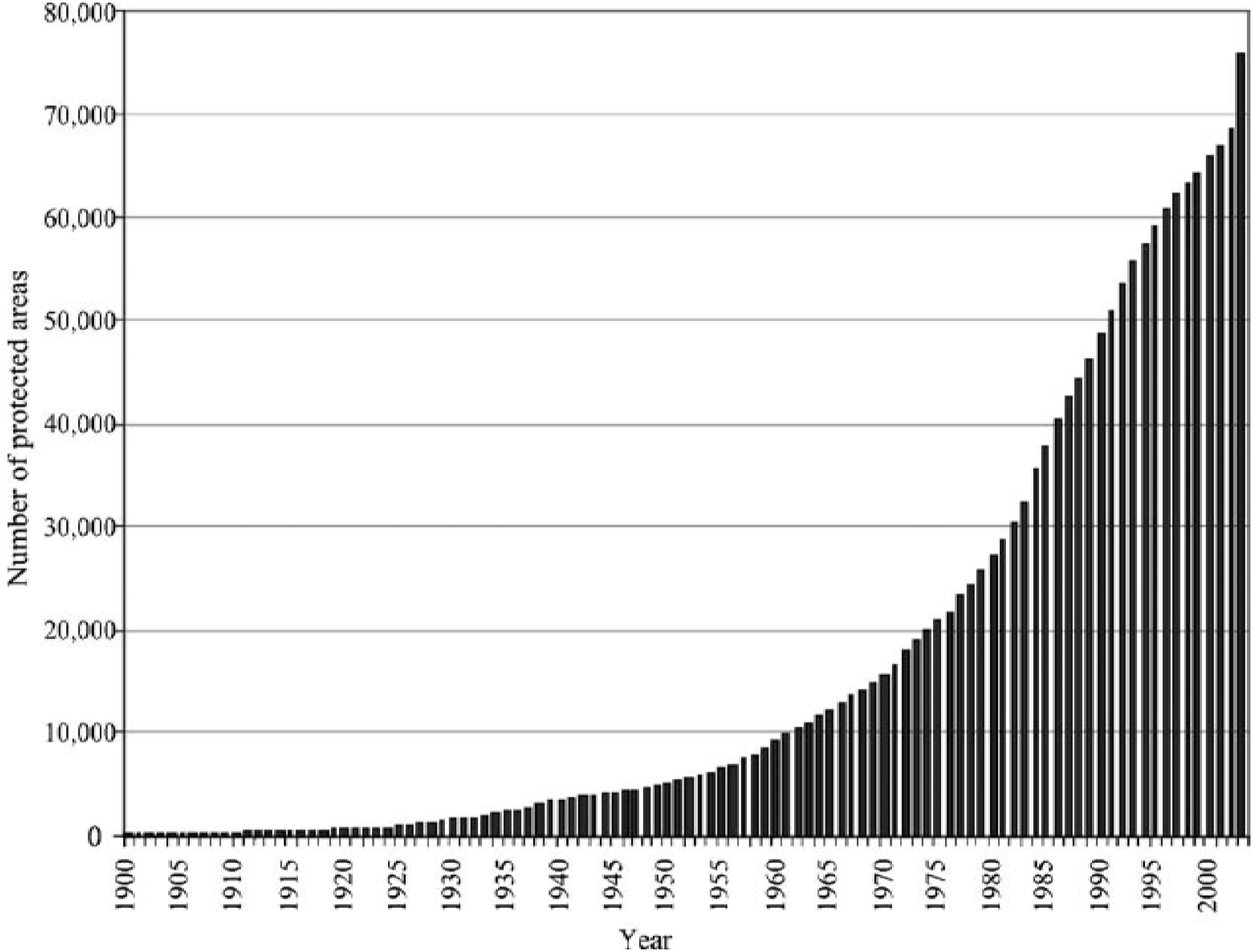
Systematic Conservation Planning

C. R. Margules & R. L. Pressey

NATURE 405 2000



Over the past 25 years, the area of land under legal protection has increased exponentially.
As of today,>100,000 protected areas have been established encompassing 17.1 million km2, or 11.5% of the planet's terrestrial surface.

Due to: 1982 World Parks Congress, Rio Summit—or 1992 United Nations (UN) Conference on Environment and Development; increased funding.

State of Protected Areas

The basic role of protected areas is to separate elements of biodiversity from processes that threaten their existence in the wild (Margules and Pressey 2000)

State of Protected Areas

Many protected areas are undergoing loss of function:

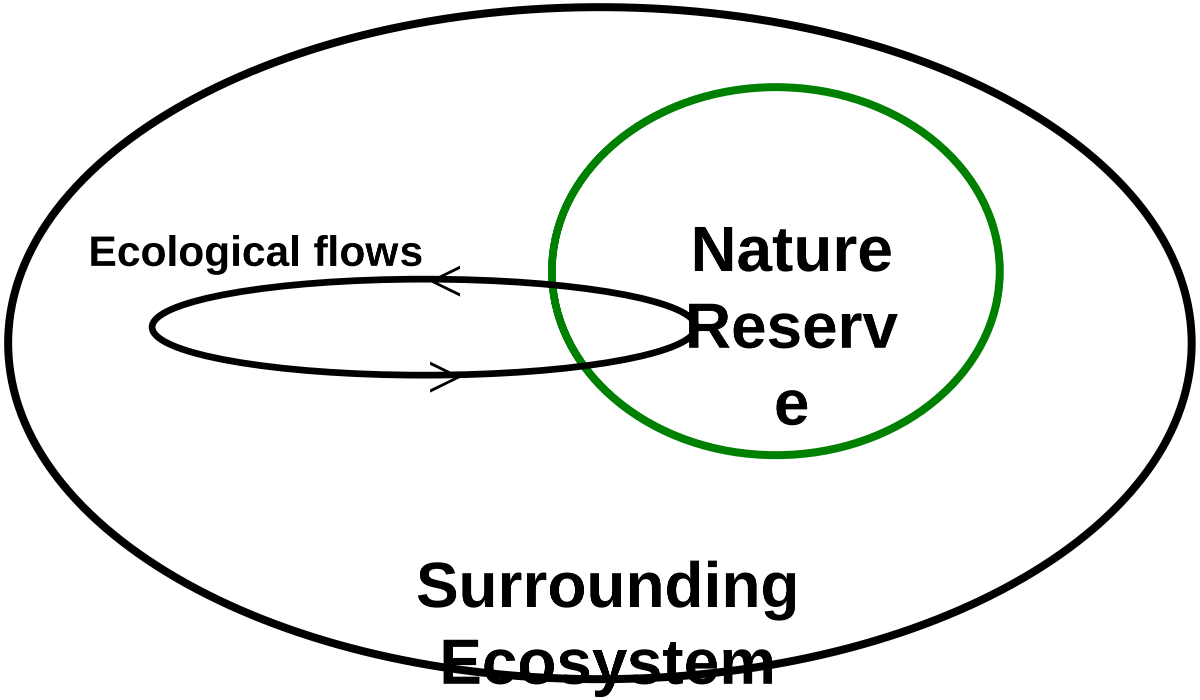
- Increased pollution
- Altered natural disturbance
- Weeds and diseases
- Extinction of native species

Boundary of Ngorongoro Conservation Area

Nairobi National Park Boundary

Partially due to the expanding human activity on the lands surrounding protected areas

