

DISCUSSION

The Lake Tahoe basin has been subject to significant landscape-altering human activity since the mid-1850s, in particular, widespread timber harvest from the 1850s to 1920s and urban development from the 1950s to the present. The consequences of changes such as impacted water quality, degraded biotic communities, and increased fire hazard resulting from modern activity have prompted rising levels of concern for the ecological integrity of the region. The goal of this project is to map, quantify, and describe the spatial and temporal distribution and variability of historical changes in land use and land cover in the southern Lake Tahoe basin for the period from 1940 to 2002 in an effort to establish a baseline understanding of regional landscape change.

This map shows areas of land-use/land-cover change in a 27,948-hectare portion of the Lake Tahoe basin identified using change-detection analysis of multitemporal land-use/land-cover datasets for four dates (1940, 1969, 1987, and 2002), which yielded three periods for analysis. Land use/land cover was mapped using manual (visual) interpretation techniques in a geographic information system (GIS) from multiple imagery sources: black-and-white digital orthophotos for 1940 and 1969, natural-color digital orthophotos for 1987, and IKONOS multispectral satellite imagery for 2002. The landscape was classified using a 0.4-hectare (1-acre) minimum mapping unit and a hierarchical classification system derived from the Anderson and others (1976) system that was modified to better characterize the Lake Tahoe basin. In total, 43 classes were interpreted as high as an Anderson Level III-equivalent thematic resolution. Impervious-surface data was derived directly from the 2002 IKONOS imagery on a per-pixel basis using digital image processing and GIS data integration (Cahill and Minor, 2003). This impervious-surface dataset has a 1-m cell size and an overall statistical accuracy of 92%.

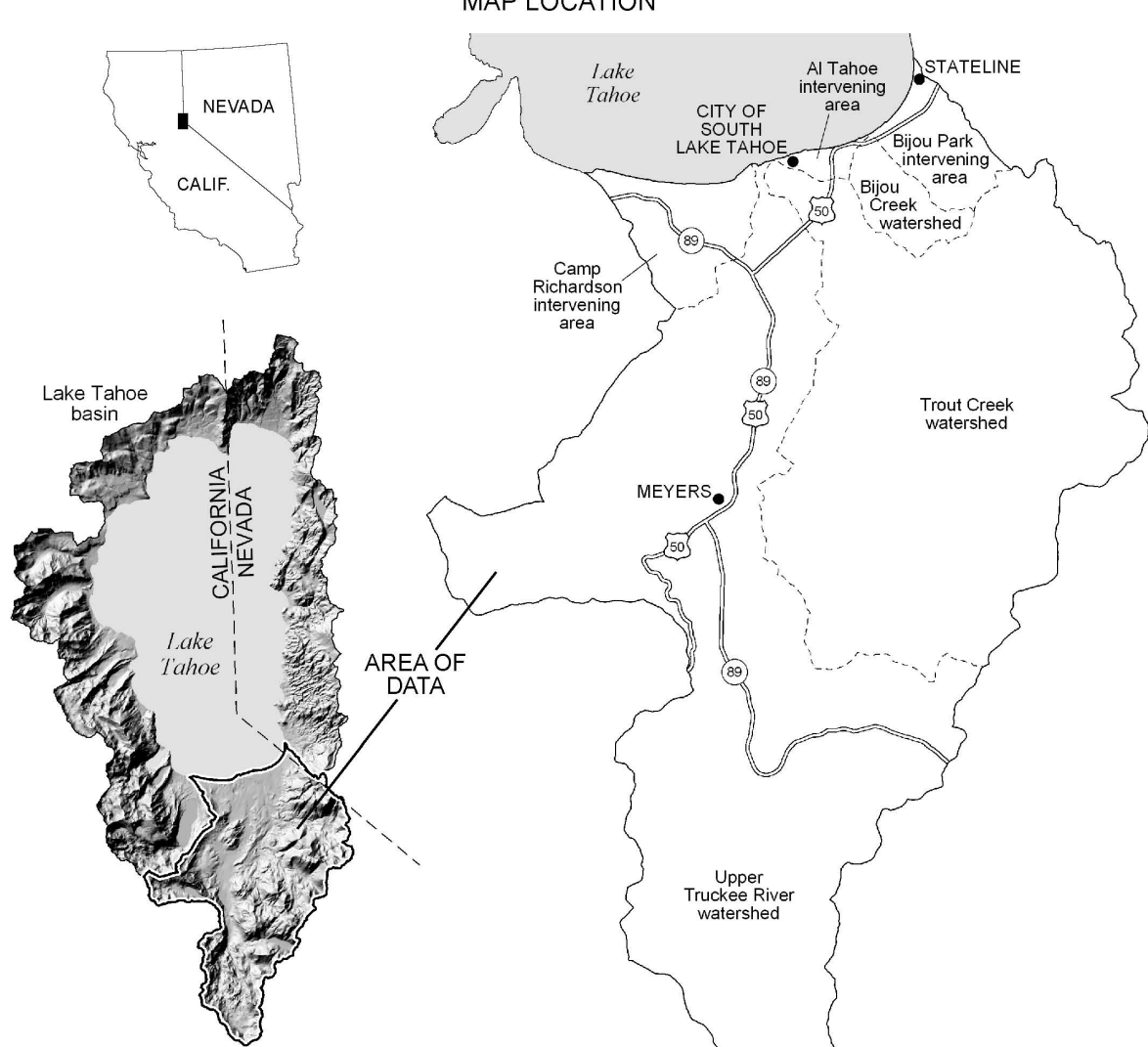
Postclassification comparison of the four dates of land-use/land-cover data provided a means to identify the locations of changed areas in the southern Lake Tahoe basin. Some areas may have changed during more than one of the three periods, and in these cases, the most recent change is shown. The most significant changes during the 62-year study period were an increase in developed lands with a corresponding decrease in natural land cover, changes in forest density within the forested areas, overall forest loss, forest expansion, and tree mortality. The highest rates of change occurred from 1940 to 1969 and rates have declined from 1969 through 2002 for all changes except forest density decrease and tree mortality. Causes of change included regional population growth, tourism demands, timber harvest for local use, fire suppression, bark beetle attack, and fuels reduction activities. Results from this study will provide a basis for making better informed land-use and management decisions aimed at minimizing ecological impacts of landscape change. This project is part of ongoing research quantifying and analyzing trends in development, land management, and forest succession during the most intensive urbanization period for the Lake Tahoe basin.

