Degradation Hotspots

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Outline

I. Definition & Selection of Biodiversity Hotspots

II. Plants, Mammals, Marine Systems

III. Hotspot Examples:
    • Aral Sea
    • Madagascar
    • Sunda Islands, Indonesia
Biodiversity Hotspots (Myers et al. 2000)

• **25 Terrestrial Biodiversity Hotspots**: Areas w/ high conc. of endemics & high loss of habitat

• Boundaries: biogeographic units, expert judgment

• **Criteria**

  #1) Area must contain at least 0.5% (or 1,500) of world’s ~300,000 plant species as endemics

  #2) After meeting #1, hotspot should have lost ≥70% of 1° veg.

  #3) Terrestrial realm

• 4 vertebrate groups (mammals, birds, reptiles, amphibians) serve as back-up support to determine congruence
25 Terrestrial Biodiversity Hotspots: Areas w/ high conc. of endemics & high loss of habitat

Biodiversity Hotspots (Myers et al. 2000)

- Contain remaining habitat of 133,149 (44%) plant species & 9,645 (35%) of vertebrates

- Occupy 2.1 million km²

- 15/25 contain >2,500 endemic plants, 10 contain >10,000

- 11/25 have lost 90% of habitat, 3 lost 95%
Hottest Hotspots (Myers et al. 2000)

Criteria:
1) endemic plants
2) endemic vertebrates
3) endemic plants/area
4) endemic vertebrates/area
5) remaining 1° vegetation as % of original extent

$\Sigma$ # of times appearing in top 10 for each criteria

Tie for 1st place:
25 Terrestrial Biodiversity Hotspots: Areas w/ high conc. of endemics & high loss of habitat

Issues w/ Myers’ Hotspots (Brookes et al. 2002)

• For oceanic islands, habitat loss underestimates extinction because invasive spp. have driven extinctions beyond those caused by habitat loss

• In large hotspots habitat loss

• Scale dependence—Hotspots of different sizes & larger areas hold more endemics;
Factor out area-relative density of endemic plants

Determine 11 hottest hotspots:
Madag., Philippines, Sundaland, Braz Atl for, Carrib, Indo-Burma, Western Ghats, Tanz-Kenya, Medit Basin, Trop Andes, MesoAmer

Other Criticisms of Myers’s Hotspot Approach

• Emphasis on plant spp.,

• Overlooks crucial ecosystems such as

• Doesn’t account for
Marine Biodiversity Hotspots (Roberts et al. 2002)

- Mapped ranges of 1,700 reef fish, 804 corals, 662 snails, 69 lobsters
- Used cell size of 50,000 km²
- Mapped richness & endemism w/i & among taxa
- Mapped threats to coral reefs based on dvpmt, overexploitation, marine & land-based pollution (Bryant et al. 1998)
- Mapped intersection of endemism & threats = reef hotspots
Fish

Corals

Snails

Lobsters

Richness (all taxa)

Threats (blue=low, red=high)
Reefs at Risk
Major Observed Threats to the World’s Coral Reefs

Source: Bryant et al., Reefs at Risk: a Map-Based Indicator of Threats to the World’s Coral Reefs, World Resources Institute (WRI), Washington DC, 1998.
Fish
Corals
Snails
Lobsters

Top 10% of cells in terms of #s of endemics (& range<10 cells)

Concordance patterns of endemism for each taxa (red included all 4, orange =3, y=2, b=1)

18 Marine biodiversity hotspots

5 most threatened: Philippines (14), Gulf of Guinea (3), Sunda Is. (17), S. Mascarene Is. (15), Eastern S. Africa (10)

Fig. 3. Threats to reefs in centers of endemism. The figure shows mean (circles), maximum, and minimum threat scores for grid cells included within each center of endemism, calculated with data from Bryant et al. (3, 13).

Mammalian Dist., Hotspots, & Conservation (Ceballos & Ehrlich 2006)

- Global examination of all nonmarine mammals (4,818) to determine patterns in richness, endemism, & endangerment
- Compare dist. in 17,800 equal-area cells

- Hotspots defined as top 2.5%, 5% of cells in each category

- Test for congruence among categories & across cells
Richness:
Endemism:
Threatened:

(Ceballos & Ehrlich *PNAS* 2006)
Fig. 2. Hotspots of species richness (A), restricted-range species (B), and threatened species (C). The 2.5% hotspots are shown in red, and the 5% hotspots are shown in yellow and red.

Richness:
Endemism:
Threatened:

No much overlap (1% common cells), Σall at 2.5% = 5% of land area

(Ceballos & Ehrlich PNAS 2006)
<table>
<thead>
<tr>
<th>2.5% Hotspots</th>
<th>Area in 10,000 km² (% total land surface)</th>
<th>Number of species (% total mammal spp)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Richness</td>
<td>443 (2.4%)</td>
<td>1,265 spp (26%)</td>
</tr>
<tr>
<td>Endemism</td>
<td>128 (1.0%)</td>
<td>1,525 spp (32%)</td>
</tr>
<tr>
<td>Threatened</td>
<td>409 (2.3%)</td>
<td>2,257 spp (47%)</td>
</tr>
<tr>
<td>Total in all hotspots</td>
<td>859 (4.7%)</td>
<td>2,833 spp (59%)</td>
</tr>
</tbody>
</table>

(Ceballos & Ehrlich *PNAS* 2006)
Global Mapping of Human Impact on Marine Ecosystems (Halpern et al. 2008)