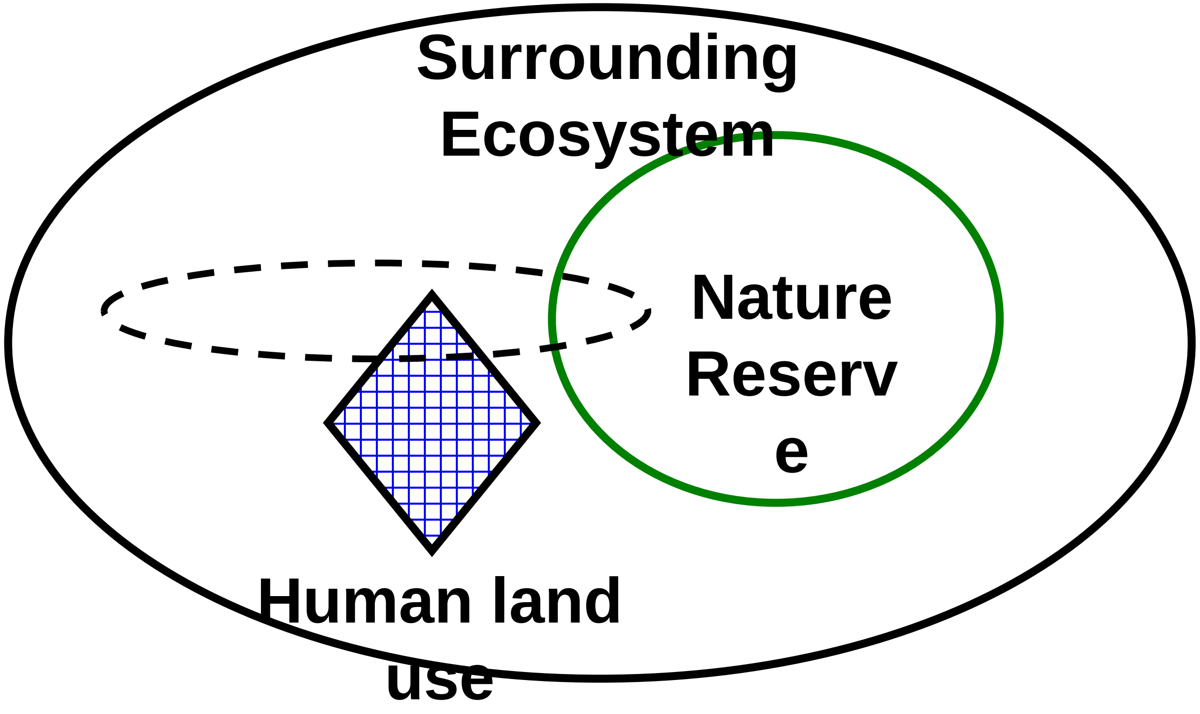
Protected Areas as Parts of Larger Ecosystems



Ecological processes such as nutrient flows, organism movements, disturbance regimes, and population dynamics may operate over areas larger than the park.

Hansen and DeFries (2007)

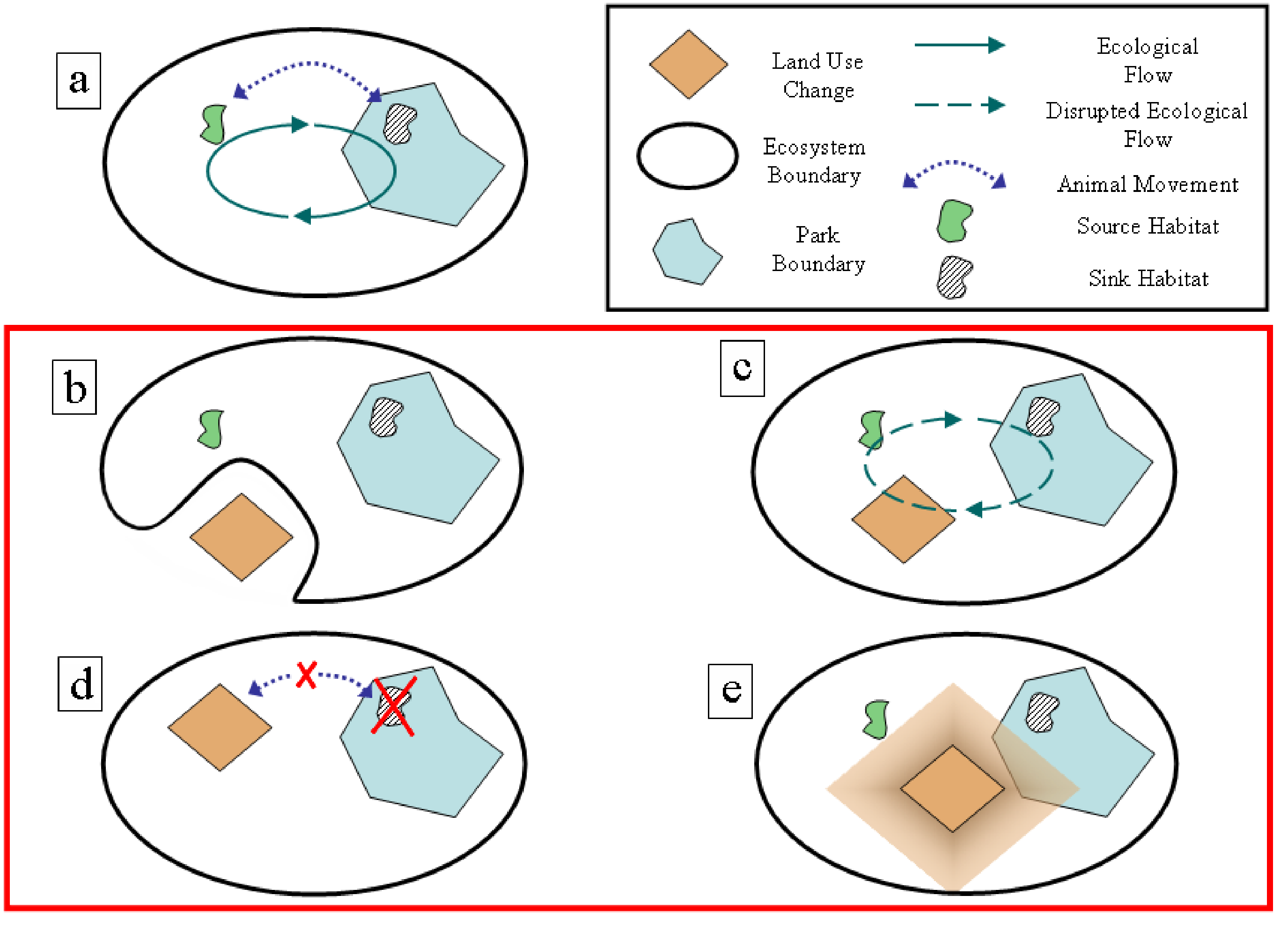
Protected Areas as Parts of Larger Ecosystems



Land use intensification outside of nature reserves may disrupt these flows and alter ecological processes and biodiversity within reserves.

Hansen and DeFries (2007)

Land use effects on Protected Areas



Overall Approach

1. Compile data on the biodiversity of the planning region

2. Identify conservation goals for the planning region

3. Review existing conservation areas

4. Select additional conservation areas

5. Implement conservation actions

6. Maintain the required values of conservation areas

Step 1.

