Tree Canopy Report: Honolulu, HI, 2013

Why is Tree Canopy Important?

Trees provide many benefits to communities, such as improving water quality, reducing storm water runoff, lowering summer temperatures, reducing energy use in buildings, reducing air pollution, enhancing property values, improving human health, and providing wildlife habitat and aesthetic benefits[1]. Many of the benefits that trees provide are correlated with the size and structure of the tree canopy, which is the layer of branches, stems, and leaves of trees that cover the ground when viewed from above. Therefore, understanding tree canopy is an important step in urban forest planning. A tree canopy assessment provides an estimate of the amount of tree canopy currently present as well as the amount of tree canopy that could theoretically be established. The tree canopy products can be used by a broad range of stakeholders to help communities plan a greener future.

[1]National Research Council. *Urban Forestry: Toward an Ecosystem Services Research Agenda: A Workshop Summary*. Washington, DC: The National Academies Press, 2013.

How Much Tree Canopy Does Honolulu Have?

An analysis of Honolulu land-cover data (Figure 1) for the year 2013, derived from high-resolution aerial imagery and LiDAR, found that 31,168 acres of the full study area were occupied by tree canopy (termed Existing Tree Canopy). This represented 23% of all land in the study area. When considering only areas zoned as urban, tree canopy covered 15,239 acres, or 19% of the urban zone (Figure 2). An additional 59% (46,584 acres) of the urban zone could theoretically be modified to accommodate tree canopy (termed Possible Tree Canopy). Within the Possible Tree Canopy category, 33% (25,864 acres) of the urban zone was classified as Vegetated Possible Tree Canopy and another 26% as Impervious Possible Tree Canopy (20,720 acres). Establishing tree canopy on areas classified as Impervious Possible Tree Canopy will have a greater impact on water quality and summer temperatures while the grasses and shrubs in Vegetated Possible Tree Canopy are more readily conducive to establishing new tree canopy.

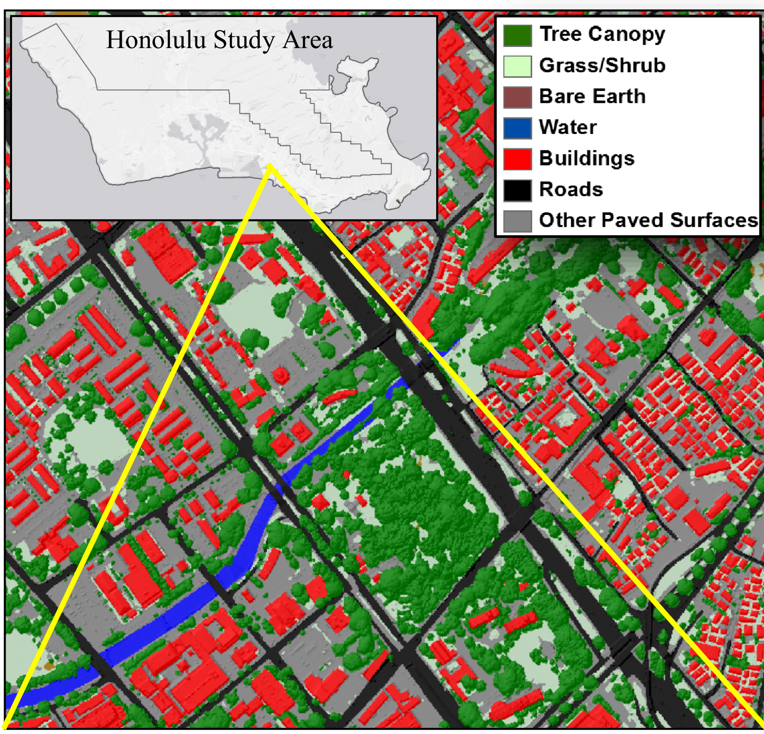

Figure 1: Study area and example of the land cover derived from high-resolution imagery for this project.

Tree Canopy Assessment Data

This project applied the USDA Forest Service's Tree Canopy Assessment protocols to Honolulu, HI. These protocols make it possible to examine a municipality's tree canopy at scales ranging from individual property parcels to landscape-level descriptors such as watersheds. Any geography of interest, whether ecological, administrative, or planning-related, can be used to summarize tree-canopy area and distribution. Ultimately, this information can be used to monitor environmental change and to prioritize tree-planting efforts.

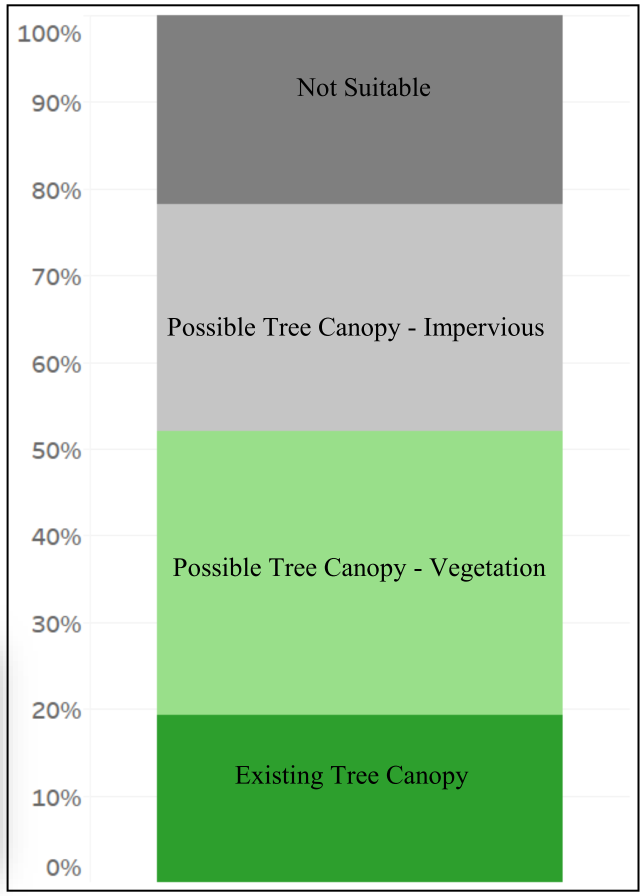

Figure 2: Tree Canopy metrics for areas of Honolulu, HI zoned as urban, expressed as percent land area covered of each tree canopy type.

Key Terms

Land Cover: Physical features on the earth mapped from aerial or satellite imagery, such as trees, grass, water, and impervious surfaces.
Existing Tree Canopy: The amount of urban tree canopy present when viewed from above using aerial or satellite imagery.
Impervious Possible Tree Canopy: Asphalt or concrete surfaces, excluding roads and buildings, that are theoretically available for the establishment of tree canopy if improvements were made.
Vegetated Possible Tree Canopy: Grass or shrub area that is theoretically available for the establishment of tree canopy.
Not Suitable: Areas where it is highly unlikely that new tree canopy could be established (primarily buildings and roads).

Tree Canopy Change, 2010-2013

One of the most important applications for Tree Canopy Assessment data is change detection: How has a region's tree canopy changed during a specific time interval and where has this change occurred? Because an assessment was previously conducted for Honolulu using data from 2010, it was possible to examine changes in tree canopy during the period 2010-2013. In this change-detection analysis, the tree-canopy map for 2013 was compared to the map for 2010 and areas of gain, loss, and no change were identified. Changes attributable to human activity (e.g., development, planting programs) were the focus of this effort because a slight offset in the input datasets complicated identification of tree growth during the relatively-short evaluation period. Thus, only large or isolated (e.g., newly-planted trees) additions were considered gains or losses. This focus also helped isolate the short-term impact of planting programs designed to improve the extent and health of the region's tree canopy.

