NASA LCLUC Program: Request for Supplemental Funds

**Project**: Land Use Change Around Protected Areas in LCLUC Sites: Synthesis of Rates, Consequences for Biodiversity, and Monitoring Strategies


**Principle Investigators**: Andrew Hansen, Montana State University
Ruth DeFries, University of Maryland

**Current Collaborators**: Paul Desanker, University of Virginia
Emilio Moran, Indiana University
Robin Reid, International Livestock Res. Institute
Billie Turner, Clark University

**Proposed Additional Collaborators**: Lisa Curran, Yale University
Jack Liu, Michigan State University
Howard Quigley, Wildlife Conservation Society



**Summary**: We request supplemental funds ($60,000 per year for each of two years) to allow three additional sites to be added to our synthesis study of land use change around nature reserves and consequences for biodiversity. These additions will substantially improve the scientific rigor of the study by: allowing samples across the biophysical and cultural gradients of interest; and increasing understanding of the ecological mechanisms that link biodiversity within reserves to land use change outside of reserves.


**Justification**:

The goal of the original study is to investigate rates of land use intensification around nature reserves and consequences for the viability of biodiversity within the reserves. Because the objective of the NASA Request for Proposals was to synthesize among NASA LCLUC sites, we drew the case study sites from among those previously funded by the NASA LCLUC program. Additional criteria used for selections were: inclusion of one or more nature reserves and surrounding human-use lands; completed analyses of land-use change over the past 10-25 years; and wide representation of biogeographic settings and cultural types among the sites; and presence of one or more ecological mechanisms hypothesized to link nature reserves with surrounding lands (Table 1). The sites selected for study were: Greater Yellowstone, USA; Southern Yucatán Region of Mexico; Santarém Region, Brazil; Mecuburi Forest Reserve, Mozambique; and the Nang Rong District, Thailand.

In the first year of the study, we carefully evaluated the suitability of the suite of suites relative to the research objectives. We concluded that the scientific merit of the study could be improved through some deletions and some additions of sites.

Table 1. Ecological mechanisms hypothesized to link nature reserves to lands surrounding reserves that may be subjected to intense land use. (From Hansen and Rotella 2002).

| Mechanism | Description | Examples | References |
|---|---|---|---|
| Ecological Process Zones | Key ecological processes move across landscapes. "Initiation" and "run-out" zones for disturbance, water, or nutrients may lie outside reserves. Land use that alters these ecological flows may change ecological processes within reserves | Clearcutting on the windward side of Yellowstone National Park has reduced incidence of fire spreading into the park.<br>Intense land use in upper watersheds alters flow of water, nutrients, exotic species, and pollutants into reserves lower in the watershed. | Baker 1992; Hansen et al. 2000; Pringle 2001 |
| Habitat area | The number of species and population sizes within a reserve is influenced by its size. The functional size of reserves includes the reserve and the natural habitats surrounding the reserve. As natural habitats in surrounding lands are destroyed, the functional size of the reserve is decreased and risk of extinction in the reserve is increased. | Increasingly fragmented forests in Kenya have undergone extinctions of bird species as predicted based on change in their area. | Brooks et al. 1999 |
| Unique habitats | The region around reserves may also contain unique biophysical settings that are required by organisms within reserves to meet life-history requirements. | Ungulates in Serengeti National Park migrate to dry-season habitats outside of the park. Conversion of these habitats to wheat fields is associated with a 75% decrease in a Serengeti wildebeest herd | Serneels and Lambin 2001 |
| Edge effects | Negative influences from the reserve periphery (e.g., human caused mortality, invasive species) sometimes extend some distance into nature reserves. | Predatory mammals African nature reserves have incurred high extinction rates due to human-induced mortality on surrounding private lands | Woodroffe and Ginsberg 1998 |
| Population source/sink dynamics | Unique habitats outside of reserves may allow high levels of population reproduction and survival and are "population" source areas required to maintain "sink" populations in reserves. | Rural home development in hot-spot habitats outside Yellowstone National Park favors exotic predators and has converted population source areas for native birds to sink areas. Consequently, extinction risk for these bird species has increased in the sink habitats in Yellowstone National Park. | Hansen and Rotella 2002 |

The Thailand site was rejected because the conservation areas there were not legally protected and were too small to be comparable to other sites. We replaced this site with the Greater Serengeti Ecosystem in Kenya and Tanzania. The GSE site is well suited to the study because: it includes six high-profile nature reserves: the largest herds of migratory mammals on earth occur here; land use change outside of the reserves is rapid and has potential to strongly influence wildlife within the reserves; and the region has been understudy by team within the international Land Use Cover and Change Program.