REFERENCES

Anderson, J.R., Hardy, E.E., Roach, J.T., and Witmer, R.E., 1976. A land use and land cover classification system for use with remote sensor data. U.S. Geological Survey Professional Paper 964.

Cahill, M.E., and Minor, T.B., 2003. Detecting and discriminating impervious cover with high resolution Ikonos data using principal components analysis and morphological operators. *International Journal of Remote Sensing* v. 24, p. 4627-4645.

MAP LOCATION



Wetland (forested)—Wetland areas that are dominated by coniferous and deciduous trees. These wetlands are often closed canopy of deciduous and evergreen trees normally associated with watercourses, edges of marshes, and isolated wetlands. Common species include willow, cottonwood, alder, aspen, and pine.

Barren—Undeveloped land with < 10% vegetative cover. Includes exposed rock, rock slides, talus cones, glacial debris, and beaches (natural and man made). Mapped barren lands are usually naturally occurring.

LAND CHANGED BETWEEN 1940 AND 2002

In areas that underwent more than one change between 1940 and 2002, the most recent change is shown.

Development (impervious)—Areas that changed from any undeveloped class or pervious-surface developed class to impervious surfaces. Impervious surfaces prevent any percolation of runoff or direct precipitation into the underlying soil. Impervious surfaces include paved roads, paved parking lots, paved driveways, and building footprints. Higher thematic resolution, developed land-use classes include single and multifamily residential, commercial, industrial, transportation, communications, utilities, and recreational.

Development (nonwetland, pervious)—Areas that changed from any non-wetland undeveloped class to any pervious-surface developed class. The pervious developed land-cover matrix allows percolation of runoff or direct precipitation into the underlying soil, although this function may be altered. Actual land covers include turf, gravel-covered areas, unpaved parking areas, unpaved roads, areas of intensive landscaping, highway medians, and mechanically disturbed areas. Some developed areas may fit the criteria for other natural-cover classes, such as forest. Higher thematic resolution, developed land-use classes include single and multifamily residential, commercial, industrial, transportation, communications, utilities (including utility corridors), and recreational. Of the 2,487 ha of developed land (pervious and impervious) converted from wetland and nonwetland areas shown, 4.5% was developed prior to 1940.

Development (wetland, pervious)—Areas that changed from any undeveloped wetland class to any pervious-surface developed class. The pervious developed land-cover matrix allows percolation of runoff or direct precipitation into the underlying soil, although this function may be altered. Actual land covers include turf, gravel-covered areas, unpaved parking areas, unpaved roads, areas of intensive landscaping, highway medians, and mechanically disturbed areas. Higher thematic resolution, developed land-use classes include single and multifamily residential, commercial, industrial, transportation, communications, utilities (including utility corridors), and recreational. Of the 2,487 ha of developed land (pervious and impervious) converted from wetland and nonwetland areas shown, 4.5% was developed prior to 1940.

