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Full Length Research Paper

Land-cover adjustment on the southern Kenai Peninsula lowlands, Alaska using USGS land cover technique

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This brief communication demonstrates land cover change on the southern Kenai Peninsula Lowlands (sKPL), Alaska, using U.S. Geological Survey, Land Cover Trends protocols. The Trends project seeks to understand the rates, causes, and consequences of land cover change for the United States between 1973 and 2000 using Landsat Multi-spectral Scanner (MSS), Landsat Thematic Mapper (TM) and Enhanced Thematic Mapper (ETM+) datasets. Two of 35 randomly selected sample blocks within the Cook Inlet Ecoregion (CIE) are analyzed here to demonstrate the types of change typical of road-accessible forested portions of the sKPL during the latter part of the 20th Century. Land cover change increased substantially during the 1995 to 2002 time period, when compared to the 1973 to 1995 time period, as a result of a bark beetle infestation that affected much of the white/Lutz spruce forests located on the sKPL, leading to timber harvest. The consequences of the bark beetle impact have been numerous: loss of sustainable, harvestable timber, forest-stand conversion, change in wildlife habitats, changes in hydrology, increases in fire hazards and shifts in fire seasonality.

Key words: Alaska, bark beetle, change detection, Kenai Peninsula, USGS land cover trends.

INTRODUCTION

Alaska is a vast land, spanning approximately 1,500,000 km^2, nearly one-fifth the size of the conterminous United States. Although the population of Alaska has increased more than 50% during the last 50 years, the land surface remains sparsely populated. Both the population and economy have traditionally been driven by boom and bust cycles, primarily from mineral discoveries, logging, military expansion, and oil and gas development (Leask et al., 2001); however, the land cover changes as a result of these factors have occurred in relatively small, localized areas. Large-scale statewide changes taking place on the landscape are primarily a result of natural processes such as wildfires, insect infestations, permafrost degradation and other processes which are often linked to changes in climate (Juday et al., 1998).

This brief communication reports on change detected as a part of the U.S. Geological Survey, National Land Cover Trends project in Alaska. The objectives of the Trends project are threefold: (1) document the types, rates, and temporal variability of land cover change in an ecoregion framework between 1973 and the early-2000s; (2) Document the regional driving forces and consequences of land cover change; and (3) synthesize individual ecoregion investigations into a national assess-ment of land cover change (Loveland et al., 2002). Here, two of 35 randomly selected, 10 square kilometer sample blocks are presented for the Cook Inlet Ecoregion (CIE). These blocks provide an example of change typical of road-accessible, forested lands on the southern Kenai Peninsula Lowlands (sKPL) between 1973 and 2002 and its implication to management as it relates to insect infestations, logging, and shifting fire hazards associated with changes in land cover.

Study area

The CIE spans a land area of 38,000 km^2 and more than 60% of Alaska's population resides here. The ecoregion is demarcated by the 600 m elevation contour along the foot hills of the Alaska, Talkeetna and Chugach Mountain Mountains, exhibits relatively low topographic relief, and experiences a combination of maritime and continental