Overall, the study area showed a 3.1% net loss of tree canopy; when considering only urban land uses, the net loss was 4.8% The size distribution of tree-canopy features indicated that most of the losses were small patches or individual trees (<0.25 acres), constituting an area of about 900 acres in more than 75,000 polygons (Figure 3). Another 200 acres were lost in medium-sized features (0.25-5 acres). Two very large patches (>=10 acres) accounted for about 100 acres, probably attributable to expansive residential or commercial development. Although the number of large-patch losses was likely underestimated (i.e., some patches consist of regularly-spaced trees rather than contiguous cover), these results suggest that the majority of losses were randomly-distributed anthropogenic (e.g., removal by landowner) or natural (e.g., storms, age) events.

Gains were similarly clustered in the Small category, with about 200 acres in 59,113 features. Most of these were likely newly-planted trees or naturally-growing stems that grew enough during the 3-year period to be captured by the analysis. Another 31 acres in 43 features occurred in the Medium class with sizes up to 5 acres. These features were probably the result of natural revegetation. New trees partially offset the observed losses, but the discrepancy in the number and area of gains and losses in the Small category illustrated the fundamental reality that, on a 1-to-1 basis, a newly-planted sapling will not immediately replace the loss of a mature tree. Furthermore, natural tree growth would have undoubtedly reduced the observed net loss if it had been captured by the analysis.

Other cities in the United States have experienced similar short-term declines in tree canopy. For example, a 3.8% loss was observed in Allegheny County, Pennsylvania (2010-2015) and a 1.6% percent loss was observed in Montgomery County, Maryland (2009-2014). Not all trends are negative, however; Virginia Beach, Virginia experienced a 3.1% increase in tree canopy during the period 2004-2012, suggesting that good stewardship, newly-planted trees, natural tree growth, and a little luck (i.e., no major canopy declines from pests or storms) can maintain or enhance municipal tree cover.

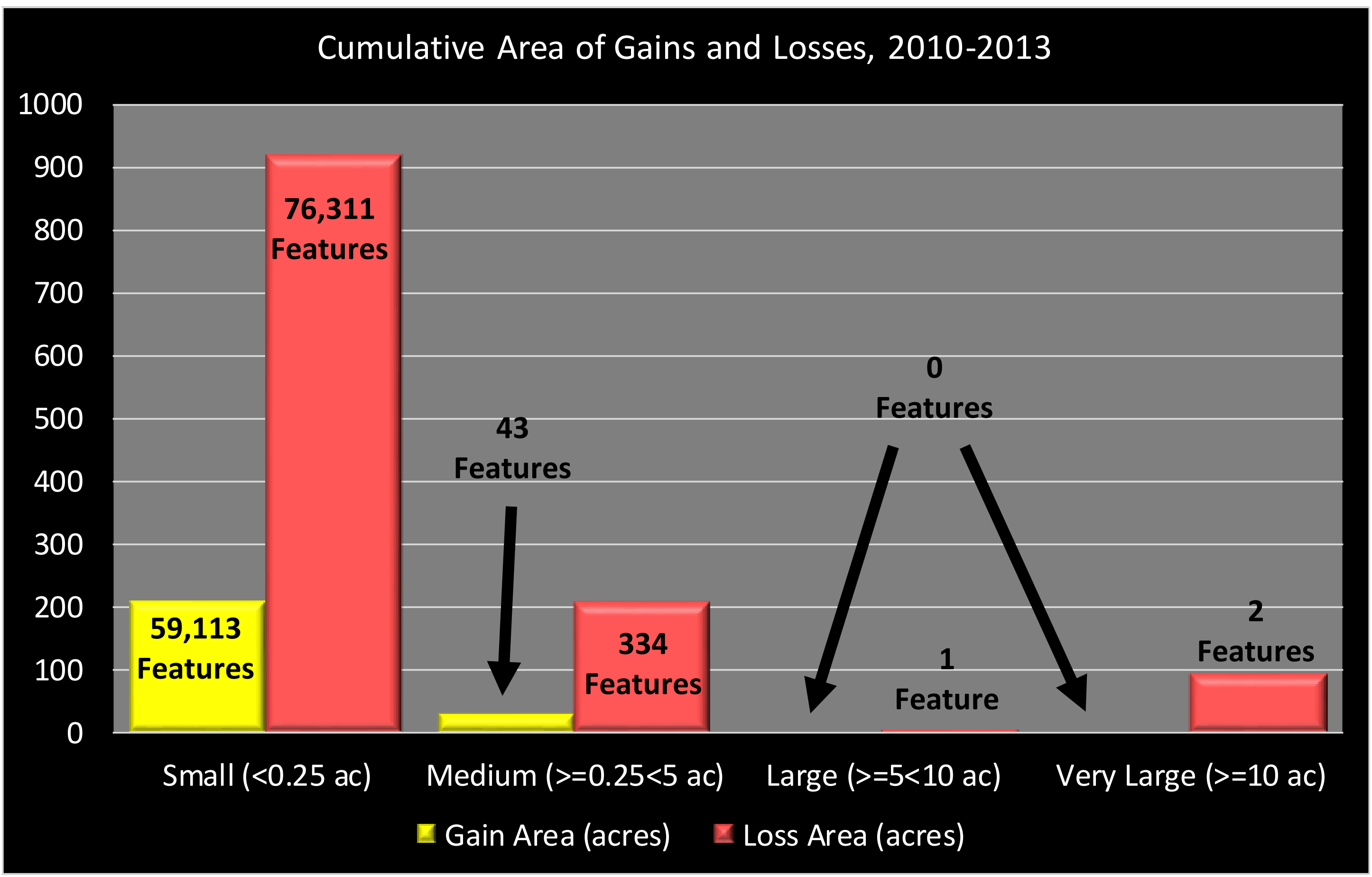

Figure 3: Size distribution of tree-canopy features labeled as gains or losses during the period 2010-2013. Most of the losses were small, isolated patches or individual trees that were only partially offset by similarly-sized gains.

Tree Canopy Change, 2010-2013: Council Districts

In addition to the study-wide totals, tree-canopy change can be calculated according to many different natural and anthropogenic geographies. One is example is council district. Council District 7, located in the center of the study area, had the highest net change by percentage of tree canopy, with a -6% loss (Figure 4). Council District 9, located in the northwestern section of the project area, had the lowest net change, with -2%. By percent loss of tree canopy, Council Districts 5 and 7 had losses of 7% (Figure 5). Each of these districts are located in densely populated areas.