1. Compile data on the biodiversity of the planning region

· Review existing data and decide on which data sets are sufficiently consistent to serve as surrogates for biodiversity across the planning region.

· If time allows, collect new data to augment or replace some existing data sets.

· Collect information on the localities of species considered to be rare and/or threatened in the region (these are likely to be missed or under-represented in conservation areas selected only on the basis of land classes such as vegetation types).

How best to represent biodiversity?

Questions

“I’m surprised that the authors did not include the idea of umbrella-species based conservation in discussing biodiversity and taxonomic surrogacy. I’ve always understood the concept as being fairly effective, and I’m curious as to why the authors would omit this while discussing biodiversity sampling. “

“The paper portrays biodiversity and surrogates thereof as the response that we should be measuring and monitoring. Can we assume that a biodiversity metric is the best way to approach reserve development?”

Step 2.

2. Identify conservation goals for the planning region

· Set quantitative conservation targets for species, vegetation types or other features (for example, at least three occurrences of each species, 1,500 ha of each vegetation type, or specific targets tailored to the conservation needs of individual features). Despite inevitable subjectivity in their formulation, the value of such goals is their explicitness.

· Set quantitative targets for minimum size, connectivity or other design criteria.

· Identify qualitative targets or preferences (for example, as far as possible, new conservation areas should have minimal previous disturbance from grazing or logging).

Step 2. Goals

Representativeness, a long-established goal referring to the need for reserves to represent, or sample, he full variety of biodiversity, ideally at all levels of organization.

Persistence. Reserves, once established, should promote the long-term survival of the species and other elements of biodiversity they contain by maintaining natural processes and viable populations and by excluding threats.

Questions

“The paper emphasizes defining explicit management objectives. A key benefit of this is that monitoring can define relative success of a program through time. Are there negative aspects of requiring explicit objectives for some environments?”

What is the applicability of the seven lines of theory to setting conservation goals?

“Thinking of the authors’ point on how conservation relates to island biogeography, I wonder how often this approach is actually employed. In regards to this point, as well as many of our discussions in class regarding development around Yellowstone, how can we ensure connectivity to habitats outside of a reserve?”

Step 3.

3. Review existing conservation areas

· Measure the extent to which quantitative targets for representation and design have been achieved by existing conservation areas.

· Identify the imminence of threat to under-represented features such as species or vegetation types, and the threats posed to areas that will be important in securing satisfactory design targets.

Step 4.

4. Select additional conservation areas

· Regard established conservation areas as ‘constraints’ or focal points for the design of an expanded system.

· Identify preliminary sets of new conservation areas for consideration as additions to established areas. Options for doing this include reserve selection algorithms or decision-support software to allow stakeholders to design expanded systems that achieve regional conservation goals subject to constraints such as existing reserves, acquisition budgets, or limits on feasible opportunity costs for other land uses.

Criteria for Reserve Selection

Complementarity

- A measure of the extent to which an area, or set of areas, contributes unrepresented features to an existing area or set of areas.
- Can be thought of as the number of unrepresented species (or other biodiversity features) that a new area adds.

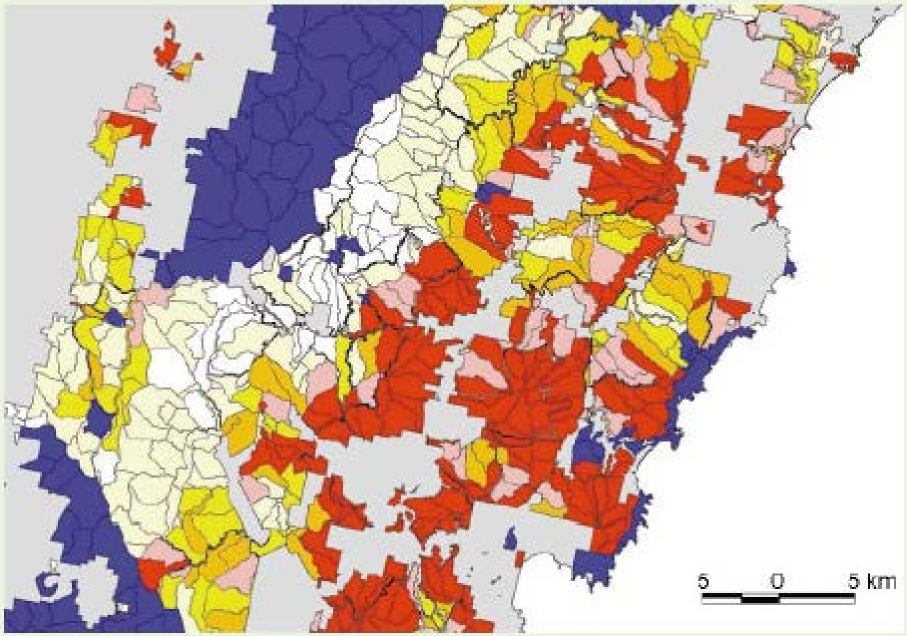


Figure 5 Pattern of complementarity on part of the south coast of New South Wales.

Criteria for Reserve Selection

Irreplaceability

Indication for each of the areas in a region the options for replacing it while still achieving conservation targets. Some areas have no replacements, whereas others have many.

Vulnerability

The risk of the area being transformed by extractive uses.

Others

Costs, commitments, masks, preferences

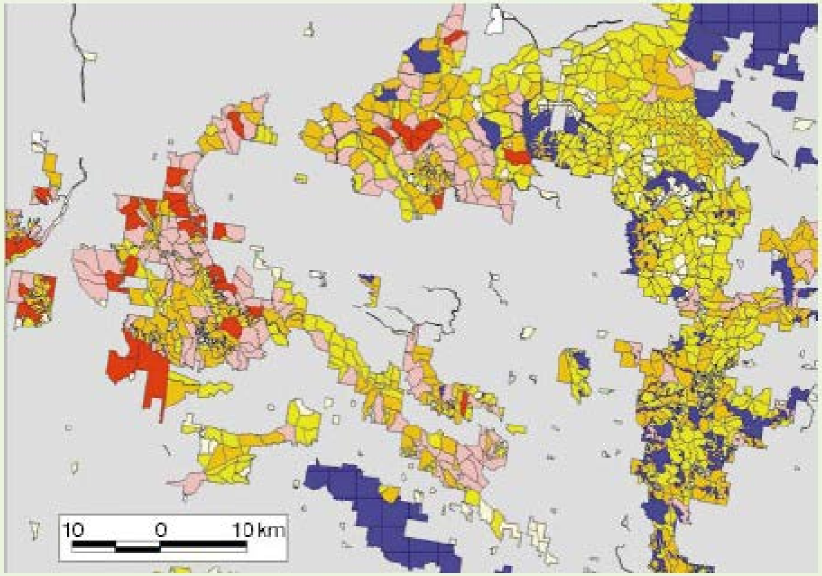


Figure 6 Pattern of irreplaceability in part of the northeast forests of New South Wales.

Questions

“There is and will be a competition between ecological protection and economics in reserve planning. How should the ecological community address these issues and how should policy balance these issues?”

“The authors acknowledge that one of the tradeoffs for the protection of biodiversity is that the area should not be available for commercial use. Do you agree with this preservationist view or do you think it is possible to find a balance between preserving biodiversity and anthropogenic needs?”