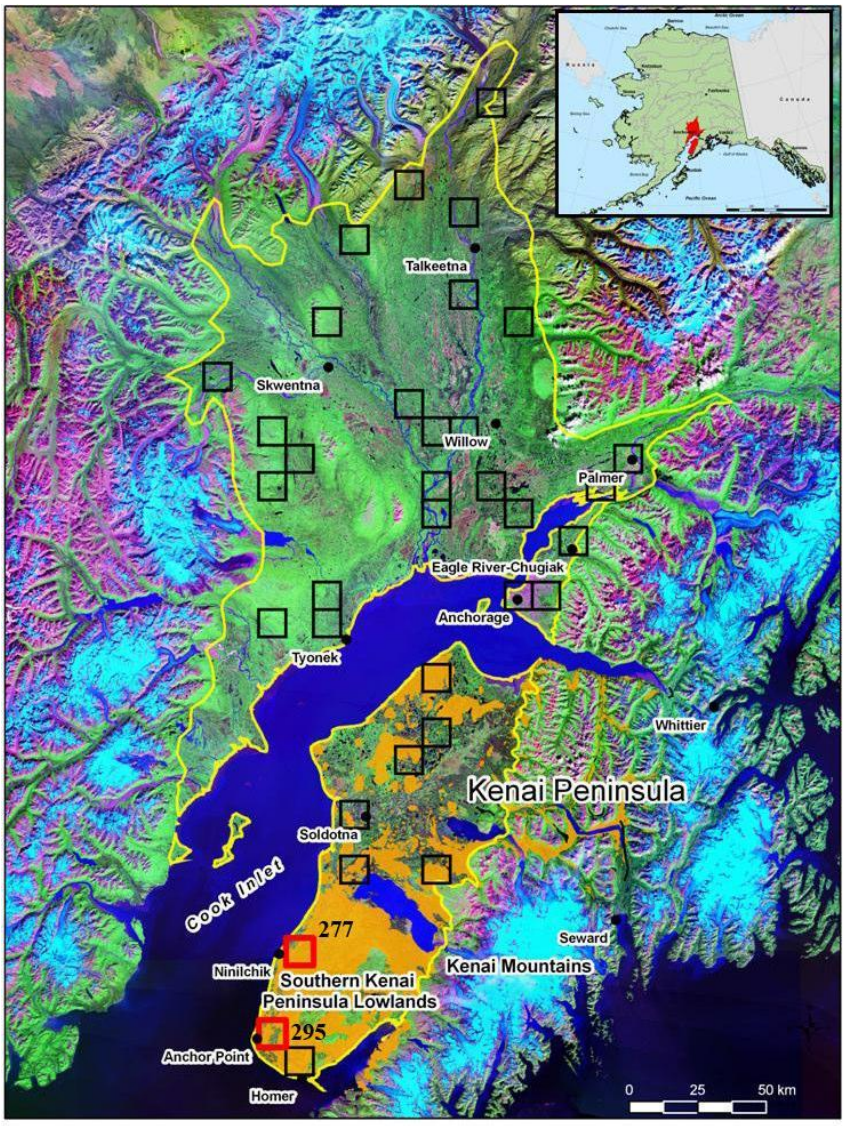

Figure 1. Landsat satellite image mosaic of portion of south central Alaska with the Cook Inlet Ecoregion outlined in yellow (shaded red in inset map). The black boxes represent the 35 sample blocks selected for analysis of land cover change in the ecoregion and the two boxes highlighted in red represent the blocks focused on in this short communication. The areas in orange are the cumulative bark beetle impact on the Kenai Peninsula between 1989 and 2002 (Data sources: USFS and AKDNR).

climatic influences. The sKPL is located at the southern end of the CIE between Cook Inlet and the Kenai Mountains. The forests of the sKPL are dominated by a mix of white spruce, Lutz spruce, paper birch, and cottonwood, with black spruce occurring at poorly drained sites.

The two sample blocks presented here are located on the sKPL near the villages of Ninilchik (Block 277) and Anchor Point (Block 295) (Figure 1). The Kenai Peninsula has recently been subject to the largest recorded case of tree mortality due to a single insect outbreak in all of North America (Matsuoka et al., 2006), which was believed to be a result of warm climatic conditions. Berg et al. (2006) suggest that increased air temperatures and reductions in precipitation sparked the outbreak resulting in a combination of increased spruce beetle population size due to over winter survival, a doubling of the maturation rate from 2 years to 1 year, as well as drought-induced stress of mature host trees. The outbreak began in 1989 and peaked in 1996 and more than 12,000 km^2 of forest have been impacted (U.S. Forest Service, 2005).

