A Global Map of Current Hotspots of Land-cover and Land-use Change

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Project Objectives

Humans are changing the world more rapidly and more profoundly than has occurred in human history, and the implications at the local, regional, and global scale are significant. It is crucial, then, that locations undergoing significant land-cover and land-use change (LCLUC) are identified. These "hotspots" of land-cover and land-use change are here defined as: areas in which existent or potential, complete- or near- irreversible changes to a resource or region are occurring, with significant local to regional or global implications, considered in the context of pressing social and environmental issues, such as human livelihoods, biodiversity loss and climate change. Through an in-depth analysis of recent literature and the media, this project aims to identify current hotspots of LCLUC, and bring these areas and the underlying processes of change to the attention of policy makers, the scientific community and the global population. The poster presented here brings our definition and identification of hotspot examples of LCLUC to life through cartographic representation.

Interactive Map and More Information: http://lcluc.umd.edu/hotspots

Glacial Retreat

Since early 1980s, glacial retreat all over the world has been significant due to global warming. Some glaciers have been retreating rapidly and some have even disappeared completely (IPCC 2001). Melting of glaciers leading to increased run off in the near term will have serious impacts on future water supplies and other important hydrologic assets (UNEP 2002), e.g. agriculture water supply and drinking water quality. Little can be done to reduce global warming on the timescales needed. At best all efforts at mitigation will only lead to a stabilization of current carbon dioxide. Therefore there is a need for scientific research on high-risk areas to develop realistic projections of water supply and mid-term land use planning on how to adapt to these changes.

A view down the Whitechuck Glacier in Glacier Peak Wilderness in 1973 (Pelto 2006)

Hotspot Locations

- Himalayas
- Tianshan Mountains
- **Cascade Range of Western North America**
- North and South Patagonia
- European Alps

Arapaho Glacier 2003 (Pelto 2006)

The same view as seen in 2006, where this branch of glacier retreated 1.9 km (Pelto 2006)

Glacial Retreat in Cascade Range

Glaciers in the Cascade Range have a huge amount of ice storage, which is as much as the total storage as of the rest of Washington state. During the last twenty years, there has been an average loss of more than one-fifth of the total volume in Cascade Range (Pelto 2006). Decline of snowfall and increase in summer temperatures are the main factors. Besides glacial lake floods, other geomorphic hazards such as landslide and debris flows can result in huge damage to nearby residents and traffic.

Citations:

IPCC, Intergovernmental panel on climate change. "2.2.5.4 Mountain glaciers". Climate Change 2001 (Working Group I: The Scientific Basis).

UNEP, United Nations Environment Programme. 2002. "Global Warming Triggers Glacial Lakes Flood Threat." April 16. UNEP News Release 2002/20.

Pelto, M. S. 2006. The current disequilibrium of North Cascade glaciers. *Hydrological Processes*, 20, 769-779.

Agricultural Expansion/Abandonment

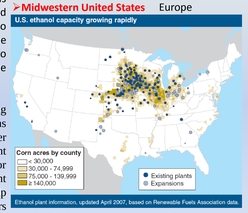
Agricultural lands are expanding in several regions of the world due to population growth and economic globalization. In addition, rising global demand for biofuels has caused widespread conversion from food to fuel crops, which have increased the price of food worldwide. This land use change is having major consequences. Agricultural expansion is causing an increase in greenhouse gas emissions through the burning of forests for farmland and the use of fossil fuels in mechanized equipment. Cropland conversion is also a threat to biodiversity due to fragmentation and destruction of natural habitats. Conversely, the spread of farms onto marginal lands has led to land degradation and abandonment due to poor management. Abandonment has also been driven by societal change following the collapse of socialism in the early 1990s.

Agricultural Land Use Change in the U.S. Midwest

Extensive areas of agricultural land in the United States, generally corn producing, are being converted from food to biofuel production. Such a transition, which has been marketed as eco friendly, is actually causing major problems. Biofuels, originally envisioned as a greener substitute for fossil fuels, may actually have a larger carbon footprint than previously thought (Searchinger et al. 2008). Additionally, the reduction in the amount of U.S. corn available for cooking has increased the price of food worldwide (Tyner 2008). The U.S. government continues to support increased biofuel production for national security reasons and to help sustain American agriculture. The result will be more land conversion to biofuels in the years to come.