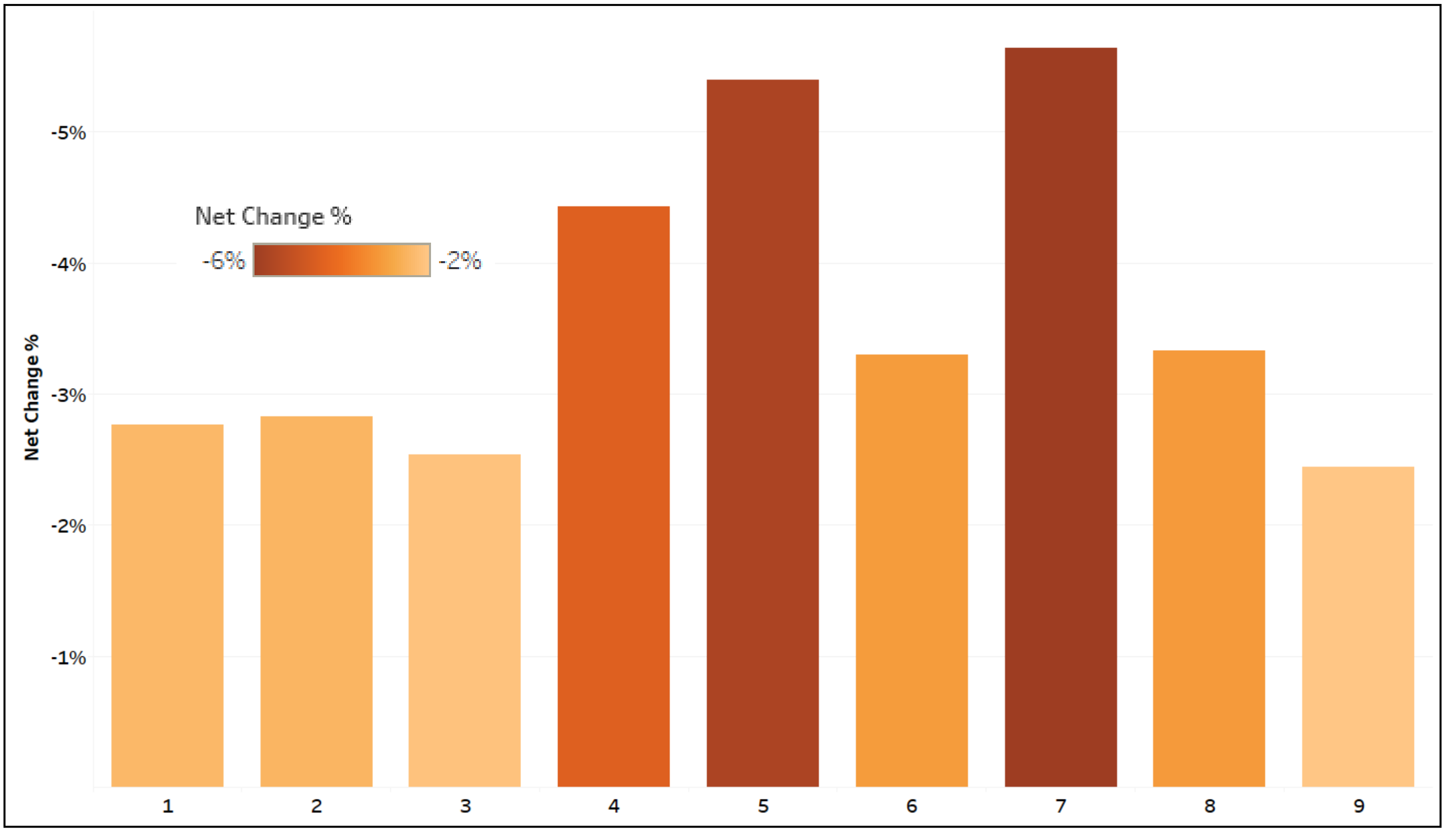

Figure 4: Percent net change in tree canopy for Council Districts, calculated as gains minus losses relative to 2010 conditions. Net change helps show the interaction between gains and losses in individual study units.

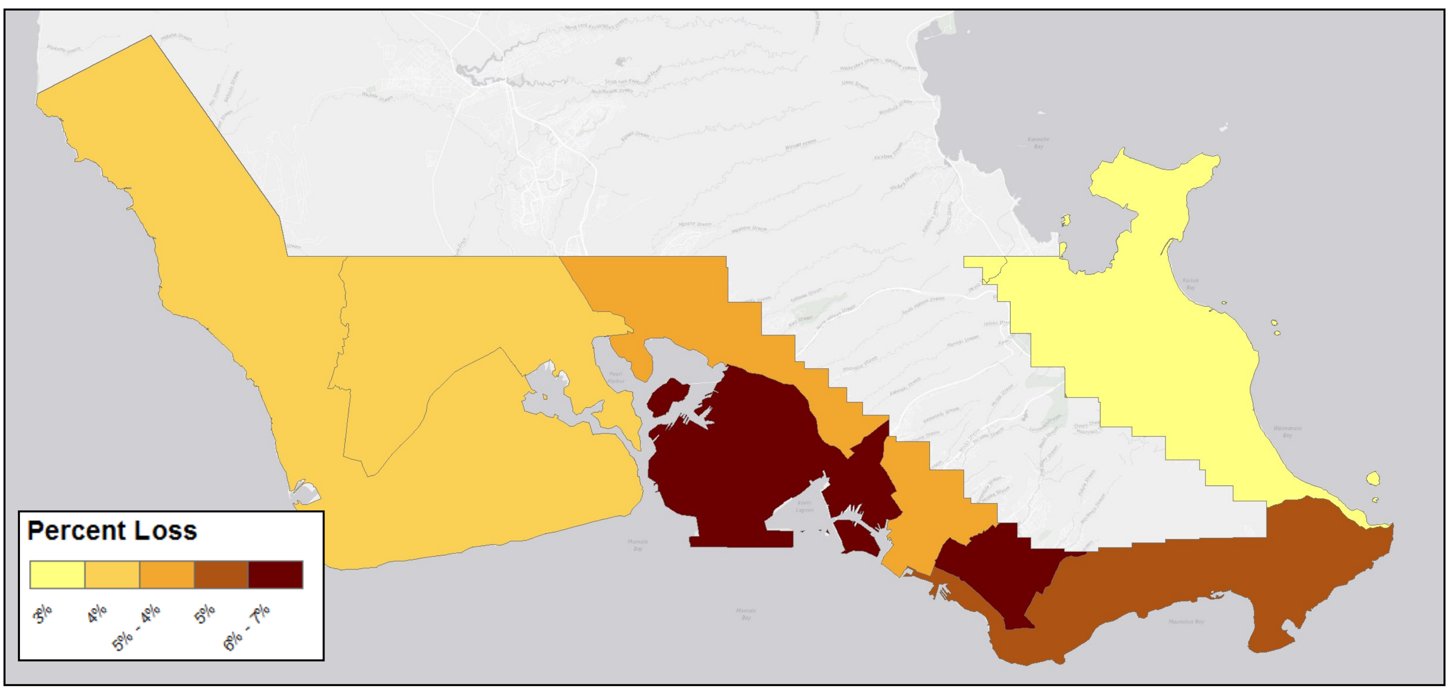

Figure 5: Percent loss in tree canopy for Council Districts, calculated as losses relative to 2010 conditions.. This chart compares the relative magnitude of losses between study units irrespective of gains.

Tree Canopy Change, 2010-2013: Land Use

By land use, the change-detection analysis found that the Urban Land Use class had the highest net percent change, with a tree-canopy loss of 5% (Figures 6 and 7). The Conservation land use class had the smallest change, losing less than 1% of its tree canopy.

