plant species at risk. For the true surrogates, the target was always 1 representation. In Figure 5.3, the different graph lines correspond to the different targets used for the estimator surrogates. (Redrawn from Garson et al. 2002a)

Figure 5.3



Example 5.4

Performance of environmental surrogates in Québec and Queensland
(Sarkar et al. 2005; Margules & Sarkar 2006)

Sarkar et al. (2005) evaluated the performance of environmental surrogates by analyzing data from Québec and Wet Tropics ecoregion of Queensland. They used seven spatial scales ranging from 0.01° to 0.1° of longitude and latitude. The true surrogates were classified as 719 plant and animal species (mostly species at risk) for Quebec and 2348 plant species for Queensland. The environmental estimator surrogates were classified in four sets, consisting of soil type, slope, elevation, aspect, and four climatic types for each set. Surrogacy graphs were constructed using the software Surrogacy. The use of environmental surrogates gives statistically significant improved results over random selection of conservation areas at larger spatial scales (particularly, at and above 0.02° scale).

Figure 5.4a

Québec (small spatial scale/high resolution): The use of environmental estimator surrogates achieved above 90% representation of true surrogates. However, the random representation did equally well at this small spatial scale.

Surrogacy Graphs for Québec at the $0.01^\circ \times 0.01^\circ$ longitude \times latitude scale, using the percentage of the estimator surrogates selected up to the 10 % target as the independent variable.

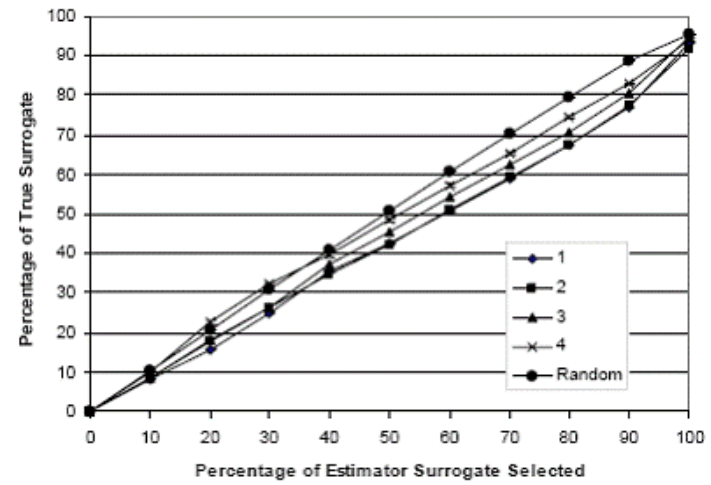
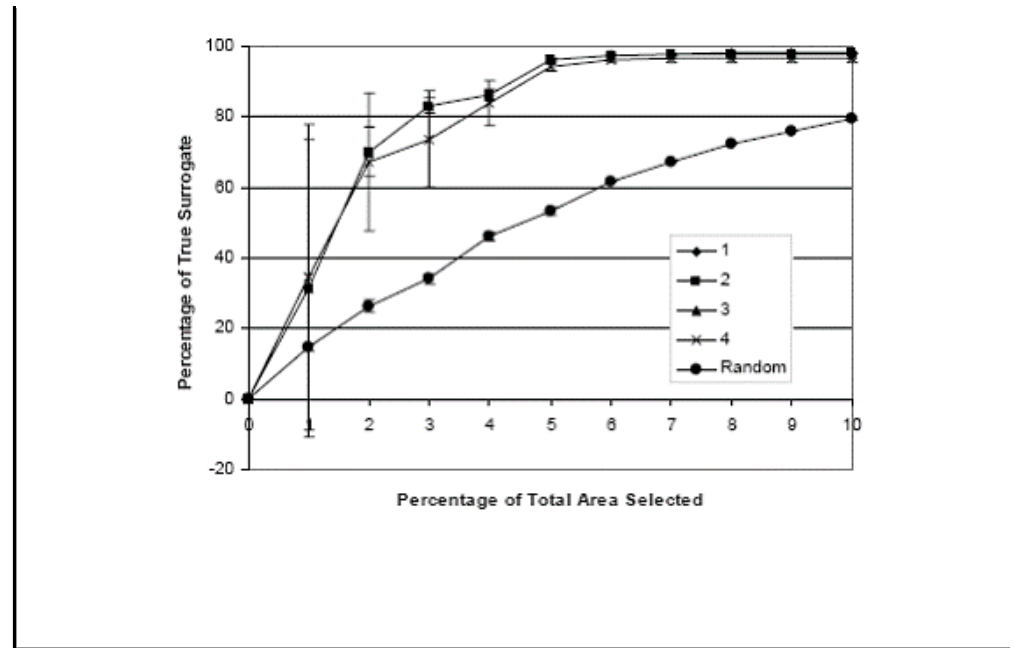


Figure 5.4b

Queensland (larger spatial scale): The use of environmental estimator surrogates outperformed the cells selected at random. The use of environmental surrogates is significant over random selection of conservation areas at larger spatial scales.

Surrogacy Graphs for Queensland at the 0.1° × 0.1° scale, using the area selected as the independent variable.



- Estimator surrogate performance in representing true surrogates can also be assessed using spatial congruence measures. In estimating the performance of estimator surrogates, the distance or spatial congruence between the cells selected (for the planning area) based on true surrogates and cells based on estimator surrogates is measured.
 - Distance functions are measured by the Hamming distance and the Jacquard index: These are measures of distance based on strings of 0s representing non-inclusion and 1s representing inclusion in the set of selected sites.
- Surrogacy graphs are the only method required for assessing the performance of estimator surrogates.
 - Ultimately all that matters is whether use of estimator surrogates results in satisfying representation targets for true surrogates.
 - Statistical or spatial correlations may be weak, BUT the representation relation may still hold in particular situations.

- Importantly, spatial congruence does not matter so long as representation targets are met.
- The Surrogate Set Identification Protocol is a concise way to identify estimator surrogate sets for conservation planning, as defined by Margules & Sarkar (2006).
 - Select a true surrogate set and a group of candidate estimator surrogate sets;
 - Divide the planning region into cells of the appropriate size and project the region into an environmental space. This is accomplished by:
 - Randomly selecting a set of locations (the calibration set) from the environmental ordination space, the larger this set, the better;
 - Survey the corresponding cells in (geographical) space for the true and all the estimator surrogate sets;
 - Construct surrogacy graphs for the sampled cells to determine the best or “optimal” estimator surrogate set;
 - Use the optimal estimator surrogate set for conservation planning for the entire region.
- Software:
 - The effectiveness of estimator surrogates can be evaluated using the Surrogacy software package, which calls the **ResNet** place prioritization package as a subroutine
- Surrogacy analysis vs. **niche modeling**
 - Niche modeling predicts the geographic range of a species from occurrence (presence-only or presence/absence) data and records.

- This presents a possible way of avoiding surrogacy analysis: all true surrogate species can potentially have their distributions modeled.
- However, since not all possible components of biodiversity can be modeled (species being only one type of biodiversity), and since there are too many species (including microbial species) that can be reasonably modeled in any situation, surrogacy analysis will remain necessary for the foreseeable future.
- The status of this argument depends on the attitude of the conservation decision-maker towards the choice of the true surrogates and whether this choice can be revised in the future.

Assess Your Knowledge

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[M2: Systematic Conservation Planning Overview](#)
[M3: Stakeholder Identification and Involvement](#)
[M4: Data Compilation, Assessment, and Treatment](#)
[M5: Surrogacy Identification and Analysis](#)
[M6: Conservation Targets and Goals](#)
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[M11: Multiple Criteria Analysis](#)
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