Final decisions have not been made about the southern African site. The Mecuburi Forest Reserve, Mozambique, is not entirely suitable because it is an extractive reserve, without the protections typical of a national park. Other candidate sites in Southern Africa are the proposed Selous/Naissa Peace Park in southern Tanzania and northern Mozambique or the proposed Gaza/Kruger/Gonarezhou Transfrontier Park in southern Mozambique and northeastern South Africa.

We propose three additional sites to balance the geographic and cultural distribution of the study. These are: Wolong Reserve, China; Shihote-Alin, Russia; and Borneo, Indonesia. With these additions, the study will include sites in tropical, subtropical, and temperate zones in both the eastern and western hemispheres (Figure 1 and Table 2). The sites vary in biome type (needle-leaved forest, broad-leaved forest, savanna) and in topography (flat, varied). Cultural groups include poor pioneering groups, poor long-settled groups, and wealthy natural-amenity groups.

Table 2. Description of the current and proposed sites to be included in the synthesis study of nature reserves and land use.

| **Site** | **Hemi-sphere** | **Latitude** | **Topo-graphy** | **Vegetation** | **Culture** | **Ecological Mechanism** | **Collab-orators** |
|---|---|---|---|---|---|---|---|
| **Yellowstone** | Western | Temperate | Mountains | Needle-leaved wet/dry | Wealthy amenity | Uniq hab Source/sink | Hansen |
| **Mayan Forest** | Western | Subtropical | Flat | Broad-leaved wet/dry | Moderate pioneering | Habitat area Edge effects | Turner Sadar – advisor Nations-advisor |
| **Santarem** | Western | Tropical | Flat | Broad-leaved wet | Poor pioneering | Habitat area Edge effects Watershed | Moran Nepstad-advisor Walsh-advisor |
| **Masai East Africa** | Africa | Subtropical | Mountains | Savanna | Poor settled\ Pioneering | Uniq hab Edge effects Souce/sink | Reid Desanker |
| **Russian Far East Shihote-Alin** | Eastern | Temperate | Mountains | Needle-leaved wet/dry | Poor pioneering | Uniq hab Source/sink | Quigley Miquelle |
| **Wolong China** | Eastern | Subtropical | Mountains | Broad-leaved wet/dry | Moderate settled | Habitat area | Liu |
| **Borneo, Indonesia** | Eastern | Tropical | Mountains | Broad-leaved wet/dry | Poor settled | Habitat area Uniq hab | Curran Kasischke |

**Description of Proposed Sites**:

**Wolong Reserve, China.**

Wolong Nature Reserve lies in Sichuan Province, southwestern China. It was established in 1962 and expanded in 1975. It is the largest among 25 nature reserves in China designated for the conservation of the giant panda. Approximately 110 pandas live in the reserve. This represents about 10% of world population of giant pandas. The reserve is situated between Sichuan Basin and the Qinghai-Tibet Plateau and is characterized by high mountains and deep valleys. The reserve includes several climatic zones, high habitat diversity. The vegetation grades from mixed evergreen and deciduous broadleaf forests to conifer forest towards higher elevations. Some 12 animal species and 47 plant species in the reserve are on China's national protection list.

Three minority ethnic human groups were permitted to remain in the reserve following its establishment. The primary land uses of these people are fuelwood collection, timber harvest, and agriculture. Because family size policies in China do not apply to ethnic minorities, the human population in the reserve has grown rapidly: 66% during 1975-1998.

The increasing intensity of human land use has reduced habitat for pandas. This species selects particular habitats: areas with flat or gentle slopes, mid elevations, and bamboo, conifer or broadleaf forests. Some 41% of reserve was thought to be suitable panda habitat prior to human presence. Twenty-one percent of these suitable habitats were lost to human activities by 1975. Between 1975 and 1995, an additional 8% of suitable panda habitats were destroyed by intense human land use. The pace of destruction of panda habitat has been even more rapid across Sichuan Provinence: 50% from 1974-1989. A moratorium on commercial logging since 1998 is expected to slow this habitat destruction.

Jack Lui and his colleagues have quantified land cover change, human demography, and panda habitat change within and immediately around Wolong Reserve. These data were used to simulate panda habitats under alternative future human demographic scenarios. They are currently conducting land change analysis across the panda reserves of China and continuing to study human social structure and demography in this region.
Publications include:

Liu, J., M. Linderman, Z. Ouyang, L. An, J. Yang, H. Zhang. 2001. Ecological degradation in protected areas: The case of Wolong Nature Reserve for giant pandas. Science 292: 98-101.

