Title
Land use change impacts on public lands and wilderness areas

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Introduction
Land uses, which include activities, such as growing food, logging, or developing urban areas, and land cover, which is the physical characteristics of the land surface respond over time to evolving economic, social, and biophysical conditions. Changes by individual landowners and land managers can be quantified using satellites, aerial photographs, on-the-ground observations, and reports from landowners.

Over the past few decades, the most prominent land changes within the U.S. have been in the amount and type of forest cover due to logging practices and development in the Southeast and Northwest and to urban expansion in the Northeast and Southwest. Land-use and land-cover changes affect local, regional, and global climate processes.

The growth of cities and their associated infrastructure have altered historic water uses. The removal of water from streams and groundwater systems to supply cities, and the land use changes associated with the development of the city, have consequences on our environment. For example, temperatures within cities are warmer than the surrounding countryside because impervious surface area is within cities, which affects the exchange of water and energy between the land and the atmosphere. Our choices regarding land-use and land-cover affect our current environment and will continue to affect our vulnerability to climate change impacts.

Current and historical
In terms of land area, the U.S. remains a predominantly rural country, especially as its population increasingly gravitates towards urban areas. In 1910, only 46% of the U.S. population lived in urban areas, but by 2010 that figure had climbed to more than 81%. In 2006 (the most recent year for which these data are available), more than 80% of the land cover in the lower 48 states was dominated by shrub/scrub vegetation, grasslands, forests, and agriculture. Forests and grasslands, which include acreage used for timber production and grazing, account for more than half of all U.S. land use by area, about 63% of which is in private ownership, though their distribution and ownership patterns vary regionally. Agricultural land uses are carried out on 18% of U.S. surface area. Developed or built-up areas covered only about 5% of the country's land surface, with the greatest concentrations of urban areas in the Northeast, Midwest, and Southeast. This apparently small percentage of developed area belies its rapid expansion and does not include development that is dispersed in a mosaic among other land uses (like agriculture and forests). In particular, low-density housing developments (suburban and exurban areas), which are not well-represented in commonly used satellite measurements, have rapidly

expanded throughout the U.S. over the last 60 years or so. Based on U.S. Census Bureau data, areas settled at suburban and exurban densities (1 house per 1 to 40 acres on average) cover more than 15 times the land area settled at urban densities (1 house per acre or less) and cover five times more land area in 2000 than in 1950.

Despite these rapid changes in developed lands, the vast size of the country means that total land-cover changes in the U.S. may appear deceptively modest. Since 1973, satellite data show that the overall rate of land-cover changes nationally has averaged about 0.33% per year. Yet this small rate of change has produced a large cumulative impact. Between 1973 and 2000, 8.6% of the area of the lower 48 states experienced land-cover change, an area roughly equivalent to the combined land area of California and Oregon.

Nationally, these annual rates of land change mask considerable geographic variability in the types, rates, and causes of change. Between 1973 and 2000, the Southeast region had the highest rate of change, due to active forest timber harvesting and replanting, while the Southwest region had the lowest rate of change.

Future patterns of land use and land cover will interact with climate changes to affect human communities and ecosystems. At the same time, future climate changes will also affect how and where land use and land cover changes.

Projections

National-scale analyses suggest that general historical trends of land-use and land-cover changes will continue, with some important regional differences. These projections all assume continued population growth based modeled rates of birth, death, and migration, which will result in changes in land use and land cover that are spread unevenly across the country. Urban land covers are projected to increase in the lower 48 states by 73% to 98% by 2050, using low versus high growth assumptions, respectively. The slowest rate of increase is projected in the Northeast region, because of the high level of existing development and relatively low rates of population growth while the highest rate is projected for the Northwest. In terms of area, the Northwest has the smallest projected increase in urban area (approximately 4.2 million acres) and the Southeast the largest (approximately 27.5 million acres).

Changes in development density will have an impact on how the human population is distributed. Some of the projected changes in developed areas will depend on changes in household size and the density of urban development. Higher population density means less land is converted from forests or grasslands, but results in a greater extent of impervious surface. Projections of housing-unit density can assess the impacts of urban land-use growth by density class. Increases in low-density exurban areas will result in a greater area affected by development and are expected to increase commuting times and infrastructure costs. The areas projected to experience exurban development will have a lower density of impervious surfaces. Approximately, one-third of exurban areas are covered by impervious surfaces, while urban or suburban areas are about one-half. Impervious surfaces have a wide range of environmental impacts and represent a key means by which developed lands modify the movement of water, energy, and organisms. For example, areas with more impervious surfaces, such as parking lots and roads tend to experience more rapid runoff, greater risk of flooding, and higher temperatures from the urban heat-island effect.