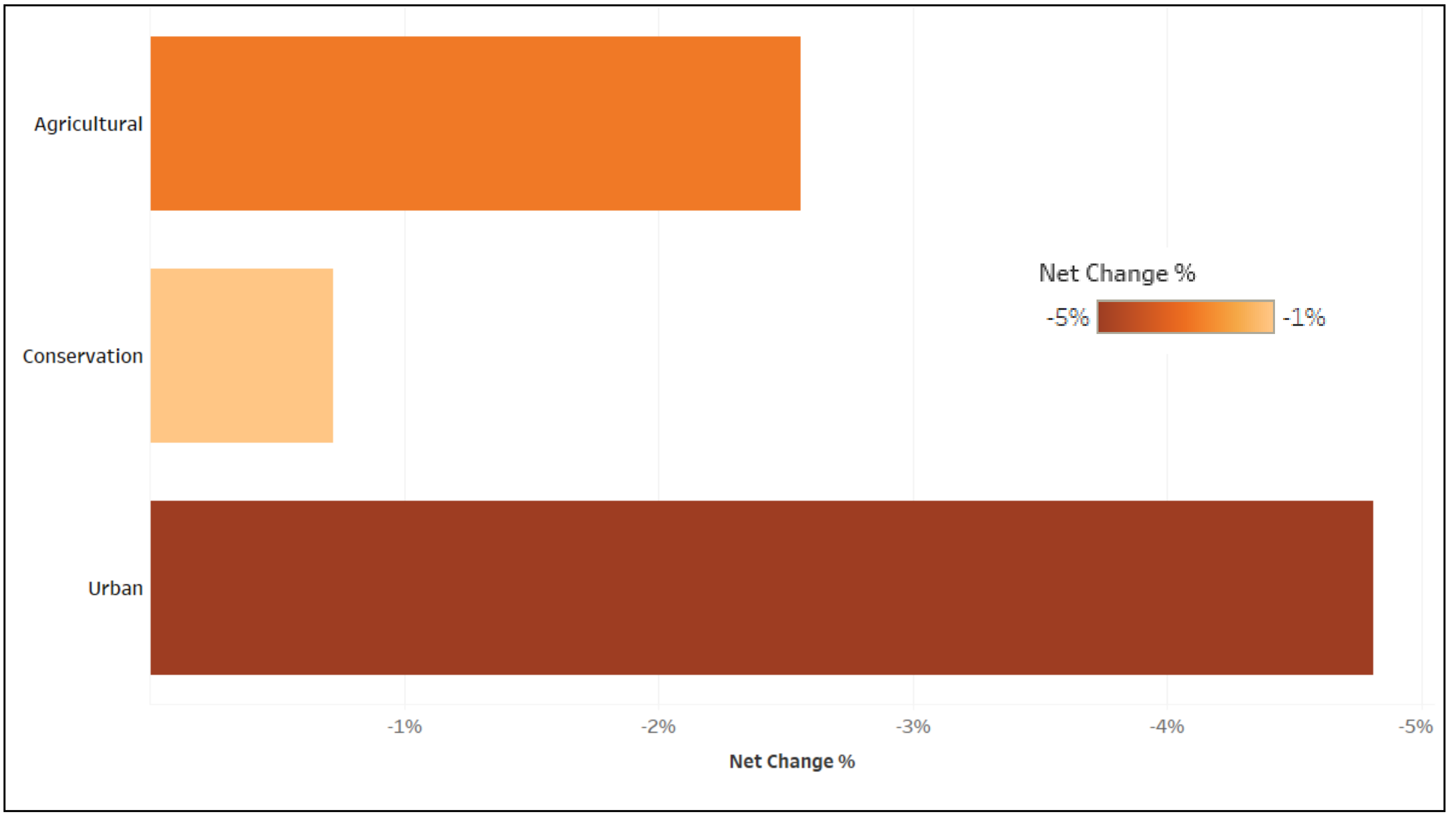

Figure 6: Percent net change in tree canopy by Land Use.

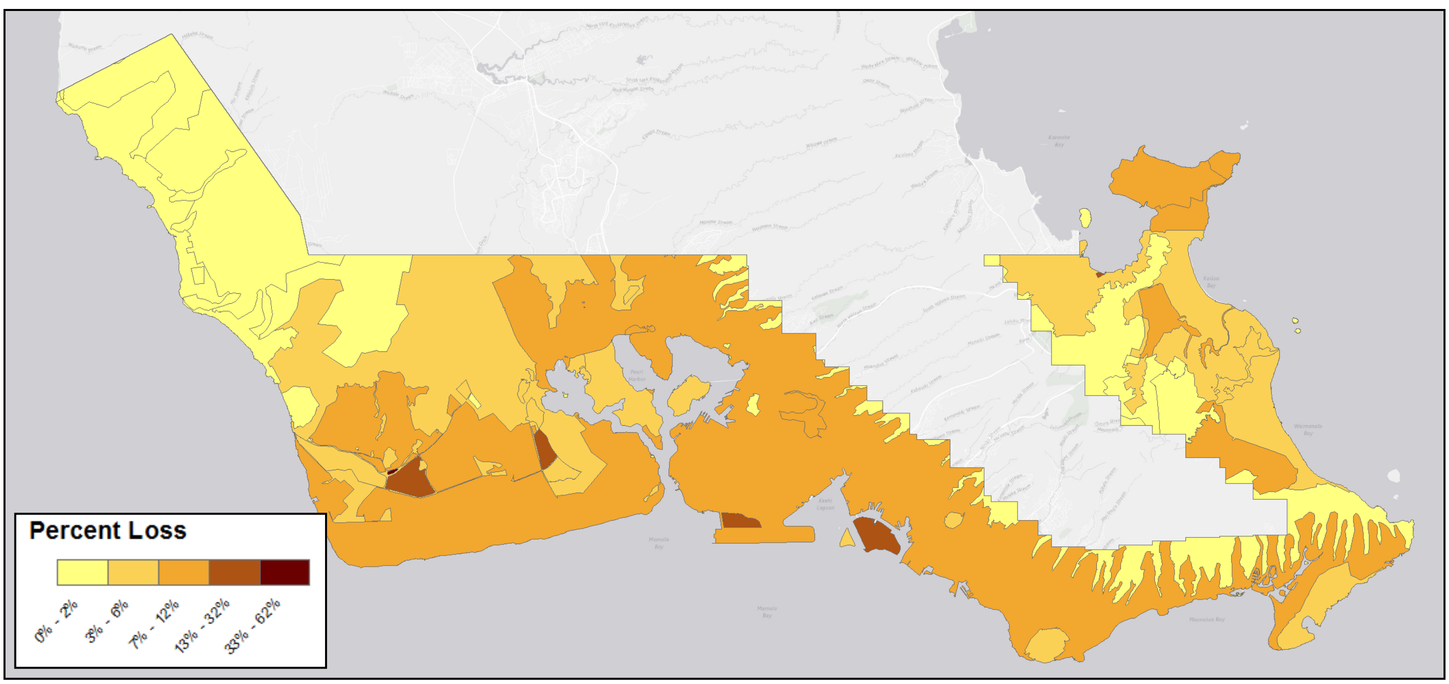

Figure 7: Percent loss of tree canopy by Land Use.

Tree Canopy Change, 2010-2013: Government Properties

By primary public-ownership type, properties owned by the Federal government had the largest net change had the highest percent net change, at –3.7%, followed by the City and County of Honolulu (-1.9%) and the State of Hawaii (-1.1%) (Figure 8). Many of the tree-canopy losses on Federal lands were likely attributable to land-use changes on military installations, including new housing on Mokapu Point (Figure 9). Losses on State and local lands were similarly attributable to land-use changes, including expansion of the landfill in Waimanalo Gulch.