An, L., J. Liu, Z. Ouyang, M. A. Linderman, S. Zhou, and H. Zhang. 2001. Simulating demographic and socioeconomic processes on household level and implications for giant panda habitats. Ecological Modelling 140:31-50.

Liu, J., Z. Ouyang, W. Taylor, R. Groop, Y. Tan, and H. Zhang. 1999. Aframework for evaluating effects of human factors on wildlife habitat: The case of the giant pandas. Conservation Biology 13(6): 1360-1370.

Liu, J., Z. Ouyang, Y. Tan, J. Yang, and S. Zhou. 1999. Changes in human population structure and implications for biodiversity conservation. Population and Environment. 21:45-58.

**Shihote-Alin, Russia**

The study area centers on the Sikhote-Alin Mountains in the Primorski and Khabarovski provinces in the Russian Far East. The mountains are bordered by Vladivostok to the southwest, the Ussuri and Amur Rivers and China to the west, and the Sea of Japan to the east. The Sikhote-Alin State Biosphere Reserve lies on the eastern slopes of the Sikhote-Alin Mountains and borders the Sea of Japan. The region includes two bioregions: the east Asian coniferous-deciduous complex and the northern boreal coniferous complex. From the coast to the high mountains, the vegetation grades from oak-birch forest to Korean pine forests to spruce-fir-larch.

The Sikhote-Alin State Biosphere Reserve is near the center of remaining habitat for the endangered subspecies of Siberian tiger, the Amur tiger. Once occupying most of the Amur River Basin, the range of the subspecies has collapsed to its eastern perimeter, with the only remaining viable population now occurring in the Primorski and southern Khabarovski Provinces. The reduction in tiger habitat resulted from urban and agricultural expansion around Vladivostok and in the Ussuri and Amur Rivers. The population was also reduced in the 1950's and 1960's by poaching and capture of cubs for international trade. Increased protection allowed the population to grow in the Sikhote-Alin reserve: from 4 in 1966 to about 30 in 1993. Other mammal species in the reserve include brown bears, black bears, the rare Amur leopard, and seven species of ungulates (red deer, wild boar, sika deer, roe deer Manchurian moose, musk deer, ghoral).

The Hornocker Wildlife Institute has studied Amur tigers in the region since in 1991. Their Siberian Tiger Project has four major goals: collect the detailed scientific knowledge needed to understand exactly how nature provides for
he Siberian tiger; use the scientific data obtained to create a comprehensive conservation management plan; contribute to the development of a new conservation ethic for the region, and model for the world; and involve the world conservation community. Thus far, they have studied the habitats of 16 radio-collared tigers, completed a digital cover map and conducted habitat analysis, and initiated a comprehensive habitat conservation plan for the region.

Key collaborators for the study are Howard Quigley and Dale Miquelle, both of the Hornocker Wildlife Institute and the Wildlife Conservation Society.

Publications on the region include:
Smirnov, E.N., and D.G. Miquelle. 1999. Population dynamics of the Amur tiger in Sikhote-Alin Zapovednik, Russia. Pgs 61-70 in J. Seidensticker, S. Christie, P.

Jackson, eds, Riding the Tiger: Tiger Conservation in Human-dominated Landscapes. Cambridge University Press, Cambridge UK.
Miquelle, D.G., et al. 1999. Hierarchical spatial analysis of Amur tiger relationships to habitat and prey. Pgs 71-99 in J. Seidensticker, S. Christie, P. Jackson, eds, Riding the Tiger: Tiger Conservation in Human-dominated Landscapes. Cambridge University Press, Cambridge UK.
Miquelle, D.G., et al. 1999. A habitat protection plan for the Amur tiger: Developing political and ecological criteria for a viable land–use plan. Pgs 273-295 in J. Seidensticker, S. Christie, P. Jackson, eds, Riding the Tiger: Tiger Conservation in Human-dominated Landscapes. Cambridge University Press, Cambridge UK.

**West Kalimantan Region, Borneo, Indonesia**

The wet tropical forests of the West Kalimantan Region in the Island of Borneo are dominated by more than 50 dipterocarp tree species, which synchronize their reproduction, limiting fruit and seed production to brief, intense periods. These bursts of reproduction are initiated by the arrival of the El Nino Southern Oscillation or ENSO, a periodic shift in tropical Pacific circulation patterns that brings drought to Indonesia. This fruit masting is thought to be an adaptation for reproduction. By saturating the seed-predator community, some seeds are able to escape predation and establish. Wild boar, orangutans, parakeets, jungle fowl, partridges and other animals congregate to eat the fruits. Because so much seed is produced simultaneously over such a large area, however, there is still enough left over to germinate and produce new seedlings.