MATERIALS AND METHODS

Thirty-five 10 square kilometer sample blocks were randomly se-

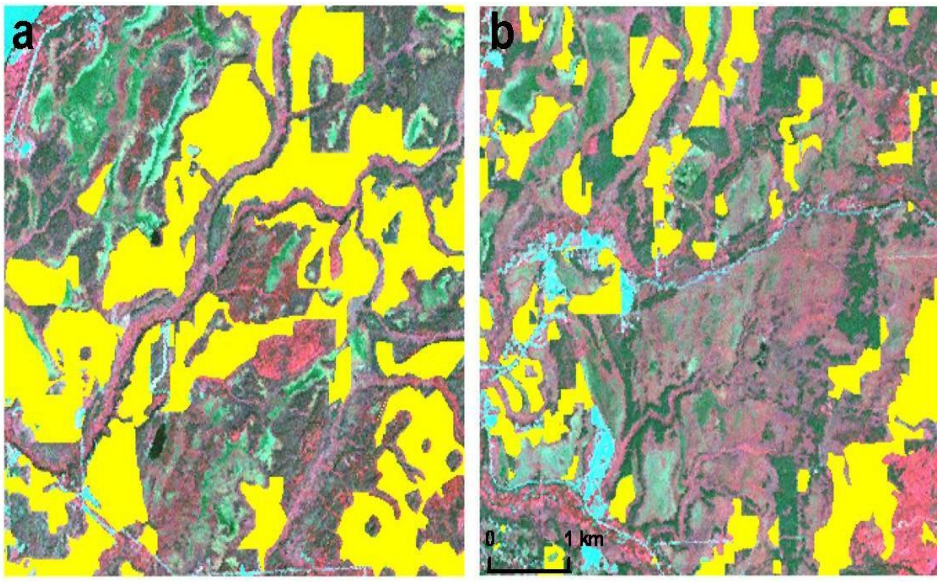

Figure 2. Areas logged (yellow) as a result of spruce bark beetle infestation for Block 277 (a) and Block 295 (b); the net change in percent cover of forest within each block declined by 33 and 20%, respectively. These logged areas are now primarily grass/shrublands; and a fundamental shift in wildlife habitat, carbon sequestration, forest stand dynamics, and fire hazard has occurred

lected in the CIE to characterize change occurring across the eco-region. Analysis of land cover change within these sample blocks was then based on manual interpretation of Landsat satellite imagery. Landsat Multi-spectral Scanner (MSS) imagery at a resolution of 60 m, Thematic Mapper (TM) imagery at a resolution of 30 m, and Enhanced Thematic Mapper (ETM+) imagery at a resolution of 30 m, were acquired for five target dates (1973, 1980, 1986, 1992, and 2000; ± 3 years); MSS data was available for the years of 1973 and 1980, TM data for the years of 1986 and 1995, and ETM+ data for the year 2002. Eleven land cover and land use categories are utilized in the classification process: water, developed, mechanically disturbed, mines and quarries, naturally barren, forest and woodlands, grasslands and shrubs, agriculture, wetland, non-mechanically disturbed, and snow and ice (Anderson, 1976). Mechanically disturbed (that is, logged) and non-mechanically disturbed (that is, forest fire) classes have been added to this classification scheme in order to detect land-use and land cover changes as a result of anthropogenic and natural forces, respectively. High-resolution aerial photography from the 1980s and 1996 and other ancillary datasets (that is, wetlands map of the Kenai (Gracz et al., 2008), National Land Cover Data for Alaska (MRLC, 2008)) aided in the interpretation of the Landsat imagery. The TM and ETM+ classifications were then resampled to 60 m to correspond to the image resolution of the MSS data. The sample block land cover data is then used to analyze the spatio-temporal pattern in the rates of change and to identify and document the causes and consequences driving land cover change (Loveland et al., 2002).