Dredging for the Tahoe Keys—Areas of herbaceous wetlands that changed to open water by way of dredging near the shore of Lake Tahoe in the mid-1960s to create the Tahoe Keys residential development. This area meets the criteria for the water class.

Forest density increase—Areas of forest that changed from a canopy-cover density of 10-50% to a canopy-cover density of > 50%.

Forest density decrease—Areas of forest that changed from a canopy-cover density of > 50% to a canopy-cover density of 10-50%.

Forest loss (nondevelopment)—Areas that changed from forest (both canopy-cover density classes) to grassland/shrubland.

Forest loss (ski runs)—Areas that changed from forest (either canopy-cover density) to grass/shrubland areas used as ski runs.

Forest encroachment or regeneration—Includes several land-cover changes: change from grassland/shrubland to forest, change from herbaceous wetland to forest or forested wetland, and change from scrub/shrub wetland to forest or forested wetland.

Tree mortality—Includes two land-cover changes: change from dead upland vegetation and change from forested wetland to dead wetland vegetation. Both of these dead vegetation classes include dead trees in areas where at least 85% of the over-story vegetation is dead. This change does not include burned vegetation.

HYDROGRAPHY FOR YEAR 2002

Although some changes have occurred to the fluvial system within the mapped area, these changes are not clear at map scale. As a result, hydrographic features for the mapped area were taken from the year 2002 land-use/land-cover data layer and do not reflect changes in the fluvial system that may have occurred between 1940 and 2002.

Lake, reservoir, or pond

Stream

Hydrographic boundary of the Lake Tahoe basin

Boundary of mapped data

Lake, reservoir, or pond (outside of mapped data area)

DESCRIPTION OF MAP UNITS

LAND UNCHANGED BETWEEN 1940 AND 2002

- Forest (10-50% canopy cover)**—Tree-covered land where the tree canopy-cover density is between 10 and 50%. Canopy cover density provides a reasonable estimate of stand density. Forests (non-wetland) in the Lake Tahoe basin are dominated by coniferous tree species. Common species include pine (such as ponderosa, Jeffrey, lodgepole, sugar, western white, whitebark), fir (white, red), mountain hemlock, incense-cedar, and juniper. Relatively small stands of deciduous trees may occur within the forest class.
- Forest (> 50% canopy cover)**—Tree-covered land where the tree canopy-cover density is > 50%. Canopy cover density provides a reasonable estimate of stand density. Forests (nonwetland) in the Lake Tahoe basin are dominated by coniferous tree species. Common species include pine (such as ponderosa, Jeffrey, lodgepole, sugar, western white, whitebark), fir (white, red), mountain hemlock, incense-cedar, and juniper. Relatively small stands of deciduous trees may occur within the forest class.
- Grassland or Shrubland**—Land predominantly covered with grasses, forbs, and (or) shrubs comprising at least 10% of the area. Grassland areas are dominated by native or exotic herbaceous plants. Shrubland areas are dominated by woody vegetation predominantly < 6 m tall with large trees comprising < 10% canopy cover. Includes evergreen and deciduous species of true shrubs, desert scrub, montane chaparral, and trees that are small or stunted because of adaptations to environmental conditions (krummholz). Common shrub species include mountain sagebrush, manzanita, chinquapin, rabbit brush, bitterbrush, desert peach, willow, mountain mahogany, creosote bush, hackberry oak, tobacco brush, Ceanothus, and whitebark pine.
- Wetland (herbaceous and scrub/shrub)**—Land where the water table is at, near, or above the land surface for a significant part of most years, and vegetation indicative of this covers more than 25% of the land surface. Wetlands include marshes, swamps situated on the shallow margins of bays, lakes, ponds, streams, or reservoirs; wet meadows or perched bogs in high mountain valleys; or seasonally wet or flooded low spots or basins. Scrub/Shrub wetlands are dominated by woody plant species < 6 m tall.

Universal Transverse Mercator projection, Zone 10
Land-use/land-cover data manually reclassified from the following imagery:
Year 2002: IKONOS satellite imagery acquired 19 Jul 2002
Year 1987: Digital orthophotos produced from natural-color photographs dated 27 Jul 1987
Year 1969: Digital orthophotos produced from black-and-white photographs dated 18 Aug 1969
Year 1940: Digital orthophotos produced from black-and-white photographs dated 13 Jul 1940
Impervious-surface data derived through digital image processing of IKONOS imagery acquired 19 Jul 2002
Hydrographic data from year 2002 land-use/land-cover data
Elevation data from USGS 30m Digital Elevation Model
Slope boundaries for the shaded-relief image from the north-south (10°) and east-west (10°) slope boundaries
Hydrographic data outside of mapped area from USGS 1:250,000-scale Digital Line Graph



Land-Cover Change in the Southern Lake Tahoe Basin, California and Nevada, 1940-2002

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