Hotspot Locations

- Indonesia and Malaysia
- Coastal Eastern Africa
- Mato Grosso, Brazil
- Sao Paulo, Brazil
- **Midwestern United States**
- Chaco Forest, Argentina
- Syria
- Post-Socialist Europe



U.S. ethanol capacity is concentrated in the Midwestern states, and is continuing to grow (P. Westcott, USDA)

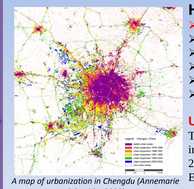
Citations:

Searchinger, T., R. Heimlich, R. A. Houghton, F. Dong, A. Elobeid, J. Fabiosa, S. Tokgoz, D. Hayes, and T. Yu. 2008. Use of U.S. Croplands for Biofuels Increases Greenhouse Gases Through Emissions from Land-Use Change. *Science* 319: 1238-1240.

Tyner, W. E. 2008. The US Ethanol and Biofuels Boom: Its Origins, Current Status, and Future Prospects. *BioScience* 58(7): 646-653.

Urbanization

For the first time in human history, over half the human population now lives in urban areas. Urbanization refers to the process by which an increasing proportion of the world's population lives in and around cities. Driven in part by the doubling of global population in the last 50 years and an unprecedented era of economic development, the urban footprint in developed and developing cities continues to grow and intensify. While in the developed world, cities are experiencing urban renewal and suburban sprawl, in the developing World mega-cities are being formed by the immigration of rural populations in search of work.



A map of urbanization in Chengdu (Annemarie Schneider 2009)

Hotspot Locations

- **Chengdu-Chongqing, China**
- Lagos, Nigeria
- Kendall County, Illinois, United States
- Dubai, UAE
- Bangalore, India
- Manaus, Brazil

The skyline of Chongqing (Wikipedia 2009)

Urban Expansion in Chengdu and Chongqing

The Chengdu-Chongqing Urban Agglomeration (CYUA) area has a total population of 40 million people in 2009 (Xie et al. 2008), and its built-up urban area increased from 678km^2 to 1382km^2 from 1998 to 2004 (Yang and Mao 2006). The close cultural and economic connection between two cities and "West Exploitation" strategy accelerate the urbanization and infrastructure construction. They are more accessible with the 68000 km built-up communication lines (Yang and Mao 2006). Due to increasing employment, CYUA has a 9%-10% GDP growth per year from 1998-2004, while the rapid urban agglomeration also leads to potential surplus labor force in the urban area (Yang and Mao 2006).

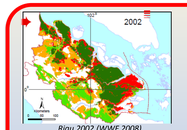
Citations:

Xie, F. Z., X. Y. Lin, W. M. Zhang, Y. F. Xu, G. R. Zhang, H. G. Xie, X, C. Xu, and X. C. Li. 2008 China Statistical Yearbook. China Statistical Press.

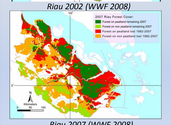
Yang, J., H. Y. Mao. 2006. The Integration and Sustainable Development of Chengdu-Chongqing Urban Agglomeration. *Chinese Journal of Population, Resources and Environment* 4(3): 3-10.

Deforestation

Deforestation occurs when forest cover changes to another land use or land cover type, or when tree canopy coverage falls below a minimum percentage threshold. Forest plays an important role in the environment and earth systems, and consequently deforestation is a significant process in the study of global change. During the past few decades, human activities and forest encroachment have significantly impacted forest cover. Drivers of deforestation include agricultural expansion, wood logging and infrastructure expansion. Research in deforestation has primarily focused on tropical and boreal forests (Hansen et al. 2008).



