Measuring Human Impacts On The Biodiversity And Carrying Capacity Of Ecosystems: Combining Remotely-Sensed Data With Species Distributions To Identify Conservation Priorities

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Abstract

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This proposal will combine remotely sensed data from NASA's Terra Mission (MODIS), AVHRR, and nighttime city lights data from DMSP with geospatial data on ecosystems and species distribution to quantify a variety of anthropogenic threats to ecosystems and biodiversity at regional and continental scales. It will be a joint effort between NASA Goddard Space Flight Center's Biospheric Sciences Branch, Stanford University's Center for Conservation Biology, and Bowie State University's Department of Natural Sciences.

Humans threaten ecosystems by directly destroying their native habitats and by over-taxing their capacities to sustainably support our increasing population (i.e., their carrying capacities). Rapid, quantitative analyses of the broad-scale patterns of these human threats are critically needed, so that conservation biologists can allocate limited resources most effectively. Data sets just being developed at NASA will greatly aid in these efforts. This project will use remotely sensed data from the Defense Meteorological Satellite to map urban areas and will combine them with census data to index the urban land use patterns to population and housing data. Data from MODIS's Land Discipline Group, AVHRR, and USGS maps, will be used to map vegetation land cover, estimate productivity, and collect land surface disturbance information with a special emphasis on agriculture. These data will be analyzed, validated, and merged in a geographic information system with an ecoregion coverage for North America, including species distribution data for over 20,000 species in eight taxa.

The combined geo-spatial analyses will allow us to address three issues of critical importance to the science and policy of biodiversity conservation and sustainable development: (i) identify areas of extreme threat to biodiversity due to anthropogenic habitat loss, (ii) analyze the fragmentation of ecosystems by urban and agricultural land conversion, and (iii) investigate human population and consumption patterns relative to the carrying capacity of the ecosystems that support them. These analyses will result in a series of technical articles in peer-reviewed journals, as well as several map products that will convey the same information powerfully to the public. We plan to focus initially on North America, with the goal of extending the analysis as data sets are expanded to cover the globe.

ESE scientific question addressed*: What are the consequences of land cover land use change*? Specifically, "What are the consequences of LCLUC on NPP and biodiversity?" "How is current land cover fragmenting ecosystems and how does the land use related reduction or gain in NPP affect the carrying capacity of the landscape?"
Social Science 10%, Change detection 15% Carbon Cycle 25%, Biodiversity 50%

Goals for this period: In our final phase for this project we will explore how the altered rates of NPP in and around urbanized areas might alter abundance and species diversity in the most affected ecoregions. **Roadmap**: 1) Produce annual sum NPP map of the US at 1km with urban systems identified. Build vegetation and urban land cover data layer using USGS land cover map and DMSP satellite data. Run CASA on 1 km AVHRR data and land cover map. (May 1 – October 2002). 2) Merge NPP map with ecoregions, develop NPP requirement functions for various species, and estimate impact (October 2002– April 30, 2003)..

Accomplishments for 2001-2002: We quantified the spatial distribution of two of the most ecologically significant land use categories (agriculture and urban development), identified ecoregions in the US at most risk due to these two land use types -separately and in combination, and identified suites of species most affected. We successfully addressed two of our three original questions: 1) Where are the likely conservation crises going to be? Where do high levels of species richness and endemism collide with high levels of human impact? 2) How have urbanization and agriculture fragmented ecosystems on broad scales, and in what areas are these impacts most severe?

Gaps, issues: It is till not clear to us how we can get MODIS data composites for FPAR calculations that are actually ready to use. It seems that only the laboratories tasked to produce those data are able to use them due to the large overhead in learning how to access the data and format them for input to a modeling environment. This conveys an unfair advantage to those laboratories.