- Synthesized 17 global datasets of anthropogenic drivers of ecol. change (benthic structures, comm. shipping, ocean-based pollution, species invasion, climate change [acidification, UV, sea temp], fishing [artisinal, low-bycatch, high-bycatch, habitat modifying], direct human, pollution [NP inor, NP org, nut input])

- For 20 marine ecosystem types (coral reefs, seagrass, mangroves, soft shallow, soft shelf, rocky reefs, hard shelf, soft slope, hard slope, soft deep, hard deep, pelagic waters, seamounts, deep waters)
Global map of cumulative human impact across the oceans (2008)

Highly-Impacted: (B) Eastern Caribbean, (C) North Sea, (D) Japanese waters

Least-Impacted: (E) Northern Australia

Fig. 3. The distribution of cumulative impact scores for each ecosystem in our analyses (means in parentheses). Individual ecosystem scores have a smaller range of values than cumulative impact scores (Fig. 2) because the latter sum all ecosystem-specific scores within a cell. Ground-truthed estimates of coral reef condition (17) were used to identify $I_e$ values at which coral reefs experience medium high to very high impact, as indicated on the coral reef histogram. Note differences in $y$-axis scales.

A Map of Human Impact to Papahānaumokuākea Marine National Monument

Final Thoughts on Myer’s Hotspot Approach

• MacArthur, Moore, World Bank, Cons. Int. have granted $750 million in response—largest sum for any single cons. strategy
• Endemism: No restoration biology to regenerate extinct species
• Adopted for marine systems
• Cited 2,721 times as of 3/12/2010 (Web of Science)
• E.O. Wilson:
Aral Sea:

Shrinking since 1960 due to diversion of water from 2 rivers (Syr Darya, Amu Darya) to irrigate nearby crop land

1989 (Jul.-Sep. Landsat mosaic, 250 m resolution, NASA)
(Landsat images from NASA)
• Salt concentration ↑ from 10‰ to >23‰, contributing to devastation of a once-thriving fishery

• Local climate shifted, w/ hotter, drier summers & colder, longer winters

• As water retreated, salty sediment remains on the exposed sea bed. Dust storms disperse ~75,000 tons yr⁻¹ of exposed sediment, dispersing salt particles, pesticide residues

• Air pollution caused widespread respiratory ailments

• Crop yields diminished

Soil and Trouble

WHEN PEOPLE INTENSIVELY TILL FIELDS and clear-cut forests, they can damage or destroy ground that has been stressed or weakened. Just how vulnerable soil is depends on underlying conditions. Mismanaged soils in windward lands can easily turn into desert, for example, and saline soils can become salt-encrusted wastelands.

This map shows the main barriers to productive farming, along with erosion risk, derived from climatic and soil conditions. Overlaid as cross-hatching are regions reported to be highly or very highly degraded according to a global survey of soil experts published in 1999. The hot spots illustrate examples of the worst soil degradation, from the most common physical type—water erosion—to chemical forms, such as that caused by solutes from industrial chemicals and waste.

An interactive version of this map appears online at www.sciencemag.org/cgi/content/summary/304(5677):1614.

Madagascar

One of most biodiverse areas on the planet-8,000 endemic species of flowering plants (Green & Sussman 1990)

• Numerous habitats degraded since arrival of humans 1,500-2,000 ya (Humbert 1927, Dewar 1984)

• Extinctions of large mammals, birds-severe (Humbert 1927, Dewar 1984)

• If deforestation rates continue unchecked, only forests on steepest slopes will survive (G&S 1990)
(www.wildmadagascar.org)
Onsite

(www.wildmadagascar.org)
Offsite

High sediment loads in the Manambolo River (www.wildmadagascar.org)

Betsiboka River & estuary, image from Space Shuttle (NASA)
Severity of Human-Induced Soil Degradation in Madagascar
Sunda Islands

• Sunda Islands hotspot encompasses 12,639 km²

• Part of the “Coral Triangle,” most diverse coastal area on earth

• High marine species richness & endemism

• Threats include: (1) land-based pollution, (2) destructive fishing practices, (3) live reef fish trade
Indonesian Reef (Carl Gustav, World Bank)


Reefs of Iryan Jaya, Indonesia
(Photo Rod Salm WWF)
FIGURE 1. Almost Half a Billion People Live Near Reefs

Number of People Within 100 km. of a Coral Reef

- Caribbean
- Atlantic
- Middle East
- Indian Ocean
- Southeast Asia
- Pacific

(Bryant et al. 1998)
(Bryant et al. 1998)
(Bryant et al. 1998)
Plume of fine silts & clays discharging into the sea in Indonesia.

(http://www.dfid-kar-water.net/w5outputs/soil_erosion_slides.htm)
Other threats

(Photo: Reefbase/ T. Heeger)
MAP 2.

Destructive Fishing is Widespread in Southeast Asia

Note: Areas classified as threatened by destructive fishing practices are based upon a 20-kilometer radius zone from known occurrences of dynamite or cyanide fishing as found in ReefBase (ICLARM, 1997) and were revised based upon expert opinion obtained at the two-day Reefs at Risk workshop held in September 1997 in Manila.
• The Bajo fishing community of Sampela on the island of Kaledupa, Indonesia

• Until around 40 years ago, the Bajo or “sea nomads” would spend their lives at sea in communities distributed across SE Asia

• Recent gov’t pressure has resulted in building of more permanent villages

• Bajo dependent upon marine resources for virtually all their food, fuel, building materials

  (www.envf.port.ac.uk/geo/courses/indonesia/)
Partner Hotspot Activity

• How would you define a “degradation hotspot?”
• What criteria would you use?
• Would you use different criteria for terrestrial vs marine hotspots?