Conservation, Restoration, & Policy
Dr. Greg Bruland
NREM 612
Conservation Terminology

**Conservation**: Protection, preservation, or mgmt of natural resources, wildlife, & ecosystems, w/ aim of preventing extinction

**Goal of cons.**:

**MVP**: Lower bound on the pop. of a sp. such that it can survive in the wild

OR

pop. size nec. to ensure bet. 90-95% prob. of survival bet 100-1000 years into the future

(Shaffer 1981, Lacava & Hughes 1984, Clark et al. 2002)
**50/500 Rule:** If pop >50 it is safe in short term, long-term success requires >500 individuals. For captive breeding & holding operations NOT natural pops (Soule 1980, Franklin 1980)

Relationship bet. initial pop. size (N) of bighorn sheep & the % of populations that persist over time (Berger 1990)

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**Median MVP = 4,169 individuals (95%CI: 3,577-5,129) (Metaanalysis, 141 sources, 212 spp, 92 redlisted, 62% mammals) (Traill et al. 2007)**

**Minimum Viable Area (MVA):**
2006 IUCN Red List Categories

(International Union for the Conservation of Nature & Natural Resources)

EW = Extinct in Wild
CR = Critically Endangered
EN = Endangered
VU = Vulnerable
NT = Not Threatened
Critical  Endangered  Vulnerable

Mammals
Birds
Reptiles
Amphibians
Fishes
Insects
Molluscs
Plants

(IUCN 2007)
Historical Background, Current Status, Future Trends for CB:

A. 5 mass extinction events in earth’s history: Ordovician (440 mya), Devonian (370 mya), Permian-Triassic (245 mya), Triassic-Jurassic (200 mya), Cretaceous (65 mya)


C. Habitat loss is leading cause of spp. extinctions & decline of eco. services (Daily et al. 1997)

D. 2 ways to reverse this trend: (Dobson et al. 1997)
E. Ancient & widespread practice to set aside reserves

F. 1916 National Parks Act

G. J. Muir (Sierra Club), T. Roosevelt (Nat for & reserves), A. Leopold (land ethic)

H. 1930s: ESA Comm. for the Study of Plant & Animal Comms. recognized that US Reserve System must:
   1. 
   2. 
   3. 
   4. 
   5. 
   6. educate public of its value (Shelford 1933, Grumbine 1993)
I. Term Conservation Biology introduced as title of conference held at UCSD in 1978 org by B. Wilcox & M. Soule

1. Goal of CB is to bridge gap bet theory of ecology/pop biology & conservation practice/policy

J. Nat/State Parks, Reserves cover:


2. **0.3-0.6%** of total sea area (Kelleher et al. 1995, IUCN 1997, Balmford 2004, UNEP 2006)
### % Coverage of Protected Areas by Region & Biome Type