Projections of both land-use and land-cover changes will depend to some degree on rates of population and economic growth. In general, scenarios that assume continued high growth produce more rapid increases in developed areas of all densities and in areas covered by impervious surfaces by 2050. Land-use scenarios project that exurban and suburban areas will expand nationally by 15% to 20% between 2000 and 2050, based on high- and low-growth scenarios respectively. Land-cover projections indicate both cropland and forest will decline by 6% to 7%, respectively, by 2050 under a scenario of high population and economic growth and by 4% and 6%, respectively under lower-growth scenarios. More forest than cropland is projected to be lost in the Northeast and Southeast, whereas more cropland than forest is projected to be lost in the Midwest and Great Plains. Some of these regional differences are due to the current mix of land uses, others to the differential rates of urbanization in these different regions.

There is growing evidence that land use, land cover, and land management affect the U.S. climate. For example:

- Air temperature and near-surface moisture are changed in areas where natural vegetation is converted to agriculture. This effect has been observed in the Great Plains and the Midwest, where overall dew point temperatures or the frequency of occurrences of extreme dew point temperatures have increased due to converting land to agricultural use. This effect has also been observed where the fringes of California’s Central Valley are being converted from natural vegetation to agriculture.
- Other areas where uncultivated and conservation lands are being returned to cultivation, for example from restored grassland into biofuel production, have also experienced temperature shifts. Regional daily maximum temperatures were lowered due to forest clearing for agriculture in the Northeast and Midwest, and then increased in the Northeast following regrowth of forests due to abandonment of agriculture.

Impacts to Wilderness

Research by Martinuzzi et al. (2014) suggests that “urban expansion will continue to be a major threat to protected areas in the U.S., and that a substantial number of protected areas are likely to see some level of decline in surrounding natural vegetation as a result of future land use change. The implementation of land use policies or changes in crop prices are not likely to change the overall pattern of future land use around protected areas, but can have important consequences at the scale of individual protected areas or regions. Their study revealed that future land-use changes will affect protected areas differently. Future land-use changes are likely to be more pronounced around Refuges, followed by Forests, Parks, and ultimately Wilderness Areas. This is explained in part by the geographic distribution of the different protected areas. Refuges occur typically in lowland areas, within an agricultural matrix, and are surrounded by private lands, while Wilderness Areas, tend to be embedded in public lands and are often located in mountainous areas, making them more isolated and protected from human land uses Projections under Business As Usual conditions (i.e. following 1990s trends) resulted in substantial changes in land use around individual protected areas, characterized typically by urban expansion, decrease in crop/pasture cover, and decrease in natural vegetation. Urbanization emerged as a major threat under our Business As Usual and most of our scenarios, reinforcing recent findings on future urban growth impacts on protected areas and highlighting the need to seriously consider urban growth in future planning for protected areas."

Research Needs on direct and indirect influences of land-use and land cover changes on wilderness areas

- Assess the impact of land use changes related to energy development for oil, oil shale, wind, coal, and wood.
- Assess indirect impacts of increasing air pollution, noise, and night lights (i.e., reducing night sky darkness).
- Assess impact of land use change on water use that could affect wilderness, such as acidification of surface waters, ground water table reduction, and downstream impacts affecting upstream ecosystems.
- Assess the influence of other ecosystem changes, such as timing of snow melt and phenology on wilderness areas.
- Will land use change lead to greater impact from invasives on native habitat?
- What are land use change impacts to biodiversity with particular emphasis on the impacts to keystone species and threatened and endangered species?
- Where will increase in visitors be greatest? Describe impacts?
- Where will the impacts from climate change be the greatest? How will it affect ecosystem type, species habitat, water provisioning, and biodiversity? Where do climate change models predict the greatest change in the frequency of extreme weather? Describe the impact to the existing ecosystems.

Results should be provided for public lands in the U.S. and for wilderness lands and by land management agency.

References

Scenarios of future land use change around United States' protected Areas. Biological Conservation. 2014 Sebastián Martinuzzi, Volker C. Radeloff, Lucas N. Joppa, Christopher M. Hamilton, David P. Helmers , Andrew J. Plantinga, David J. Lewis. http://nca2014.globalchange.gov/report/sectors/land-use-and-land-cover-change#intro-section-2