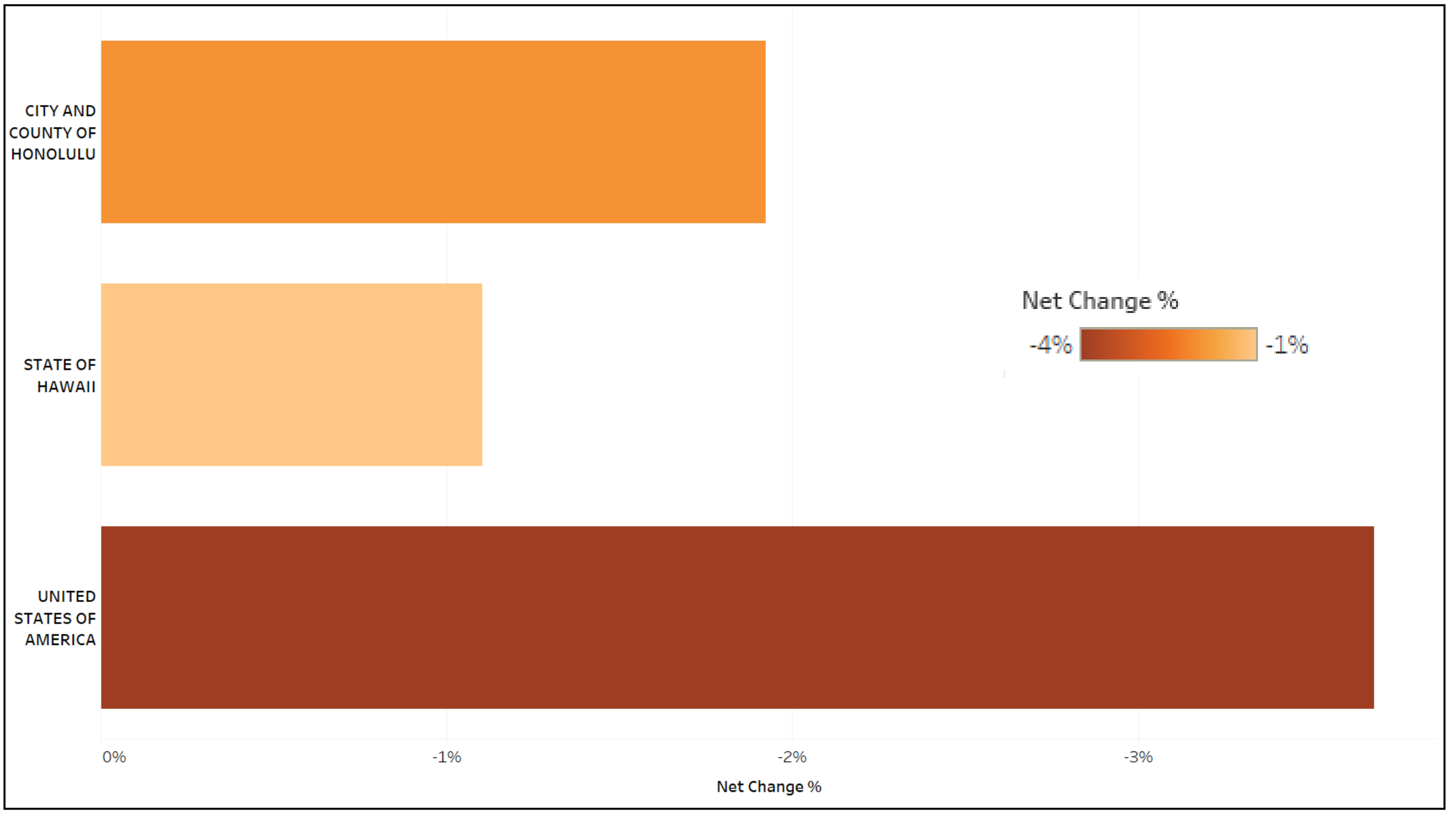

Figure 8: Percent net change in tree canopy by public-ownership type.

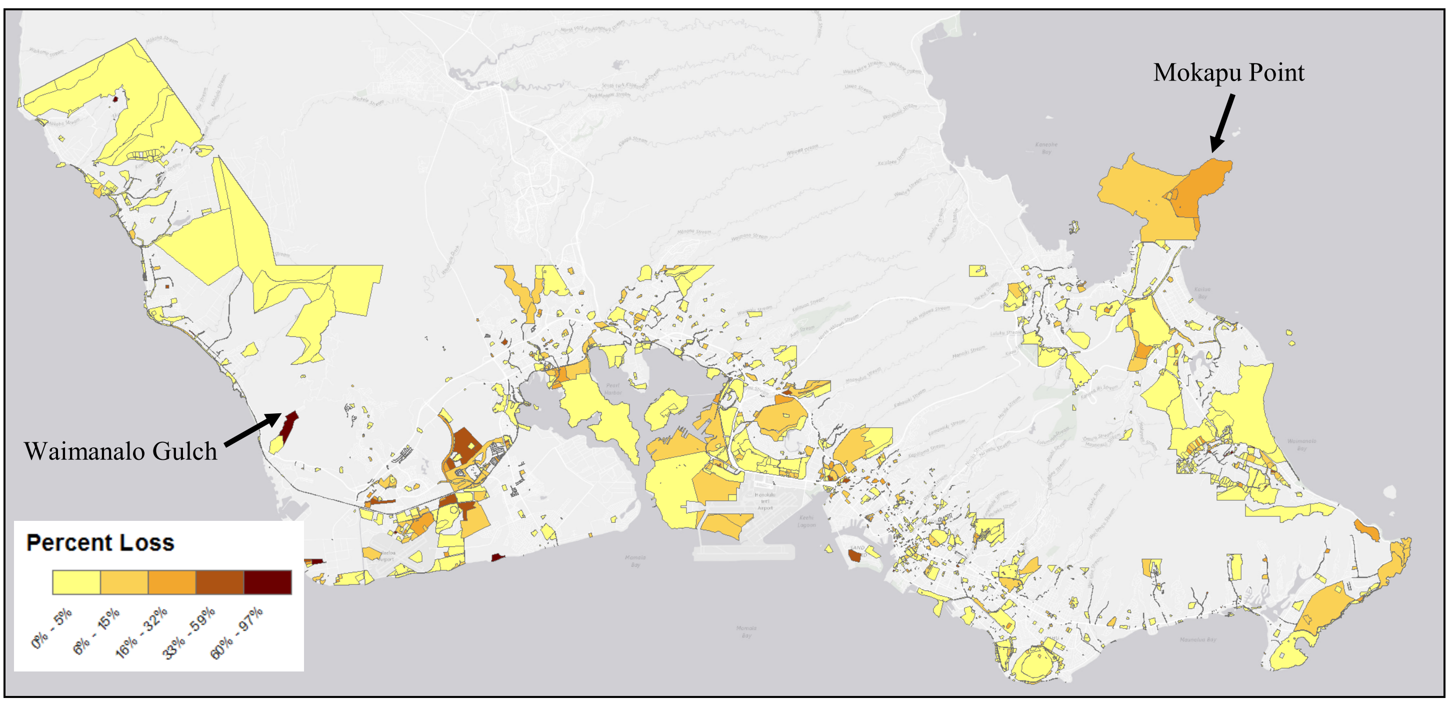

Figure 9: Percent loss in tree canopy for public-ownership types.

Tree Canopy Change, 2010-2013: Parks

When considering publicly-owned parks by type (Figure 10), the Community Garden class had very little change (~ 0%). In contrast, however, the Beach Right-of-Way class exhibited a 7% net loss in tree canopy. When considering individual parks, Halawa District Park had one of the largest changes in tree canopy, losing 33% (Figure 11).