<table>
<thead>
<tr>
<th>Biome Type</th>
<th>Global</th>
<th>Australasia</th>
<th>Afrotropic</th>
<th>Indo-Malay</th>
<th>Nearctic</th>
<th>Neotropic</th>
<th>Oceania</th>
<th>Palearctic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Global</td>
<td>12</td>
<td>8</td>
<td>15</td>
<td>10</td>
<td>16</td>
<td>16</td>
<td>8</td>
<td>9</td>
</tr>
<tr>
<td>Tropical and subtropical moist broadleaf forests</td>
<td>18</td>
<td>14</td>
<td>16</td>
<td>10</td>
<td>–</td>
<td>24</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Tropical and subtropical dry broadleaf forests</td>
<td>0</td>
<td>11</td>
<td>6</td>
<td>8</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Tropical and subtropical coniferous forests</td>
<td>6</td>
<td>–</td>
<td>–</td>
<td>6</td>
<td>5</td>
<td>8</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Temperate broadleaf and mixed forests</td>
<td>9</td>
<td>12</td>
<td>–</td>
<td>15</td>
<td>13</td>
<td>25</td>
<td>–</td>
<td>7</td>
</tr>
<tr>
<td>Temperate coniferous forests</td>
<td>25</td>
<td>–</td>
<td>–</td>
<td>18</td>
<td>34</td>
<td>–</td>
<td>–</td>
<td>12</td>
</tr>
<tr>
<td>Boreal forests and taiga</td>
<td>10</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>10</td>
<td>–</td>
<td>–</td>
<td>9</td>
</tr>
<tr>
<td>Tropical and subtropical grasslands, savannas, and shrublands</td>
<td>13</td>
<td>5</td>
<td>15</td>
<td>10</td>
<td>3</td>
<td>8</td>
<td>43</td>
<td>–</td>
</tr>
<tr>
<td>Temperate grasslands, savannas, and shrublands</td>
<td>5</td>
<td>2</td>
<td>–</td>
<td>–</td>
<td>7</td>
<td>3</td>
<td>–</td>
<td>4</td>
</tr>
<tr>
<td>Flooded grasslands and savannas</td>
<td>18</td>
<td>–</td>
<td>29</td>
<td>70</td>
<td>–</td>
<td>10</td>
<td>–</td>
<td>7</td>
</tr>
<tr>
<td>Montane grasslands and shrublands</td>
<td>15</td>
<td>50</td>
<td>12</td>
<td>29</td>
<td>–</td>
<td>13</td>
<td>–</td>
<td>15</td>
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<tr>
<td>Tundra</td>
<td>15</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>18</td>
<td>–</td>
<td>–</td>
<td>13</td>
</tr>
<tr>
<td>Mediterranean forests, woodlands, and scrub</td>
<td>6</td>
<td>8</td>
<td>12</td>
<td>–</td>
<td>26</td>
<td>1</td>
<td>–</td>
<td>4</td>
</tr>
<tr>
<td>Deserts and xeric shrublands</td>
<td>10</td>
<td>8</td>
<td>12</td>
<td>8</td>
<td>23</td>
<td>8</td>
<td>–</td>
<td>8</td>
</tr>
<tr>
<td>Mangroves</td>
<td>16</td>
<td>20</td>
<td>10</td>
<td>9</td>
<td>4</td>
<td>26</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>

(WDPA Consortium 2003)
How are conservation areas selected?

A. Areas w/ as many components of orig. ecosystem as possible should be chosen to provide a complete pool of colonizers for restoration (Barrow 1991)

1. In practice, representative areas seldom chosen, instead areas chosen are:
   a.
   b.
   c.
   d.
   e. held by wealthy landowner who hasn’t exploited
B. How to conserve ecosystems at landscape/watershed scale?

1. Mostly done in a haphazard, site by site manner to date

   a. Useless to establish river otter population at a site downstream from a polluting industry (gold mine)

   b. Preserving habitat requires protecting surrounding landscape in which site located
What about size & shape? Mgmt strategies?

A. Size misleading b.c. a small area w/ diverse terrain, may be better than large area w/ uniform terrain

1. Min size for trop forest reserve = 2,500 km$^2$ (Barrow 1991)

2. Min size to protect top carnivores in N Am NPs = 20,000 km$^2$ (Newmark 1987)

B. Arrangement of conservation areas (Diamond 1975, Barret 1980, Barrow 1991)
Is a single large reserve better than several small reserves?

a.

b.
**Cores & Buffers**

1. **Core**: Actual reserve area, access limited, may have hiking trails, NO vehicle access, sewer systems, or piped water

2. **Inner buffer**: Surrounds core, role is to prevent edge effects, may have more sophisticated campgrounds that handle vehicles

3. **Outer buffer**: Less emphasis on wildlife/habitat protection, serves as barrier to worst forms of degr. Forestry, agroforestry, public gardens, low density res dvpmnt with large lot sizes suitable.
Nodes & Corridors

1. **Nodes**: Areas of high biodiversity/pristine habitat

   a. Nodes identified, linked by corridors of wildland that allow for movement bet. nodes

   b. The longer the corridor the wider it must be

      i. Bobcats need corridors >2.5 km wide

      ii. Wolves in Alaska need corridors >12-22 km wide (Bush 2003)
Aerial bridges over roads for howler monkeys in Belize (Primack 2010)
Local farmers may try to poach in the park.