Riau 2002 (WWF 2008)



Riau 2007 (WWF 2008)

Hotspot Locations

- **Riau, Island of Sumatra, Indonesia**
- Congo Basin, Central Africa
- Eastern Siberia, Russia
- Rondonia, Brazil
- Honduras
- Madagascar

An indirect consequence of forest loss: elephant family poisoned near Mahato village in February 2006. (Samsuardi/WWF Indonesia)

Forest Cover Change in Riau

Forest cover in Riau has declined from 78% of the province in 1982 to 27% in 2007. Riau province produces more than two thirds of Indonesia's pulp, mainly from two of the world's largest pulp mills, Asia Pulp & Paper (APP) and Asia Pacific Resources International Holdings Limited (APRIL). The conversion of forests has resulted in the emission of greenhouse gases, damage and destruction of habitats for endangered animal species, and carbon loss from the peat soils (WWF 2008).

Citations:

Hansen, M. C., D. P. Roy, E. Lindquist, B. Adusei, C. O. Justice, and A. Altstatt. 2008. A method for integrating MODIS and Landsat data for systematic monitoring of forest cover and change in the Congo Basin. *Remote Sensing of Environment* 112 (5):2495-2513.

WWF Indonesia. 2008. How Pulp & Paper and Palm Oil from Sumatra Increase Global Climate Change and Drive Tigers and Elephants to Local Extinction. http://www.worldwildlife.org

Afforestation

While the vast majority of land cover changes are perceived as negative, afforestation and reforestation represent an important exception with constructive, positive impacts for the environment. Afforestation/reforestation can improve soil quality, minimize erosion, and enhance biodiversity (Allen and Chapman 2001). Afforestation is defined as the planting of new trees in previously non-forested areas, at least within the last 50 years (Verchot et al. 2007). Reforestation is the replacement of trees in locations where they have traditionally been found in the past 50 years but have been removed by human or natural forces (Zomer et al. 2008). The rationale for afforestation/reforestation programs typically stem from desires to control storm surges, limit desert encroachment and move recently to sequester carbon.

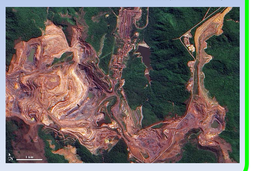
Reforestation is seen as a necessity to recover lands damaged and degraded not just by agricultural activities, but also by mining, like this location in the municipality of Carajas in north central Pará (J. Allen, NASA)

Hotspot Locations

- Aceh, Indonesia
- Green Wall of China
- Midwestern U.S.
- **Pará, Brazil**
- Southeast Texas

Afforestation Project in Pará, Brazil

One of the world's largest reforestation projects is "One Billion Trees for the Amazon." This is a government sponsored initiative concerned with reforesting the Brazilian state of Pará, which has been noted for years as one of the most deforested areas of the Amazon. The government hopes that by succeeding in this major reforestation effort, the reputation of Pará can be rehabilitated from destroyer to protector of forests. An additional goal of this program is for reforestation to be seen as an economically viable activity for Pará and elsewhere (SAGRI 2009).



Citations:

Allen, A., and D. Chapman. 2001. Impacts of afforestation on groundwater resources and quality. *Hydrogeology Journal* 9 (4): 390-400.

SAGRI (Secretaria de Estado de Agricultura). www.sagri.pa.gov.br (last accessed 20 October 2009)

Zomer, R.J., A. Trabucco, L.V. Verchot, and B. Muys. 2008. Land area eligible for afforestation and reforestation within the Clean Development Mechanism: a global analysis of the impact of forest definition. *Mitigation and Adaptation Strategies for Global Change* 13:219-239.

Wetlands Loss

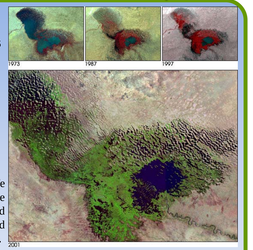
Wetland ecosystems comprise some of the most biologically diverse systems in the world, exhibiting complex ecosystem processes and nutrient flows. Naturally-functioning wetlands provide a range of benefits and services for people's livelihoods and well-being, including food, fiber, flood protection, water purification, and water supply. Wetlands include marsh, swamp, lakes, rivers, fen, peatland, coral reef, mangrove, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water with a depth of less than six meters. Wetlands may also incorporate riparian and coastal zones adjacent to the wetlands (RAMSAR Convention 1971).