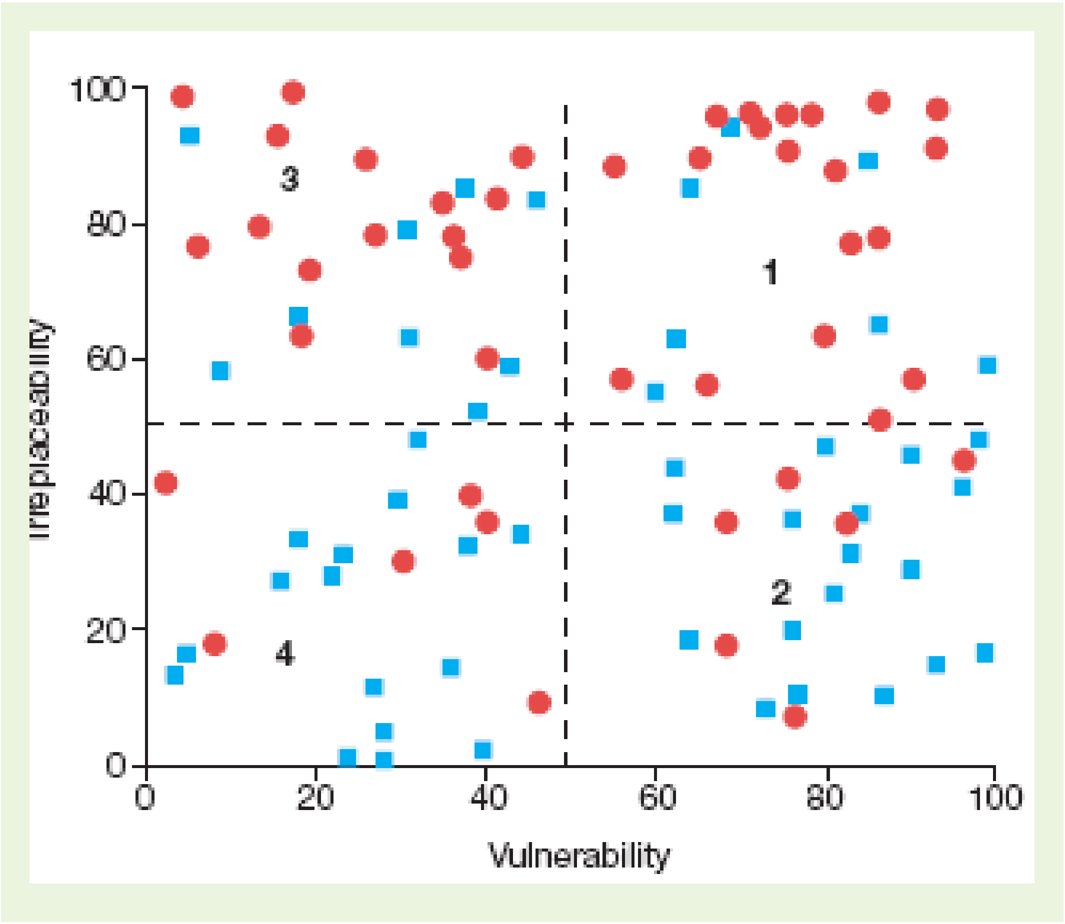
Step 5.

5. Implement conservation actions

· Decide on the most appropriate or feasible form of management to be applied to individual areas (some management approaches will be fallbacks from the preferred option).

· If one or more selected areas prove to be unexpectedly degraded or difficult to protect, return to stage 4 and look for alternatives.

· Decide on the relative timing of conservation management when resources are insufficient to implement the whole system in the short term (usually).



Irreplaceability
100
80
60
40
20
0
0
20
40
60
80
100
Vulnerability
1
2
3
4

Questions

“One strategy for scheduling conservation action is selecting areas that are high in both irreplacebility and vulnerability. Do you agree with this strategy? Do you think it would be effective in protecting conservation areas?”

Step 6.

6. Maintain the required values of conservation areas

· Set conservation goals at the level of individual conservation areas (for example, maintain seral habitats for one or more species for which the area is important). Ideally, these goals will acknowledge the particular values of the area in the context of the whole system.

· Implement management actions and zonings in and around each area to achieve the goals. Set management actions by recycling through stages 1-5 for each management unit. “Adaptive management”

· Monitor key indicators that will reflect the success of management actions or zonings in achieving goals. Modify management as required.

Questions

“The paper emphasizes defining explicit management objectives. A key benefit of this is that monitoring can define relative success of a program through time. Are there negative aspects of requiring explicit objectives for some environments?”

“Do you think the plan laid out by the authors for conservation planning is realistic for managers to use? Why or why not?”
And
“Once a reserve is established, it must be protected; I contend that this is not possible. What do you think?”

“What are the major difficulties in maintaining the conservation in a protected area?”

“Which organisms or people, decide to introduce and finance a systematic conservation planning?”

Relevance Today

Evolution of Protected Areas Targets

Year	Event	Outcome/target
1968	Biosphere Conference	Creation of MAB programme
1971	Ramsar Convention	Parties to designate and conserve wetlands
1972	World Heritage Convention	Conserve natural heritage
1982	3rd World Parks Congress	Objective to protect 10% of terrestrial ecosystems
1987	Brundtland Commission	"triple" protected areas (~12%)
1992	4th World Parks Congress	> 10% of each major biome (by 2000)
1992	Convention on Biological Diversity (CBD)	National systems of protected areas
2002	CBD COP-6	10% of world's ecological regions protected
2004	CBD COP-7	10% +effective, comprehensive, representative, etc. by 2010/2012
2010	CBD COP-10	Strategic Plan/Aichi Target 11: 17% terrestrial/10% marine by 2020

Relevance Today

CBD Parties (193) Committed to Aichi Target 11

- Global Target to protect 17% terrestrial, 10% [territorial] marine
  - areas of particular importance for biodiversity & ecosystem services
  - effectively and equitably managed
  - ecologically representative
  - Well-connected
  - other effective area-based conservation measures
  - and integrated into the wider landscapes and seascapes

CBD Decision x/2

A Multicriteria Assessment of the Irreplaceability and Vulnerability of Sites in the Greater Yellowstone Ecosystem

Noss, R.F., C.Carroll, K. Vance-Borland, G. Wuerthner.
Conservation Biology 16:895-908.

Data/Mapping

- **Elemental occurrences (records of species by location)**
- **Biophysical units**
- **Focal species**

Noss et al. 2002.

General Goals:

- **Representing all kinds of ecosystems, across their natural range of variation, in protected areas;**
- **Maintaining viable populations of all native species in natural patterns of abundance and distribution;**
- **Sustaining ecological and evolutionary processes within their natural ranges of variability;**
- **Building a conservation network that is adaptable to environmental change.**

Noss et al. 2002.

More Specific Goals:

- **Protection of special elements—identifying, mapping, and protecting rare species occurrences (and particularly “hotspots” where occurrences are concentrated), watersheds with high biological values, imperiled natural communities, and other sites of high biodiversity value;**

- **Representation of habitats—inclusion of a full spectrum of habitat types (e.g., vegetation, abiotic habitats, aquatic habitats) in protected areas or other areas managed for natural values;**

- **Conservation of focal species—identifying and protecting key habitats of wide-ranging species and others of high ecological importance or sensitivity to disturbance by humans.**

Key Metrics

Irreplaceability - a quantitative measure of the relative contribution made by different areas to reaching conservation goals, thus helping planners choose among alternative sites.