Many potential points of entry from the river. Impossible to protect against poaching.

(Bush 2003)
<table>
<thead>
<tr>
<th>Worse</th>
<th>Better</th>
</tr>
</thead>
<tbody>
<tr>
<td>(A) Ecosystem partially protected</td>
<td>Ecosystem completely protected</td>
</tr>
<tr>
<td>(B) Smaller reserve</td>
<td>Larger reserve</td>
</tr>
<tr>
<td>(C) Fragmented reserve</td>
<td>Unfragmented reserve</td>
</tr>
<tr>
<td>(D) Fewer reserves</td>
<td>More reserves</td>
</tr>
<tr>
<td>(E) Isolated reserves</td>
<td>Corridors maintained</td>
</tr>
<tr>
<td>(F) Isolated reserves</td>
<td>“Stepping-stones” facilitate movement</td>
</tr>
<tr>
<td>(G) Uniform habitat protected</td>
<td>Diverse habitats (e.g., mountains, lakes, forests) protected</td>
</tr>
<tr>
<td>(H) Irregular shape</td>
<td>Reserve shape closer to round (fewer edge effects)</td>
</tr>
<tr>
<td>(I) Only large reserves</td>
<td>Mix of large and small reserves</td>
</tr>
<tr>
<td>(J) Reserves managed individually</td>
<td>Reserves managed regionally</td>
</tr>
<tr>
<td>(K) Humans excluded</td>
<td>Human integration, buffer zones</td>
</tr>
</tbody>
</table>

(Shafer 1997, Primack 2010)
Systematic Conservation Planning  
(Margules & Pressey 2000)

1. Compile data on biodiversity of planning region

2. Identify conservation goals/objs
   a. 

3. Review existing cons. areas

4. Select additional cons. areas

5. Implement cons. actions

6. Maintain required values of cons. areas
Vulnerability Irreplaceability Matrix

**Vul**: risk of area being transformed by extractive uses (ag, timber pot.)

**Irr**: extent to which loss will compromise regional cons. targets

100 potential conservation areas: Red = selected to achieve targets but not yet reserves, Blue = possible replacements

(Margules & Pressey 2000)
Reserve Networks:

• Network of reserves buffers against environmental variability & provides greater protection than a single reserve.

• Effective networks need to span large geographic distances & encompass a substantial area to protect against catastrophes & provide stable platform for long-term persistence of ecological communities.

(Lubchenko et al. 2003)
Restoration Terminology

Ecological Restoration is an intentional activity that initiates or accelerates the recovery of an ecosystem with respect to its health, integrity, & sustainability (SER 2004)

Def: “the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed” (SER 2004)

Includes:

Ecological Restoration is the practice of the discipline of "restoration ecology"
**Reclamation**: Includes stabilization of terrain, assurance of public safety, aesthetic improvement, return of land to useful purpose

**Rehabilitation**: Reparation of ecosystem processes, productivity & services & return to a better but different than original/historic condition

**Mitigation**: Action intended to compensate environmental damage

**Ecological Engineering**: Manipulation of natural materials, living organisms, & physical-chemical environ. to achieve specific goal & solve technical problems
Historical Background, Current Status, Future Trends for RE:

A. Land managers, laypeople, stewards practicing rest. for 1000s of years (Anderson 2005)

B. Builds on fields of forest & range mgmt, wildlife biol, horticulture, landscape architecture

C. RE gains momentum in 70s, explosive growth in 00s

1. Economic growth based on exploitation ↓; growth based on restoration ↑ (Cunningham 2002)

2. Restoration = spirit & business of 21st cent

   a. Part of huge, almost hidden econ sector in which >$1 trillion yr⁻¹ poured into rest (Cunningham 2002)
“Here is the means to end the great extinction spasm. The next century will, I believe, be the era of restoration in ecology.”