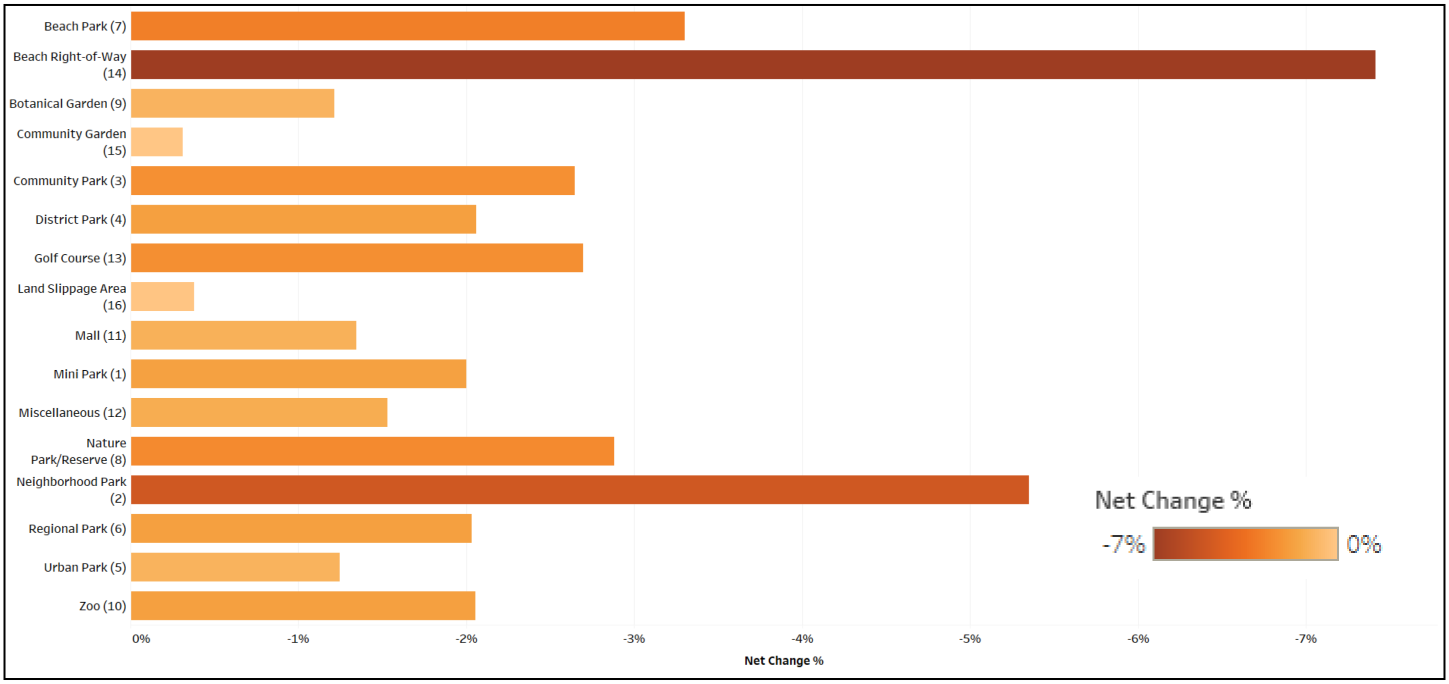

Figure 10: Percent net change in tree canopy for Parks based on park types.

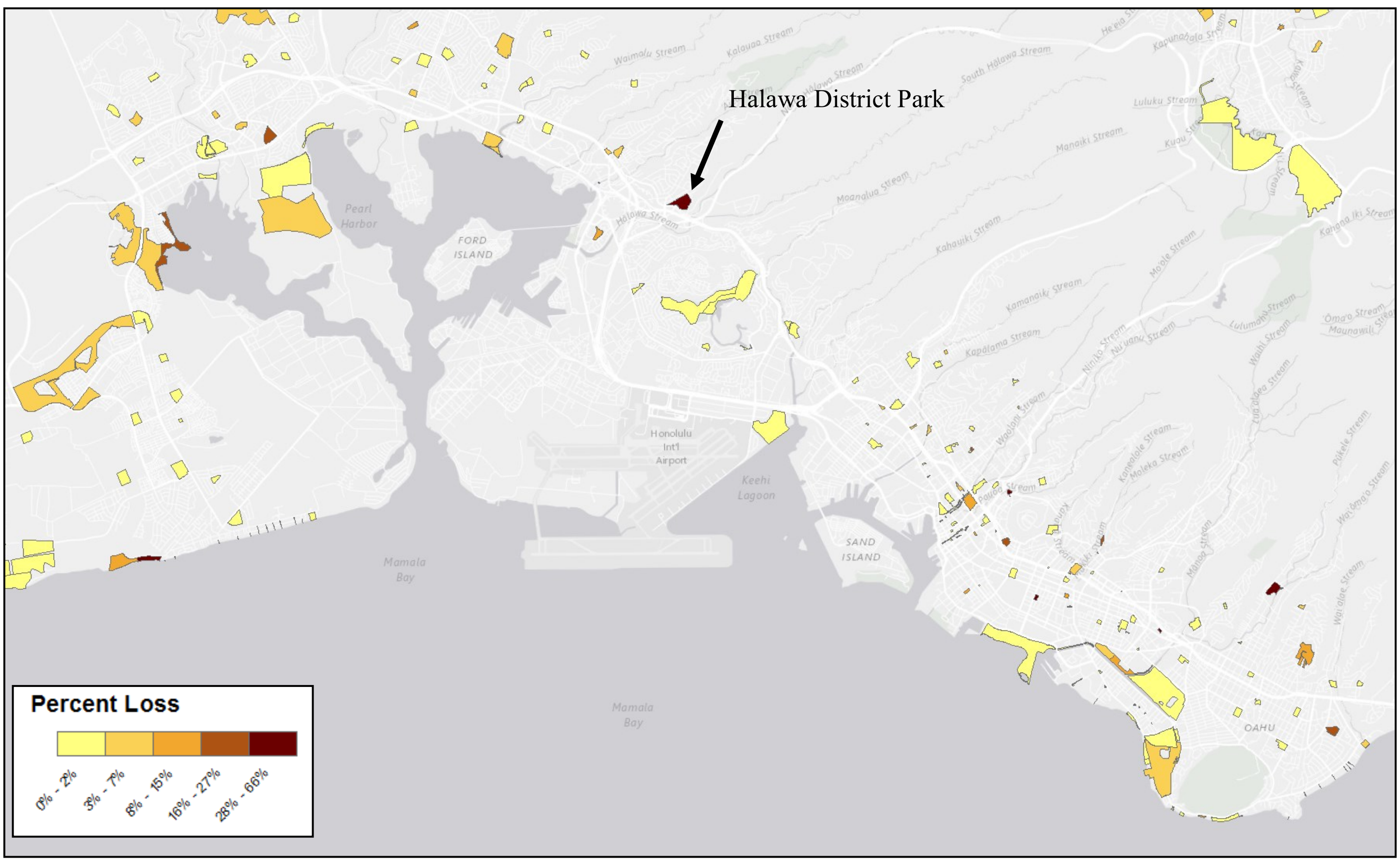

Figure 11: Percent loss in tree canopy for Parks based on individual parks.

Tree Canopy Change, 2010-2013: Watersheds

Tree-canopy change was also examined by watershed. Kalihi watershed, which is located in the center of the study area in a densely settle urban neighborhood, exhibited a net loss of 11% (Figure 12). The Kamauleunu, Kaupuni, and Makaha watersheds, located in rural areas with little to no urban development, had 0% net change. Nuuanu watershed, located on Sand Island, had the most loss by tree-canopy percentage, with 21% (Figure 13).