Vulnerability - assessed on the basis of expert opinion and consensus about the threats faced by each site, taking into account available quantitative data.

Methods

Planning units – 6th order catchments

The SITES Selection Algorithm

SITES attempts to minimize portfolio “cost” while maximizing attainment of conservation goals in a compact set of sites. This set of objectives constitutes the “Objective Cost function:”

Cost = Area + Species Penalty + Boundary Length

where Cost is the objective (to be minimized), Area is the number of hectares in all planning units selected for the portfolio, Species Penalty is a cost imposed for failing to meet target goals, and Boundary Length is a cost determined by the total boundary length of the portfolio.

Special Elements

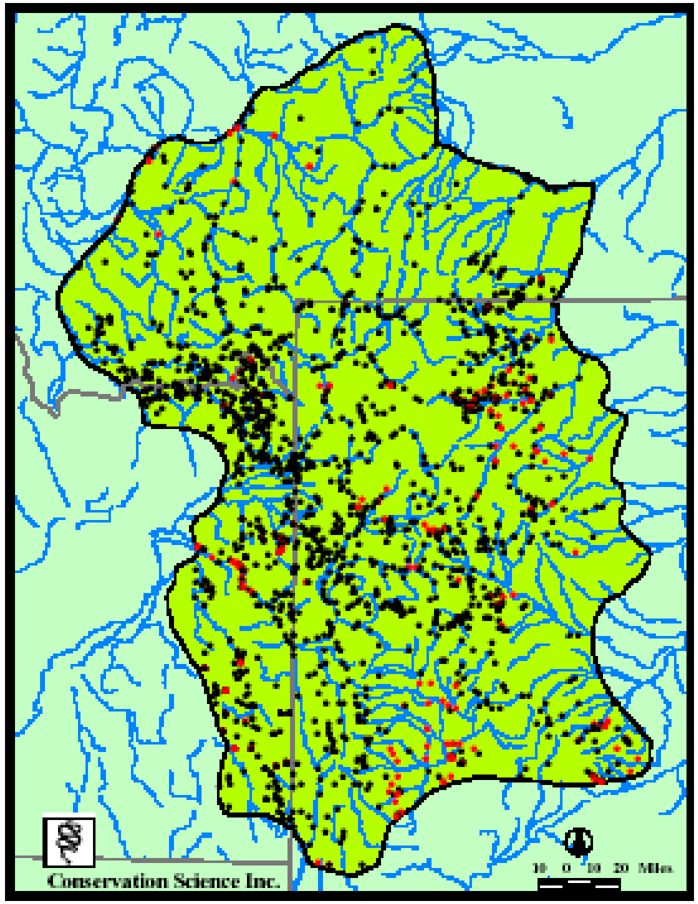


Figure E2. GYE natural heritage data. G1 and G2 in red, others black

We set goals for capturing 100% of the G1 and G2 occurrences in all groups and at least 50% of occurrences of less-threatened elements.

Representation

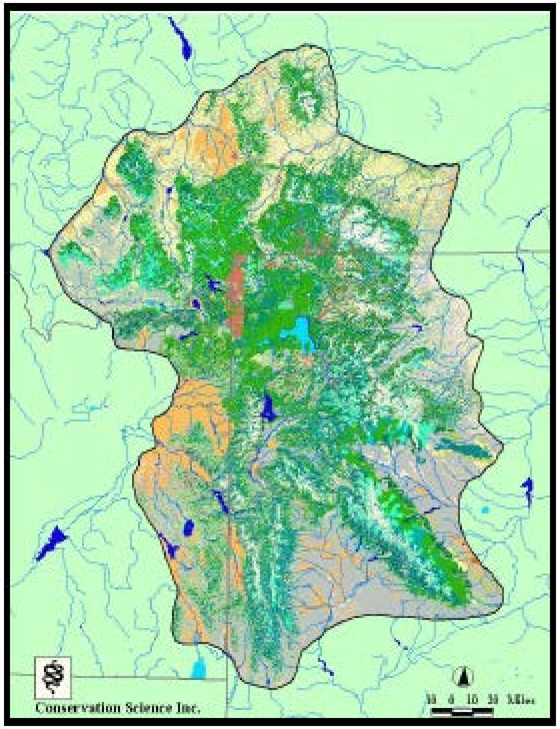


Figure E3. GYE Gap Analysis Program vegetation types.

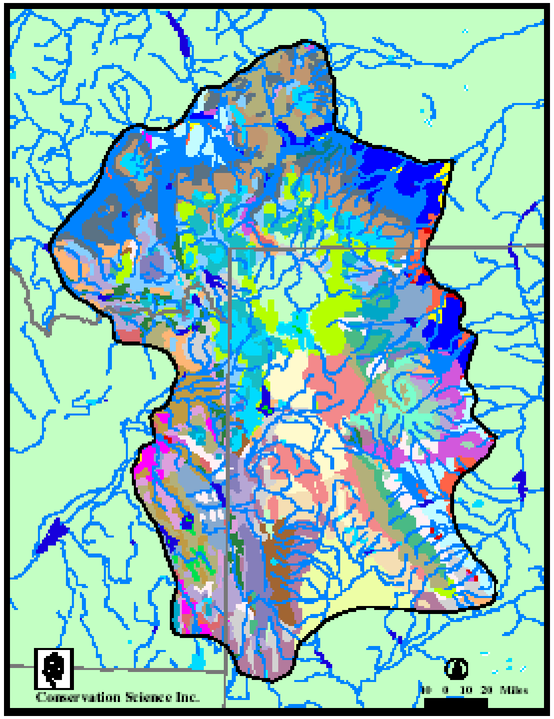


Figure E4. GYE physical habitat types

"Moreover, representing a spectrum of physical substrates and associated vegetation—ideally along intact gradients—may facilitate shifts in species distributions in response to climate change".

Focal Species

We selected four area-limited carnivores and an ungulate:

grizzly bear,
gray wolf (*Canis lupus*),
wolverine (*Gulo gulo*),
lynx (*Felis lynx*), and
elk (*Cervus elaphus*).

Focal Species

Species-distribution data included sightings records of wolverines, radiotelemetry locations of grizzly bears, and the boundaries of wolf-pack territories.

Habitat data included vegetation, satellite-imagery metrics, topography, climate, and variables related to human impacts (e.g., road density; Mladenoff et al. 1995; Merrill et al. 1999).

We used multiple logistic regression to compare habitat variables at telemetry or sighting locations with those at random points. We used the coefficients from the final model to calculate a resource selection function (RSF) for used (occurrences) and available (random) resources.

Focal Species

We performed population viability analyses with the program PATCH (Schumaker 1998).

PATCH links the survival and fecundity of individual animals to GIS variables corresponding to mortality risk and habitat productivity, measured within individual or pack territories.

The model tracks the population as individuals are born, disperse, and die and allows the landscape to change through time. Hence, the user can predict the consequences of landscape change for population viability and identify probable sources and sinks.

Our landscape change scenarios used estimates of potential change in human-associated impact factors (e.g., roads and human population) during the period 2000–2025, given increased development on either private and public lands or on private lands only.