E.O. Wilson (1992)
Restoration Ecology

*What are important factors to consider for successful ecosystem restoration?*

1. Reintroduction of veg/spp:
2. Harness successional processes:
3. Substrate:
4. Surrounding & watershed land-use(s):
5. Adaptive Mgmt:
6. Climate change:
7. **Stakeholders**: human dimensions, urban vs rural, developed vs developing, indigenous/native concerns, involvement
8. **Funding**: who pays? over what period? is it enough? how to judge success?
What are some General Principles of Ecosystem Restoration?

1. Design for minimum maintenance

2. Use natural energy

3. Be prepared for disturbances

4. Give the system time

5. Design system to fulfill multiple goals

6. Involve stakeholders:
Attributes of SUCCESSFUL Restored Ecosystems (SER 2004)

1. Contains characteristic assemblages of species that occur in ref. ecosystem
2. Consists of indigenous spp. to greatest practical extent
3. All functional groups needed for dvpmt/stability are present or have potential to colonize
4. Physical environ. capable of sustaining reproducing pop.
5. Restored system functions normally for its ecol. stage
6. System is integrated in larger ecol. matrix
7. Potential threats to health have been eliminated/reduced
8. System is resilient to normal periodic stress
9. System is self-sustaining to same degree as ref. ecosystem
<table>
<thead>
<tr>
<th>Trait</th>
<th>CB</th>
<th>RE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mind Set</td>
<td></td>
<td></td>
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<tr>
<td>Dom. Org Levels</td>
<td></td>
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<tr>
<td>Dom. Taxon</td>
<td></td>
<td></td>
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<tr>
<td>Dom. Conceptual Theme</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dom. Mode of Inquiry</td>
<td></td>
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</tr>
</tbody>
</table>

(Young 2000)
Commonalities & Differences of Conservation Biology & Rest. Ecol?

Both have temperate terrestrial bioregion bias

CB has strong zoological/descriptive/theoretical bias, while RE has strong botanical/experimental bias (Young 2000)

CB focus more on individuals, genetic & pop dynamics, RE focuses more at ecosystem level

EBM Concept

EBM wasn’t adopted by most scientists, managers, policy-makers until late 1980s (Grumbine 1993), major push for EBM in 2000s

EBM involves mgmt of spp., other natural resources, & humans as components of a larger ecosystem (Arkema et al. 2006)

EBM addresses interactions among different spatial & temporal scales, within & among ecological & social systems, & among stakeholder groups & communities interested in health & stewardship of ecosystems (Leslie & McLeod 2007)
4 Key Principles of EBM

1) Multiple spatial, temporal scales, & interactions must be addressed

Humans use ecosystems at diff scales, interactions @ one level influence dynamics @ other levels

Figure 18.4 The three main ecological variables of scale plotted on a three-dimensional grid, as suggested by Steele (1988).
4 Key Principles of EBM

2) Recognizes linkages among ecosystems & human communities that depend on them

Katrina highlighted role of coastal wetlands in protecting human lives & infrastructure from storm & wave damage
4 Key Principles of EBM

3) Mgmt efforts need to occur across air, land, sea not political boundaries
4 Key Principles of EBM

4) Meaningful engagement w/ stakeholders needed to create mgmt initiatives that are credible, enforceable, & realistic

(Gutrich et al. 2005)
Solutions & Policy Instruments

A. Governance

1. Failures result when central govts exert sole authority

   a. Top down models often lead to degr: Indonesia, Borneo; Wolong Nature Reserve, China; northern cod industry, East coast of Canada (Dietz et al. 2003)

2. Good governance should employ diversity of instit. types (i.e., hierarchies, markets, self-governance), utilize a variety of decision rules to change incentives, ↑ info, monitor use, induce compliance (Dietz et al. 2003)

   a. 
B. Transform from sectoral to integrated landscape conservation & mgmt

1. USA: forests (USFS), wildlife (USFWS), soil (NRCS), wetlands (ACoE), fisheries (NOAA), not holistic, turf wars, funding squabbles, vs. NZ (DOC)
C. Develop Community-Based Conservation (CBC)