Hotspot Locations

- Arctic Lakes, Siberia
- **Lake Chad, Central Africa**
- Kalimantan, Indonesia
- Pantanal, Brazil, Paraguay and Bolivia
- Alberta, Canada
- Aral Sea, Central Asia

Change of Wetlands in Lake Chad

The wetlands of Lake Chad are disappearing due to drought and intensified anthropogenic uses. This has created concerns for life extending not only for the migratory birds, who seasonally inhabit the area, or the various flora and fauna found among the shallow lake, but also for the livelihoods of the local people as well. Located on the boarders of Chad, Niger, Nigeria, and Cameroon in West Africa, the permanent shallow lake expands with seasonal rain and floods the surrounding grassland and savannah, though increasing demands for use and climatic changes have reduced the extent of the lake dramatically (FAO 2009).



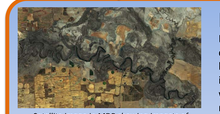
Wetland loss in Lake Chad (NASA GSFC)

Citations:

Ramsar Convention, 1971. International Agreement for the Protection of Wetlands. Ramsar, Iran, 2 February.

UNEP/GRID-Arendal, Lake Chad: almost gone, UNEP/GRID-Arendal Maps and Graphics Library, http://maps.grida.no/go/graphic/lake-chad-almost-gone (last accessed 20 October 2009).

Land Degradation



Satellite image in MDB showing impacts of intensive and extensive agriculture LCLUC (Google Maps, Digital Globe, Terrametrics 2009)

Land degradation is the semi-permanent degradation of land in terms of a loss of productivity that does not return with rain (Prince et al. 1998). Drylands are particularly susceptible to degradation. Best estimates indicate that degrading areas currently support 1.5 billion people (Bai et al. 2008). Often these populations are more rural and underdeveloped and are subject to the larger and more imminent threats of hunger, poverty, and conflict. Local livelihoods are jeopardized by soil erosion, salinization, vegetation loss, water scarcity, and air pollution. Moreover, regional and global ecosystem services rendered by drylands, such as carbon cycling, make it a cumulative problem that is not limited to the developing world (Reynolds and Stafford Smith, 2002).

Hotspot Locations

- **Murray Darling Basin, Australia**
- South Africa
- Inner Mongolia, China
- Rajasthan, India
- Middle East
- Central Asia

Murray Darling Basin, Australia

The Murray-Darling Basin (MDB) is the "breadbasket" of Australia. Roughly the size of France and Spain combined, it houses 43% of the country's farms (UNCCD 2009). An ongoing drought has reduced precipitation in what is already a low-nutrient ecosystem, engineered in the past to provide water now to roughly 65% of the country's agriculture (Draper 2009). The major impacts are on the agriculture and livestock industries, and include loss of productivity and biodiversity and soil salinization, acidification, and erosion. Direct human health impacts include water pollution from acidification/salinization and air pollution from dust. Under current climate change scenarios, the future outlook for this region is cause for concern.

Land degradation caused by overgrazing (SSchilling on Flickr, Creative Commons license for free reuse 2009)

Citations:

Bai, Z.G., Dent, D.L., Olsson, L. & Schaepman, M.E. 2008. Global assessment of land degradation and improvement. 1. Identification by remote sensing. Report 2008/01, ISRIC – World Soil Information, Wageningen.

Lepers, E., Lambin, E.F., Janetos, A.C., DeFries R., Achard F., Ramankutty, N., Scholes, R.J. 2005. A Synthesis of Information on Rapid Land-cover change for the Period 1981-2000. *Bioscience* 55(2):115-124.

Prince, S. D., Brown de Colstoun, E., & Kravitz, L. 1998. Evidence from rain use efficiencies does not support extensive Sahelian desertification. *Global Change Biology* (4):359–374.