Focal Species

Table 1. Focal species resource-selection function models for grizzly bears, wolves, and wolverines of the Greater Yellowstone Ecosystem.[a]

Variable	*Grizzly bear*	*Wolf*	*Wolverine*
July brightness	−	−	
July greenness	+	+	
July wetness		−	−
November brightness	+		
November greenness	+		
November wetness	−	−	
Annual precipitation			cx[b]
Annual snowfall		cx	
Elevation			cx
Slope	+	cx	
Elk winter range	+	+	
Road and trail density	−	−	
General public land	+	−	+
Wilderness	+	+	+
Park	+	+	+
Road density × public land	−		
Road/trail density × wilderness	−		
Road/trail density × park	−		
November brightness × wetness	+		

[a] *Selected models are those that explained the most variation in occurrences (locations). Models were highly significant ($p < 0.001$) for each species. Variables are shown as positively (+) or negatively (−) associated with occurrences. See Noss et al. (2001) for model coefficients and other details.*

[b] *cx, quadratic, convex up.*

Focal Species

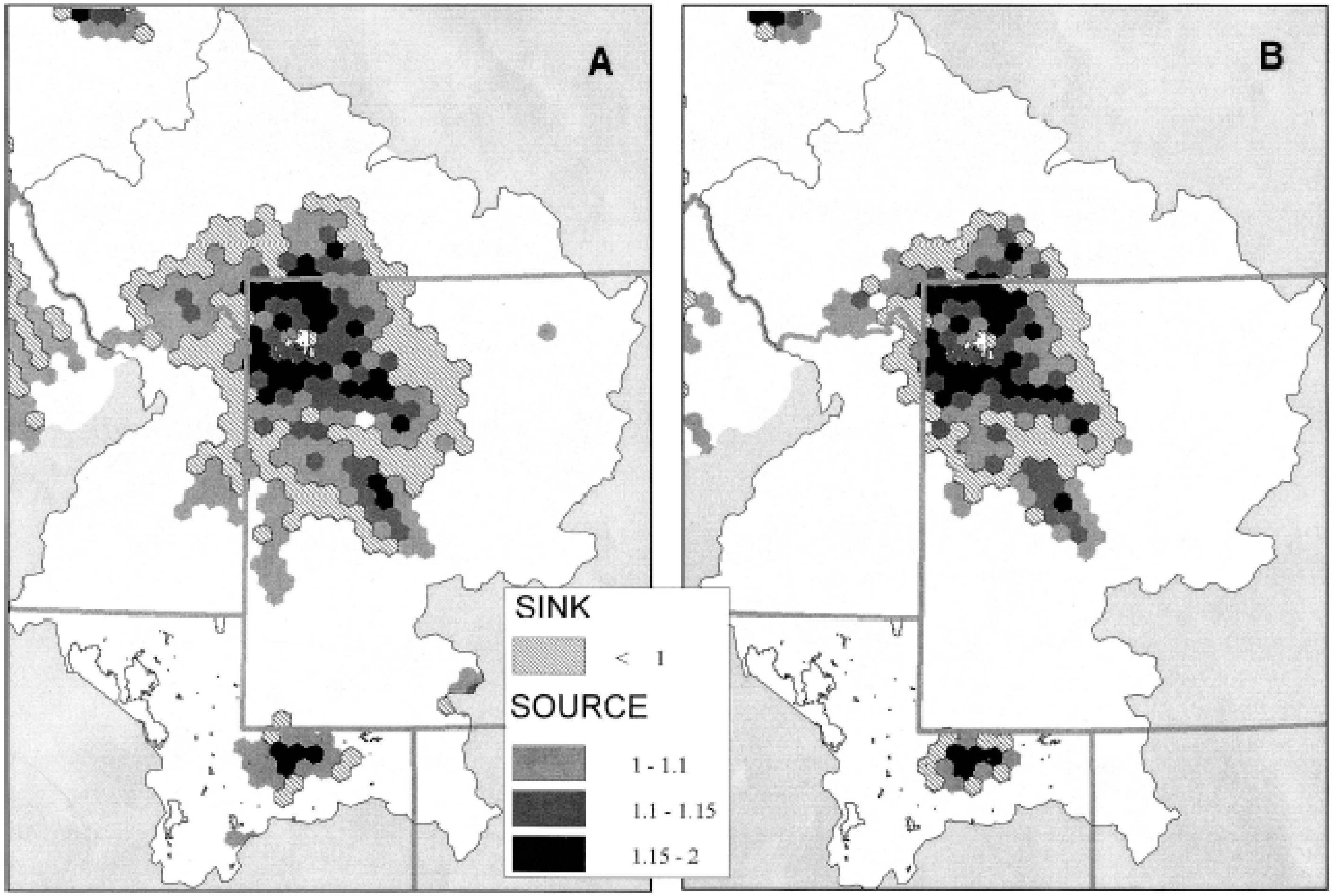
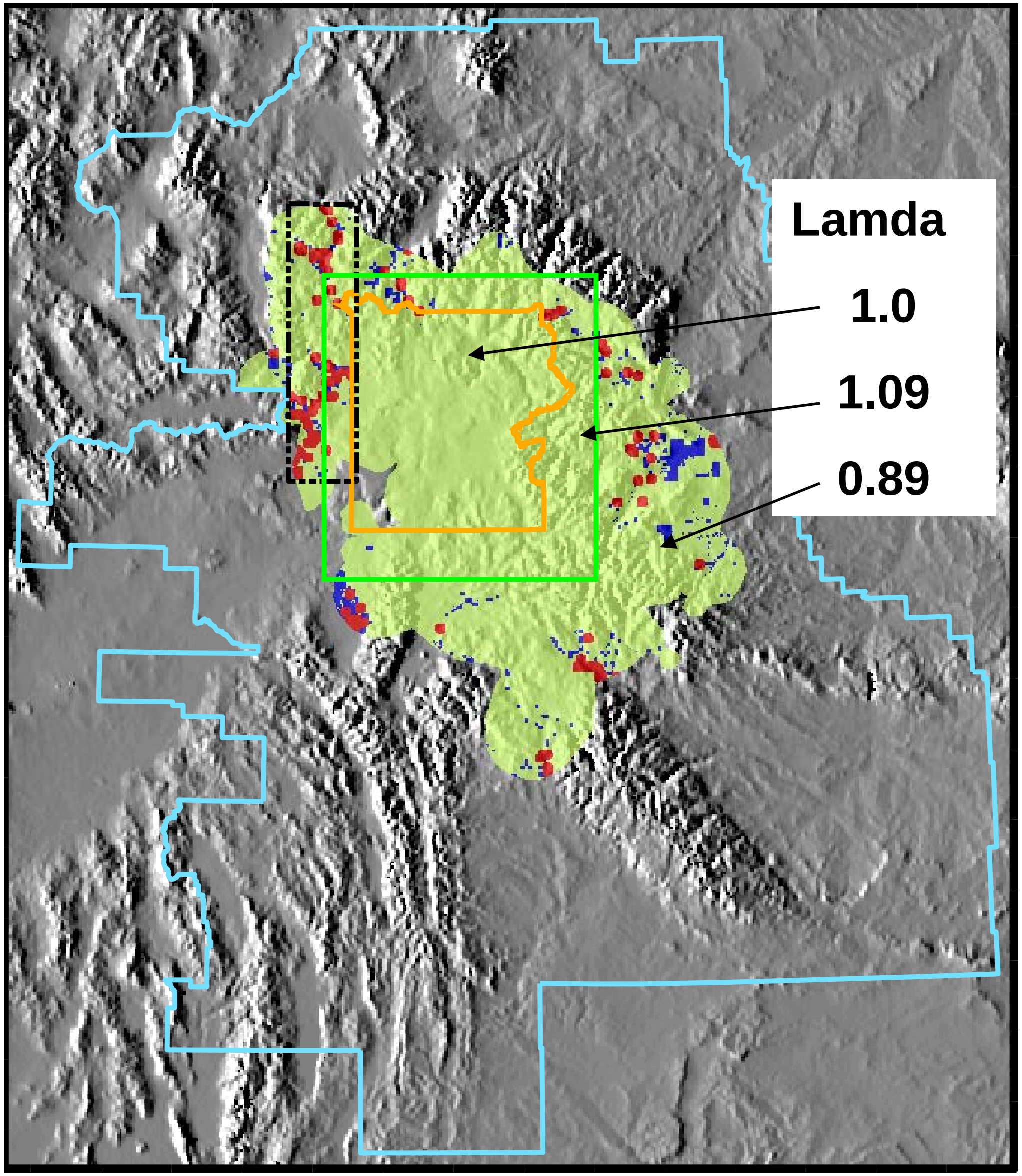