**Def:** Improvement of lives of local people, while conserving areas thru creation of parks or reserves (Gerzon 1997)

**Goal:** Achieve combination/balance of conservation & development serving interests of both (Berkes 2004)

1. Builds on local knowledge, skills, institutions

2. Causes decentralization, meaningful participation (Agrawal & Gibson 1999)

3. Ineffective to date b.c. of inadequate res., uneven implementation, neocolonialist undertones
D. Embrace Traditional Ecological Knowledge (TEK)

**TEK**: Knowledge held by indigenous cultures about their immediate environments & cultural mgmt practices that build on that knowledge (Ford & Martinez 2000)

1. TEK ideas of “connectedness” & “nature as home” have implications for cons, rest, EBM

   a. In traditional way of knowing, no such thing as isolation from rest of creation

(Berkes 2000)
Growing recognition that TEK can contribute to conservation of biodiversity, rare species, protected areas, ecol processes, & sustainable resource use (Berkes et al. 2000)

**Practices found in both modern NRM & in traditional societies:**
1) Monitoring of spp abundance, ecosys change
2) Total protection of certain spp
3) Protection of vulnerable life hist stages
4) Temporal harvest restrictions

**Practices abandoned by NRM but found in some trad societies:**
1) Multiple spp mgmt to maintain ecosys structure & function
2) Resource rotation
3) Succession mgmt

**Practices seldom found in NRM but found in trad societies:**
1) Management of landscape patchiness
2) Watershed-based mgmt
3) Managing ecological processes @ mult. scales
4) Responding to & managing pulses & surprises
5) Nurturing sources of ecosystem renewal
F. Emergence of Environmental Economics

Use of innovative non-market valuation techniques:

**Contingent Valuation:** *How much are people willing to pay?*

**Travel Cost:** *How much do people pay?*

**Hedonic Pricing:** *Difference in price between areas w/ different conditions, eco services*

**Avertive Expenditures:** *How much would people pay to avoid damages?*
Balmford et al. (2002) reviewed studies that estimated values of goods & services delivered by an ecosystem when relatively intact, & when converted by human LU

**Total economic value (TEV)** considers market & non-market values

<table>
<thead>
<tr>
<th>Comparison</th>
<th>Intact TEV ($ ha⁻¹)</th>
<th>Human-dom TEV ($ ha⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Thailand</strong>: Mangrove vs Shrimp Farm</td>
<td>60,400</td>
<td>16,700</td>
</tr>
<tr>
<td><strong>Malaysia</strong>: Forest vs Clear Cut</td>
<td>13,000</td>
<td>11,200</td>
</tr>
<tr>
<td><strong>Philippines</strong>: Coral Reef vs Blast Fishing</td>
<td>3,330</td>
<td>870</td>
</tr>
<tr>
<td><strong>Canada</strong>: FW Wetland vs Agriculture</td>
<td>8,800</td>
<td>3,700</td>
</tr>
</tbody>
</table>

Conversion made sense in terms of short-term econ benefits, not after considering external costs

Overall benefit:cost ratio of an effective program for conservation of remaining wild nature is at least 100:1 (Balmford et al. 2002)
Unanswered Questions

Should focus be on CB or RE?

Will conservation work or will areas continue to be degraded?

Should focus be on conservation or slowing the processes that lead to degradation?

Do we know enough science to identify the areas to protect or is more research necessary?

What is target for RE? How far back do we need to go? What about shifting baselines? How do we know reference sites are not also degraded?
Final Thoughts

“The biodiversity crisis represents the greatest challenge that humans have ever faced. To the extent that this generation will continue to fail, it will represent our greatest failure as a species, and the one for which we are least likely to be forgive by the generation to come. To the extent that we at least partially succeed, it will represent our species greatest achievement. Conservation biology in the short-term and restoration ecology in the long-term are the complementary activities that will form the basis of our belated (but not hopeless) attempt to salvage the disaster.”

T. Young (2000)