Logging has expanded in recent decades in the region and has jeopardized dipterocarp reproduction even with protected areas such as Gunung Palung National Park. Between 1968 and 98, 72 timber concessions occupied as much as 79% of West Kalimantan's forested land. Approximately, 77-87% of the land within a timber concession was altered by logging. From 1991 to 1998, production of viable dipterocarp seed fell dramatically within the National Park. This was attributed to increased drought conditions and fires related to logging. It was also attributed to a reduction in the size of the area of fruit masting. Because seed predators can't find food outside the park, they move inside to eat the dipterocarp seeds before they germinate. Hence logging has apparently altered the spatial scaling of the fruit masting/predator interaction, resulting in a concentration of seed predators in the nature reserve, and reducing the viability of dominant tree species.

Lisa Curran and colleague Eric Kasiscke are currently completing land cover change analysis within a portion of West Kalimantan that includes three national parks. They are also studying the movement of seed predators across the landscape to better understand the dynamics of fruit masting.

Publications include:
Curran, L.M., et al. 1999. Impact of El Niño and Logging on Canopy Tree Recruitment in Borneo. Science 286:2184-2188.

Curran, Lisa M., and M. Leighton. 2000. Vertebrate responses to spatiotemporal variation in seed production of mast-fruiting Dipterocarpaceae. Ecological Monographs 70:101-27.

**Collaborative Arrangements:**

The P.I.s will execute the studies and analyses described in the original proposal to meet the research objectives. Two workshops will be held during the project, one in the second and one in the third year. The workshops will involve all of the collaborators and investigators. In the first workshop, collaborators will provide background and data for their respective sites developed during their individual LCLUC projects: participate in land use change analyses; and help with validation of the initial Modis land cover maps. Frequent communications with the collaborators will ensure detailed information about each site. A second workshop will be held in the third year to synthesize results on biodiversity and prepare publications. Collaborators will receive funding to attend the workshop and to cover costs of data analysis and other activities necessary for the project.

Analysis of Modis data will be carried out at the University of Maryland. We expect that visits to the collaborators' institutions will be necessary to gain in-depth knowledge of the sites based on the expertise of the collaborators and their research teams.

Responsibilties of the investigators are as follows:

A Hansen (PI), Montana State University – Coordination of case study data; analysis of biodiversity consequences; overall management of the project. A. Hansen will be assisted by a M.S.-level Research Associate.

R. DeFries (PI), Unversity of Maryland – Analysis of coarse resolution data; coordination with A. Hansen on overall management of the project. A research faculty assistant (10%) will assist with providing and analyzing the MODIS data. A graduate student will assist with the data processing.

Each of the new collaborators will be considered subcontractors. Their duties will be to advance the research objectives for their respective study sites by:

1. Providing expertise and previously-acquired data for the case study site (e.g., land cover/use, biophysical factors, socioeconomic factors, etc.);
2. Participating in a workshop on analysis of land use change and a workshop on biodiversity (travel support will be covered by the P.I.s);
3. Interpreting/evaluating results of analyses on land use change, biodiversity, and utility of MODIS products;
4. Helping to prepare publications;
5. Help facilitate visits by the P.I.s to the case study site.