Figure 3. Distribution and demographic potential of grizzly bears in the expanded study region under (a) current and (b) future landscape conditions, assuming road development on both private and public lands. Legend shows population growth rate (lambda) values predicted by the PATCH model simulations. Hexagons represent individual territories.

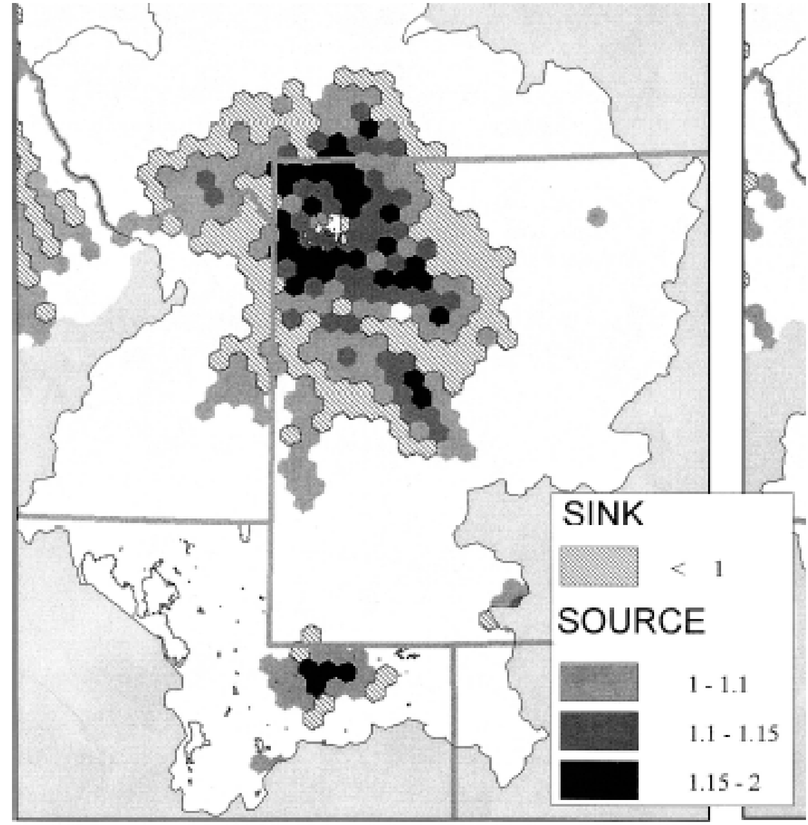
Source Sink Dynamics:



Currently Occupied Grizzly Bear Habitat

- Not Impacted by Agriculture and/or Housing
- Impacted by Agriculture and/or Low Density Housing
- Impacted by Exurban Housing

- YNP Boundary
- GYE Boundary
- Recovery Zone



Scoring

Irreplacability. We assigned irreplaceability values to megasites based on nine criteria assessed as contributions to the following goals (each considered a minimum threshold). Each megasite was scored from 0 to 10 for each of the nine criteria.

Vulnerability. Based on expert opinion and 1-100 ranking.

Ranked sites

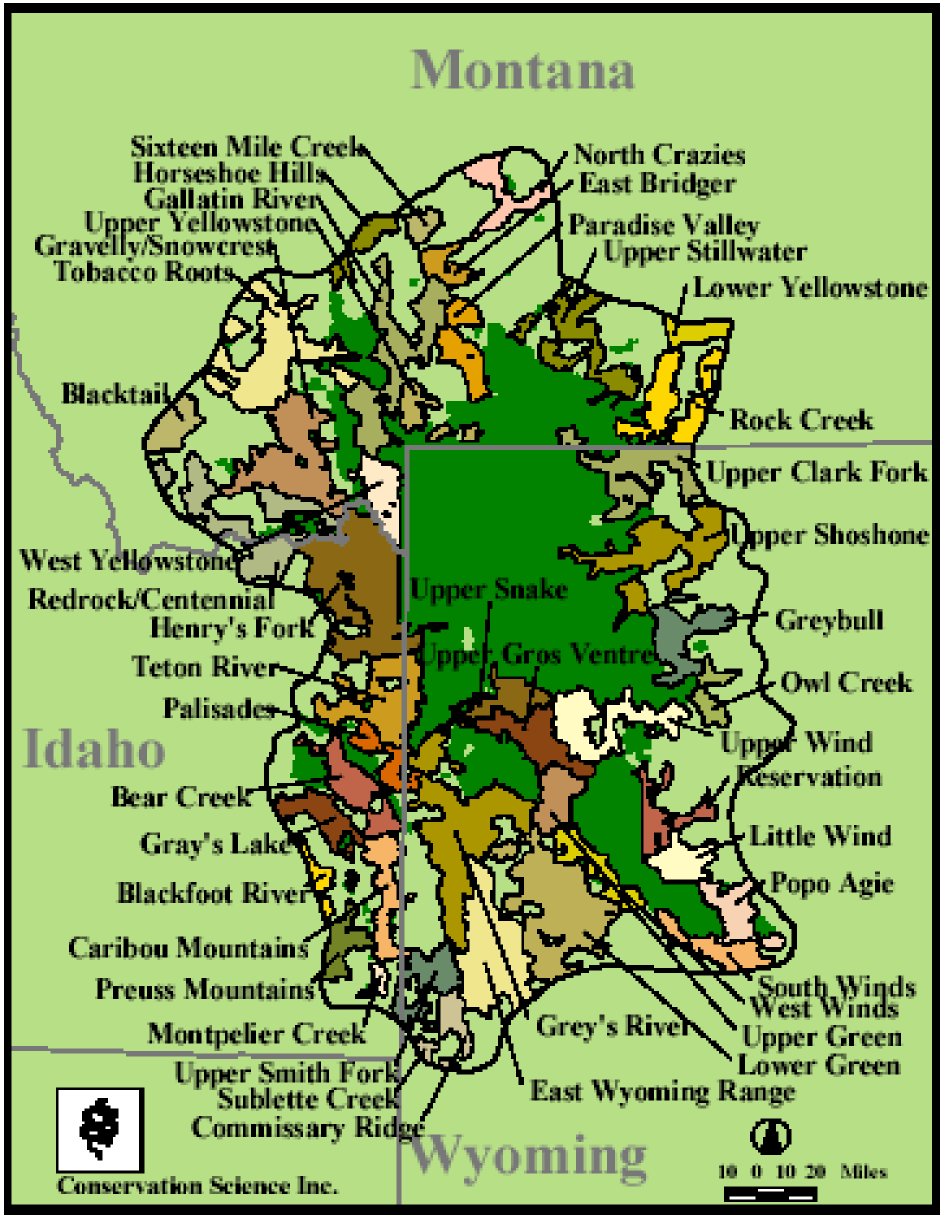


Figure E5. Proposed portfolio of conservation sites (existing protected areas dark green).