RESULTS AND DISCUSSION

The primary drivers of change along road-accessible areas on the sKPL were due to the spruce bark beetle infestation in the early to mid-1990s and subsequent salvage logging operations in the infested areas. The impacts related to the recent activity on the Kenai Peninsula are evident in both blocks analyzed (Figure 2). Change within each of the blocks increased dramatically during the time period 1995 to 2002 when compared to the earlier time period, 1973 to 1995, as a result of logging in response to the beetle infestation (Table 1). More than 30% of the forested lands were logged in Block 277 and nearly 20% of the forested lands were logged in Block 295. Logging within these areas has occurred for two primary reasons: (1) to salvage timber for wood chipping and (2) to remove dead timber that provides a source of fuel for forest fires (Wittwer et al., 1998) . In order to more fully understand change in land cover types, areas originally classified as mechanically disturbed (logged) were included in percent cover type estimates of grass and shrub lands, as these areas are now representative of this cover type. Thus, the reduction in forest cover corresponded to a nearly identical increase in the percent cover of grass and shrub lands. While wildfires and human-induced fires have occurred in areas affected by the spruce bark beetle outbreak on the Kenai Peninsula all of the loss of forest in these two blocks occurred as a result of logging. Excluding changes in fo-rest and grass/shrub lands, estimated percent cover change for all other land cover types remained below 1% in each of the time periods.

The sKPL has been the hardest hit area on the Kenai Peninsula as a result of the spruce bark beetle outbreak. Not only has the infestation led to widespread logging in areas accessible via the road network, but also dramatic changes in forest composition, with high spruce mortality and increases in early successional grasses and forbs,

Table 1. Estimated percent cover change between 1973 and 2002 for Blocks 277 and 295. Percent cover change by land cover class has been grouped into two time periods, 1973 - 1995 and 1995 - 2002, to reflect pre- and post-peak in spruce bark beetle infestation on the southern Kenai Peninsula Lowlands.

	1973 to 1995		1995 to 2002		1973 to 2002	
	Block 277	Block 295	Block 277	Block 295	Block 277	Block 295
Open Water	-0.09	-0.01	0.06	0.01	-0.03	0.00
Urban Developed	0.14	0.20	0.27	0.65	0.41	0.85
Mining/Quarries	0.04	0.74	0.00	0.23	0.04	0.97
Naturally Barren	0.06	0.00	0.02	0.00	0.08	0.00
Forest	-3.46	-4.84	-29.60	-14.69	-33.04	-19.53
Grass/Shrub	3.29	3.90	29.24	13.82	32.53	17.72
Agriculture	0.00	0.00	0.00	0.00	0.00	0.00
Wetland	0.00	0.01	0.00	-0.01	0.00	0.00

such as blue joint grass and fireweed (Boucher and Mead, 2006). The socioeconomic conditions of the region have also been altered due to loss of sustainable, harvestable timber, long-term stand conversion, changing wildlife habitats and behavior, impacts on aesthetic value, increases in fire hazard conditions, and impacts on hydrology and fisheries (Forest Health Monitoring, 2004; Werner et al., 2006). Not only have fire hazard conditions increased due to standing and downed dead timer, the timing of fire outbreaks has shifted such that early season fires are more likely due to the conversion from healthy forests to unhealthy forests surrounded by successional grasses (KPB-SBBMP, 2008).

Conclusion

These findings show examples of the types of change that can be assessed through the use of U.S. Geological Survey Land Cover Trends methodology in a small portion of Alaska. Rates of land cover change increased over the study period for the two sample blocks assessed in this short communication. The increase in the rate of change of land cover in the more recent time period, due to changes in the primary land cover type (that is, forests), was caused by an insect infestation that began in 1989 and peaked in 1996. Logging of the infected spruce forests to salvage timber and mitigate wildfire hazards followed soon thereafter. These logged areas are now largely grass and shrub lands. Land cover con-versions such as these result in several consequences such as increased early season fire hazard, reduced carbon sequestration, warmer surface temperatures due to reduced evapotranspiration, changes in wildlife habitat, and changes in forest stand dynamics.

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