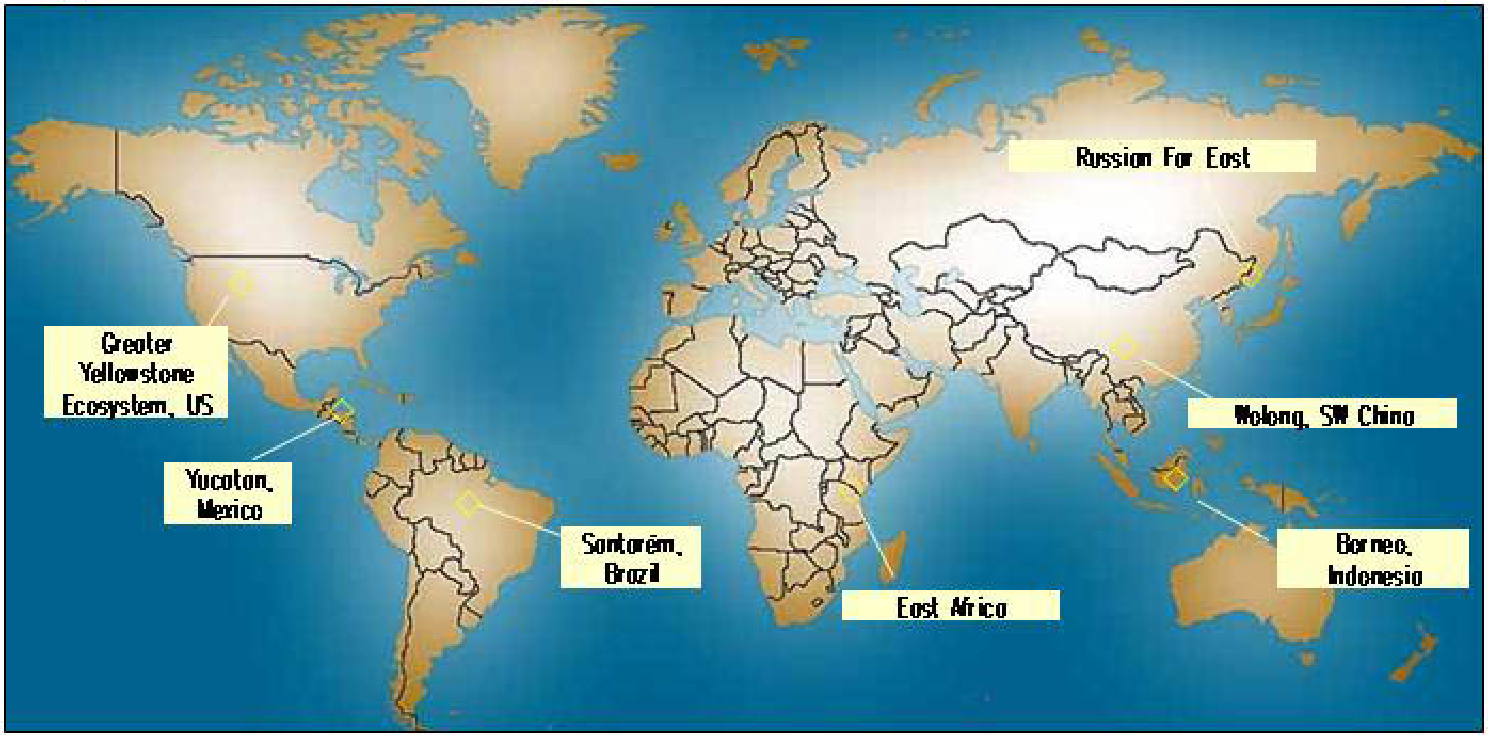
Unlike the other sites, the Shihote-Alin site in the Russian Far East has not yet been the subject of a land use change analysis. Additional funds are requested to support a

Russian Graduate Student that will work with co-P.I. DeFries on land cover mapping and change analysis for this region.

Funds Requested: Funds are requested for each of two year.

| | |
|---|---|
| Montana State University | |
| Res.Assist. support for biodiversity analyses | $1000/site/yr |
| Travel: P.I. visit to sites | $1500/site/yr |
| Travel: subcontractors travel to workshops | $2000/site/yr |
| University of Maryland | |
| GRA support for MODIS mapping | $2,000/site/yr |
| GRA support for Russian site change analysis | $15,000/yr |
| Travel: P.I. visit to sites | $1500/site/yr |
| Liu Subcontract | $7000/yr |
| Quigley Subcontract | $7000/yr |
| Currans Subcontract | $7000/yr |
| Total per site per year | |
| China | $15,000/yr |
| Russia | $30,000/yr |
| Indonesia | $15,000/yr |
| Total per year if all sites funded | $60,000/yr |

# Fig 2. Current and Proposed Sites for Nature Reserve Study




Western Hemisphere

| | | | |
|---|---|---|---|
| Yellowstone: | Temperate/boreal | Coniferous-wet/dry | Mountains |
| Yucutan: | Subtropical | Broadleaf-wet/dry | Flat |
| Santarem: | Tropical | Broadleaf-wet | Flat |

Eastern Hemisphere

| | | | |
|---|---|---|---|
| Russiae: | Temperate/boreal | Coniferous-wet/dry | Mountains |
| Wolong: | Subtropical | Broadleaf-wet/dry | Mountains |
| Indonesia: | Tropical | Broadleaf-wet | Mountains |

Africa

| | | | |
|---|---|---|---|
| East Africa: | Subtropical | Savanna | Mountains |