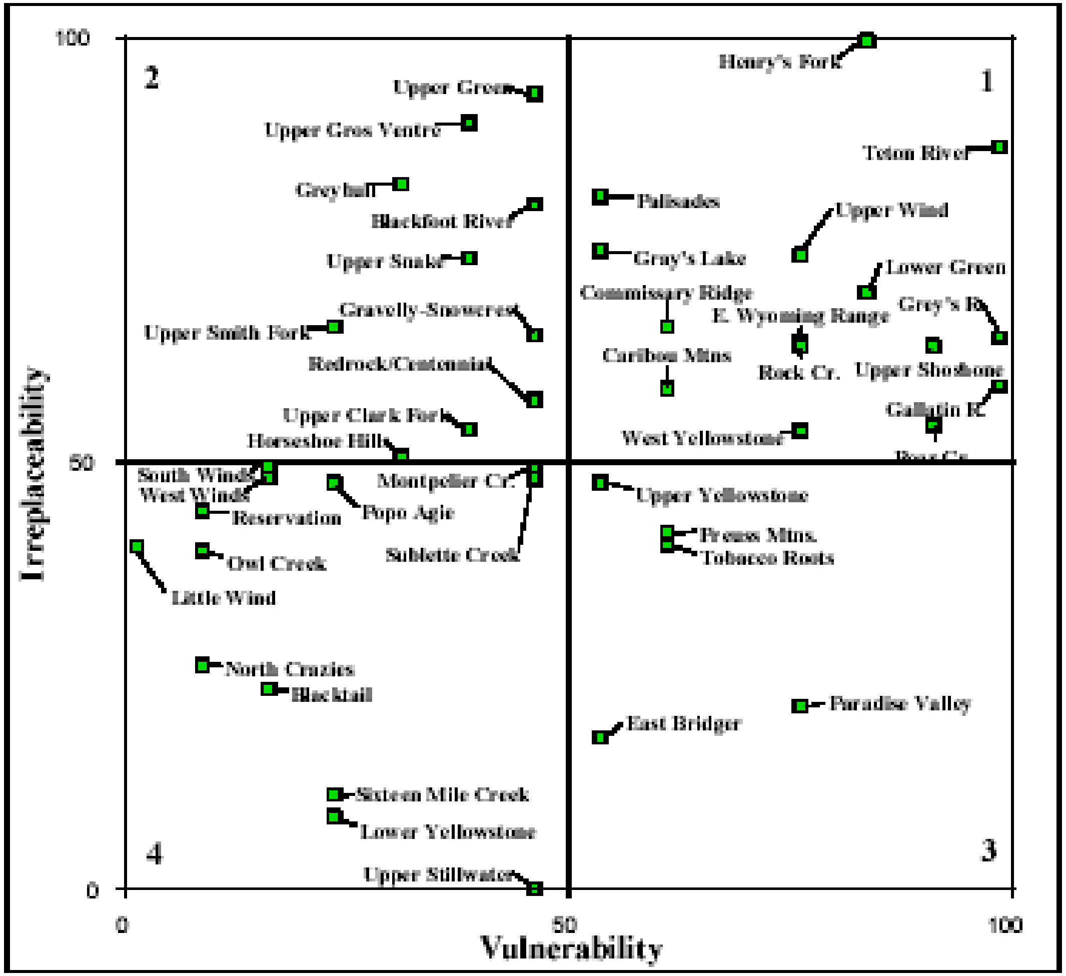


Figure E9. Megasite irreplaceability vs. vulnerability.

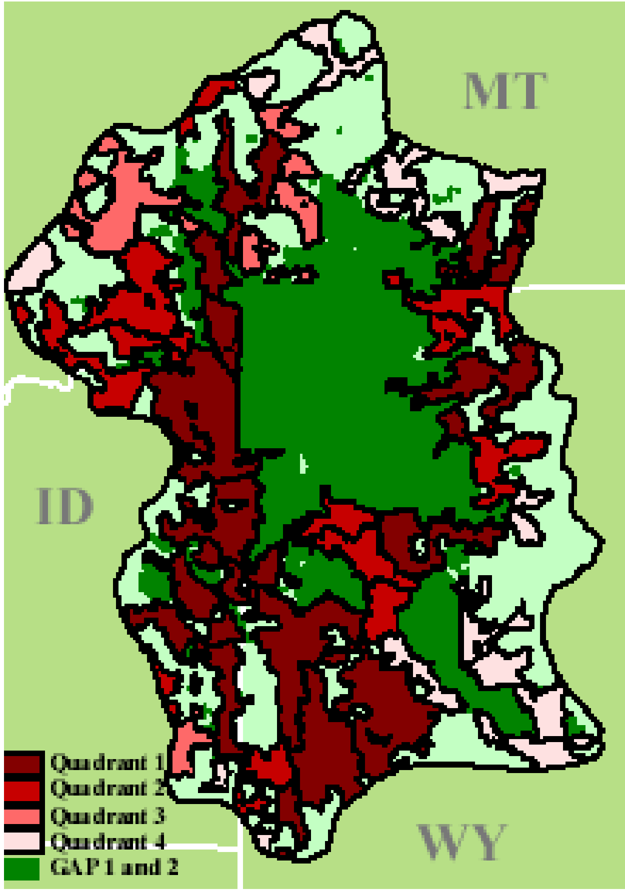


Figure E10. Megasite quadrants.

Recent Applications

Groves, Craig R., et al. "Incorporating climate change into systematic conservation planning." Biodiversity and Conservation 21.7 (2012): 1651-1671.

Hermoso, V., et al. "Addressing longitudinal connectivity in the systematic conservation planning of fresh waters." Freshwater Biology 56.1 (2011): 57-70.

Sarkar, Sahotra, and Patricia Illoldi-Rangel. "Systematic conservation planning: an updated protocol." Natureza & Conservacao 8 (2010): 19-26.

Stein, Janet Louise. "A continental landscape framework for systematic conservation planning for Australian rivers and streams." (2011).

Game, Edward T., et al. "Informed opportunism for conservation planning in the Solomon Islands." Conservation Letters 4.1 (2011): 38-46.

Langford, William T., et al. "Raising the bar for systematic conservation planning." Trends in ecology & evolution 26.12 (2011): 634-640.

Ban, Natalie C., et al. "Systematic conservation planning: a better recipe for managing the high seas for biodiversity conservation and sustainable use." Conservation Letters (2013).