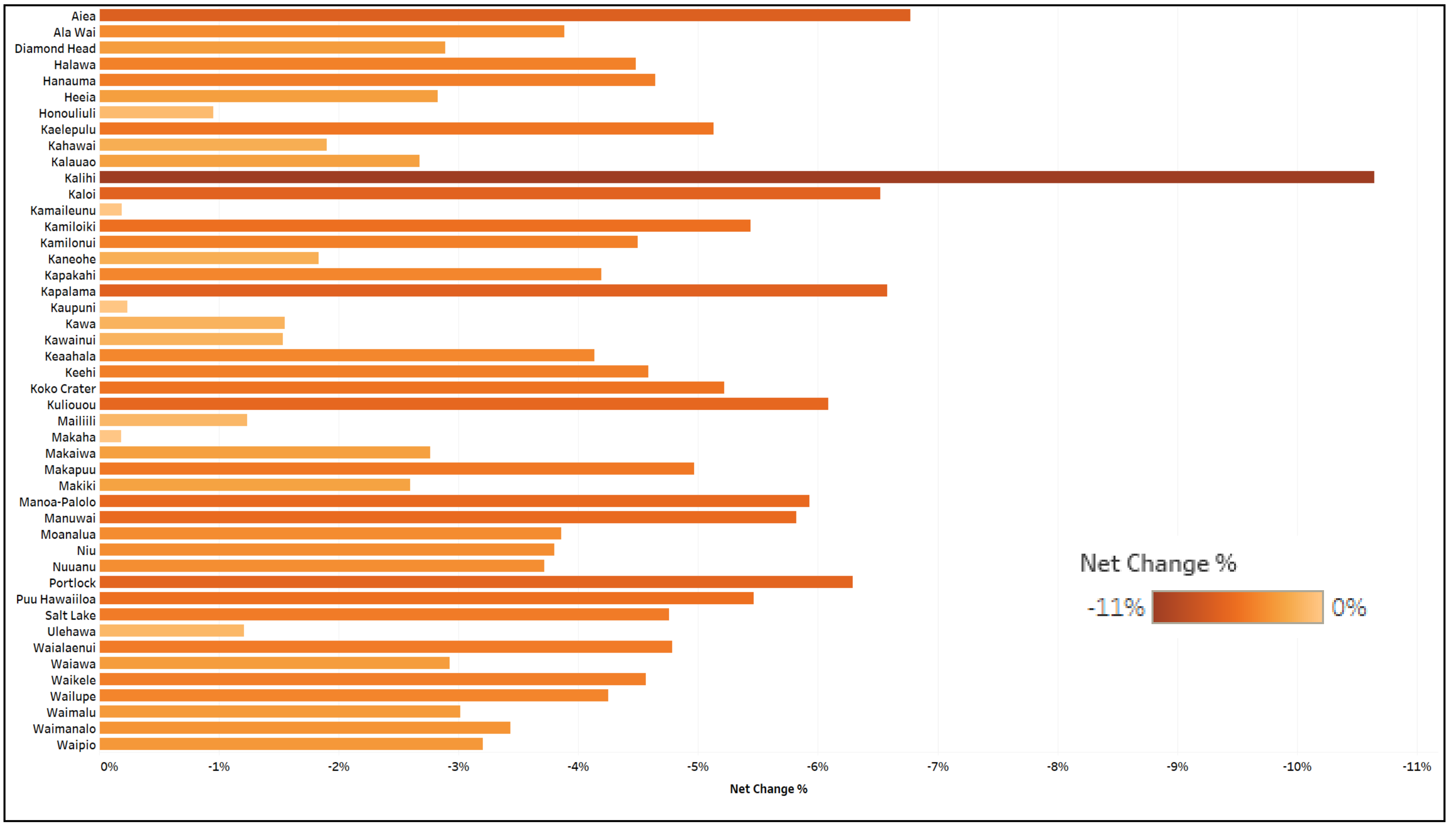

Figure 12: Percent net change in tree canopy for Watersheds.

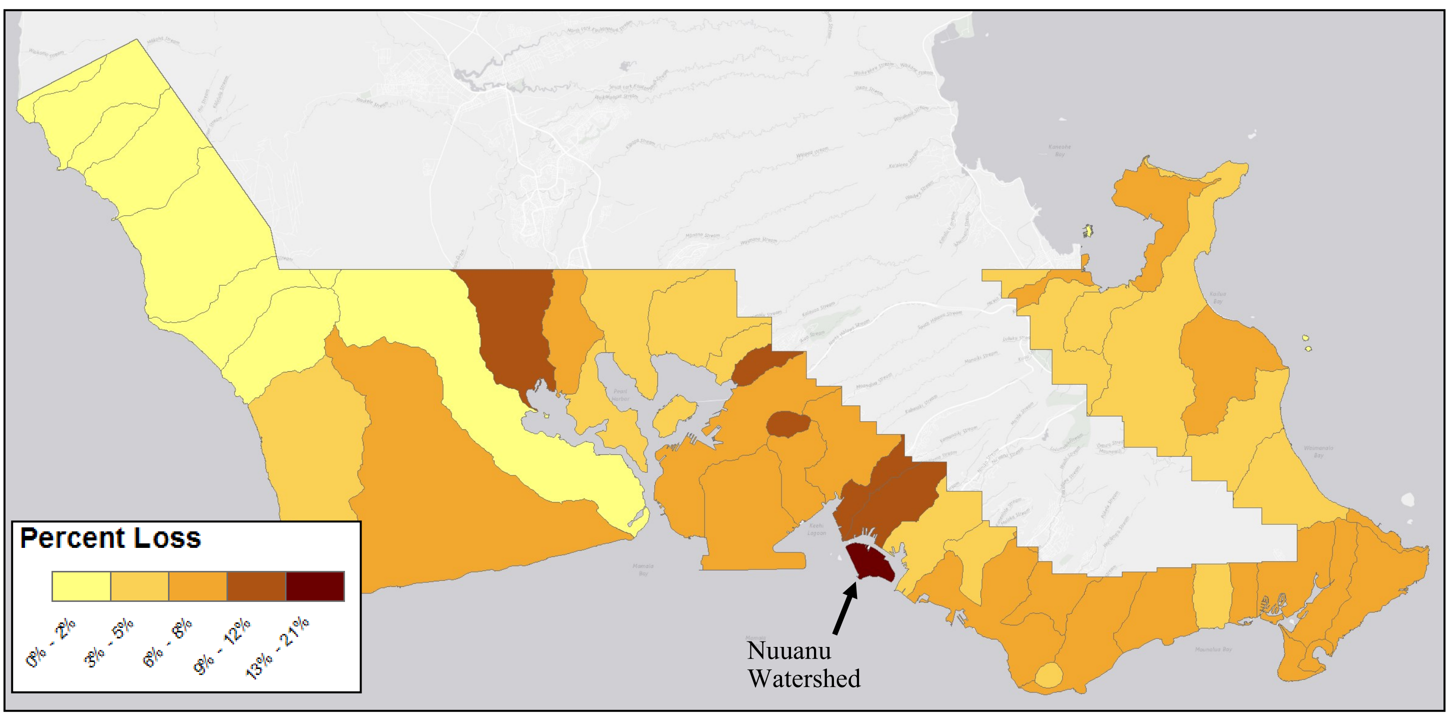

Figure 13: Percent loss in tree canopy for Watersheds.

Tree Canopy Change, 2010-2013: Zoning

By zoning, the Residential class had the highest net change with a 37% loss in tree canopy (Figure 14). The State Jurisdiction class had the least change, with only a net loss of 2%. New residential developments just north of the Kalaeloa Airport had large changes in tree canopy, with nearly a 100% tree-canopy loss for some Zoning parcels (Figure 15).