Approach/method: Unchanged. Described in abstract

Results 2001-2002:

- **The distribution of both biodiversity and human threats is extremely heterogeneous in the US and Canada affirming the importance of establishing clear conservation priorities (since some areas are so much more threatened and/or diverse than others).**
- **Urbanization and agricultural development are both taking place most rapidly within the most biologically diverse regions in the US).**
- **Our analyses identified four "priority sets" of ecoregions where high levels of biodiversity and human land use coincide. These ecoregions are concentrated in the southeastern U.S., California, the Atlantic coast, southern Texas, and the U.S. Midwest.**

We found that the distribution of both biodiversity and human threats is extremely heterogeneous in the US and Canada. For example, some ecoregions contain over 25% of North American species (averaging over the 8 taxa considered), while other ecoregions contain less than 6% (Table 1). Similarly, urbanization varied from less than 0.1% to more than 60%. This heterogeneity affirms the importance of establishing clear conservation priorities, since some areas are so much more threatened and/or diverse than others. Comparing richness and urbanization yields 16 ecoregions that fall above the 66th quantile on both axes. The ecoregions in this "priority set" contain both extraordinary species richness and high levels of urbanization. For richness and agriculture, 11 priority ecoregions are similarly identified. Comparing endemism and urbanization yields a priority set of 12 ecoregions. Of the 76 ecoregions considered, our analyses identified four "priority sets" of 6-16 ecoregions (8-21% of total number) where high levels of biodiversity and human land use coincide. These ecoregions tend to be concentrated in the southeastern U.S., in California, and, to a lesser extent, the Atlantic coast, southern Texas and the U.S. Midwest. Several ecoregions are members of more than one priority set and two ecoregions in Florida are members of all four sets. These ecoregions may be considered of additional concern, as they face multiple sources of habitat destruction and contain both high richness and high endemism. (article in Press – see #1 below).

New Products:

Publications (Refereed) published or were accepted for publication in 2001-2002:

1) Biodiversity, urbanization, and agriculture: locating priority ecoregions for conservation. Taylor H. Ricketts and Marc L. Imhoff. Conservation Ecology, (in Press for June-July 2002).

2) Night-time lights of the world: 1994-1995. Elvidge CD, Imhoff ML, Baugh KE, Hobson VR, Nelson I, Safran J, Dietz JB, Tuttle BT, ISPRS Journal Of Photogrammetry And Remote Sensing 56 (2): 81-99 December 2001.

3) A closer look at U.S. and global surface temperature change, J. Hansen, R. Ruedy, M Sato, M. Imhoff, W. Lawrence, D. Easterling, T. Peterson, and T. Karl, JGR Atmospheres, Vol. 106, D20, pages 23947-23963, October 27, 2001.

4) Assessing the impact of land conversion to urban use on soils with different productivity levels in the USA, Nizeyimana EL, Petersen GW, Imhoff ML, Sinclair HR, Waltman SW, Reed-Margetan DS, Levine ER, Russo JM, Soil Science Society Of America Journal, 65: (2) 391-402 MAR-APR 2001.

New Data sets.

1) Ecoregion fragmentation maps due to urban and agriculture land use land cover.
2) Ecoregion Risk Maps: Urban and Agriculture, Combined Ag-Urban
3) Species-at-risk lists for the US

Conclusions:

We found that the distribution of both biodiversity and human threats is extremely heterogeneous in the US and Canada. This heterogeneity affirms the importance of establishing clear conservation priorities, since some areas are so much more threatened and/or diverse than others. Of the 76 ecoregions considered, our analyses identified four "priority sets" of 6-16 ecoregions (8-21% of total number) where high levels of biodiversity or endemism and either agricultural or urban land use coincide. These ecoregions tend to be concentrated in the southeastern U.S., in California, and, to a lesser extent, the Atlantic coast, southern Texas and the U.S. Midwest. Several ecoregions are members of more than one priority set and two ecoregions in Florida are members of all four sets where both urban and agricultural land transformation is taking place in regions with very high endemism and species richness. These ecoregions may be considered of additional concern, as they face multiple sources of habitat destruction and contain both high richness and high endemism.