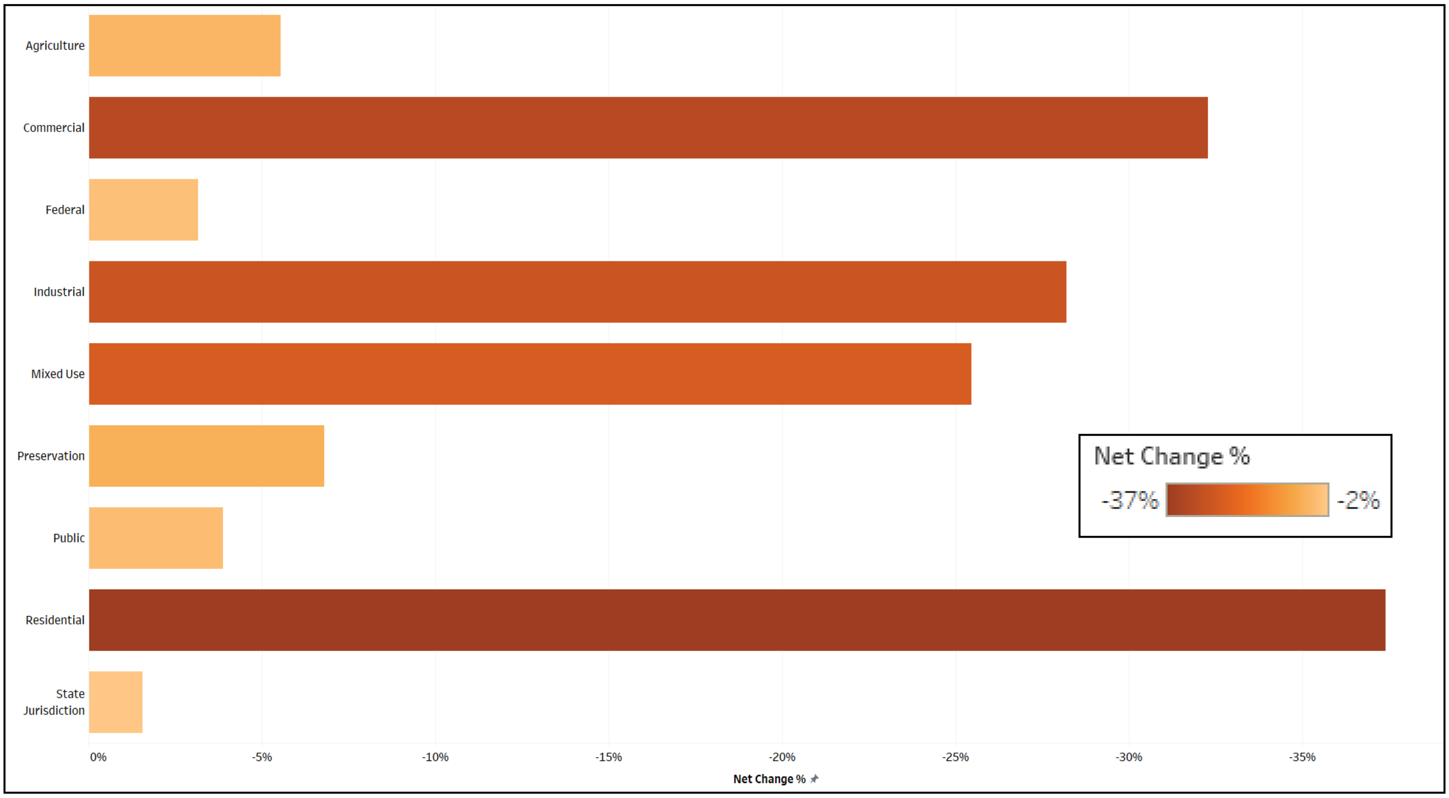

Figure 14: Percent net change in tree canopy for Zoning.

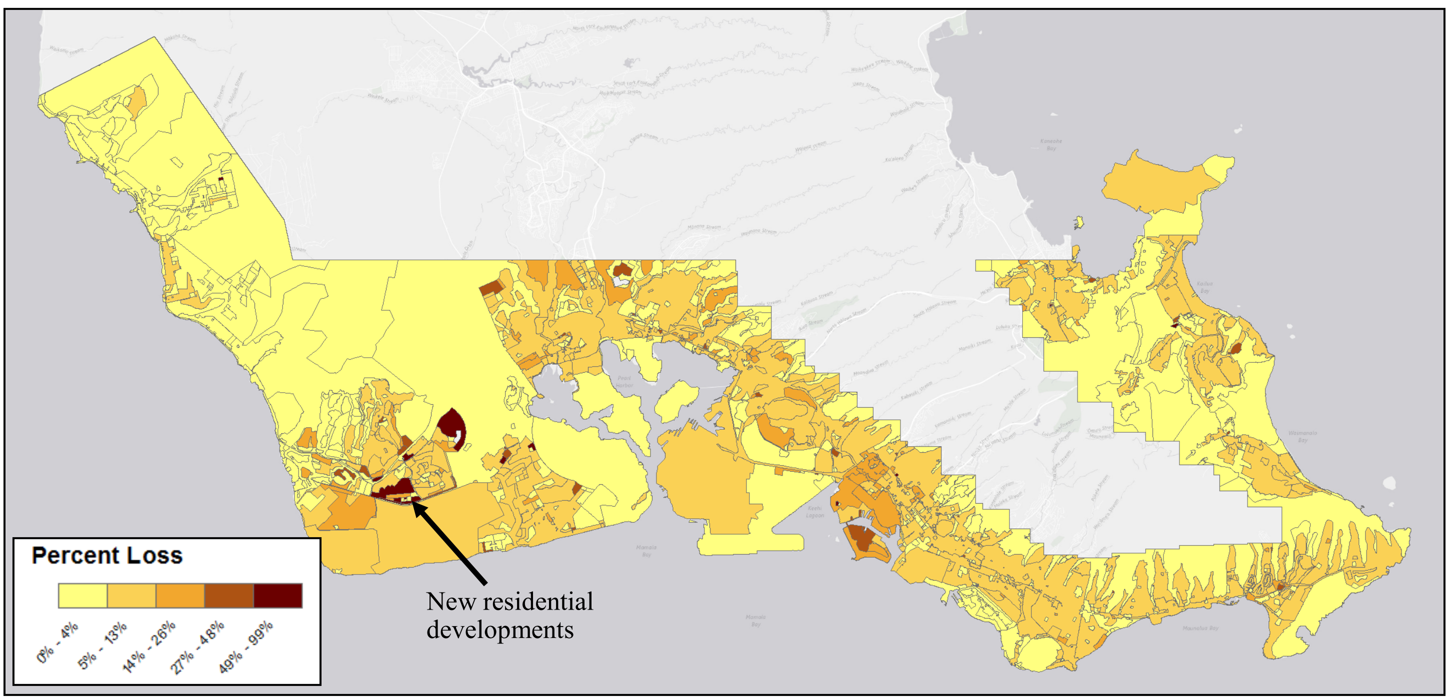

Figure 15: Percent loss in tree canopy for Zoning.

Conclusions

- During the 3-year period between 2010 and 2013, Honolulu and adjacent areas in Southern Oahu lost about 3% of its tree canopy. Some of this loss was attributable to new commercial and residential developments in communities such as Kapolei and Waimanalo (Figure 16). Additional losses occurred through scattered attrition of mature trees in existing neighborhoods and infrastructure improvements such as the commuter rail system.

- Planting programs in the region added thousands of individual trees during the study period. Some of these trees were either too small to be picked up by the available remote-sensing imagery or its relative contribution to total tree canopy was small relative to development-related losses. Nonetheless, these planting programs are very important contributions to Honolulu's future tree canopy, and over time growth of these trees will partially compensate for recent changes in tree distribution and volume.

- When considering these results, note that the change-detection analysis focused on capture of trees that were added by public or private planting efforts; natural tree growth was not mapped unless it included a total area exceeding the size of individual trees. This criterion helped reduce overestimation of tree growth when input datasets from different time periods were compared (i.e., a slight offset may exist between datasets). However, it is also likely that actual tree growth was underestimated during the study period.

- The data provided by this assessment can serve as baseline information for subsequent tree-canopy mapping and monitoring efforts. They can also be summarized by any geography of interest to help planners, researchers, and concerned citizens understand the environmental and social factors that affect Honolulu's tree canopy.

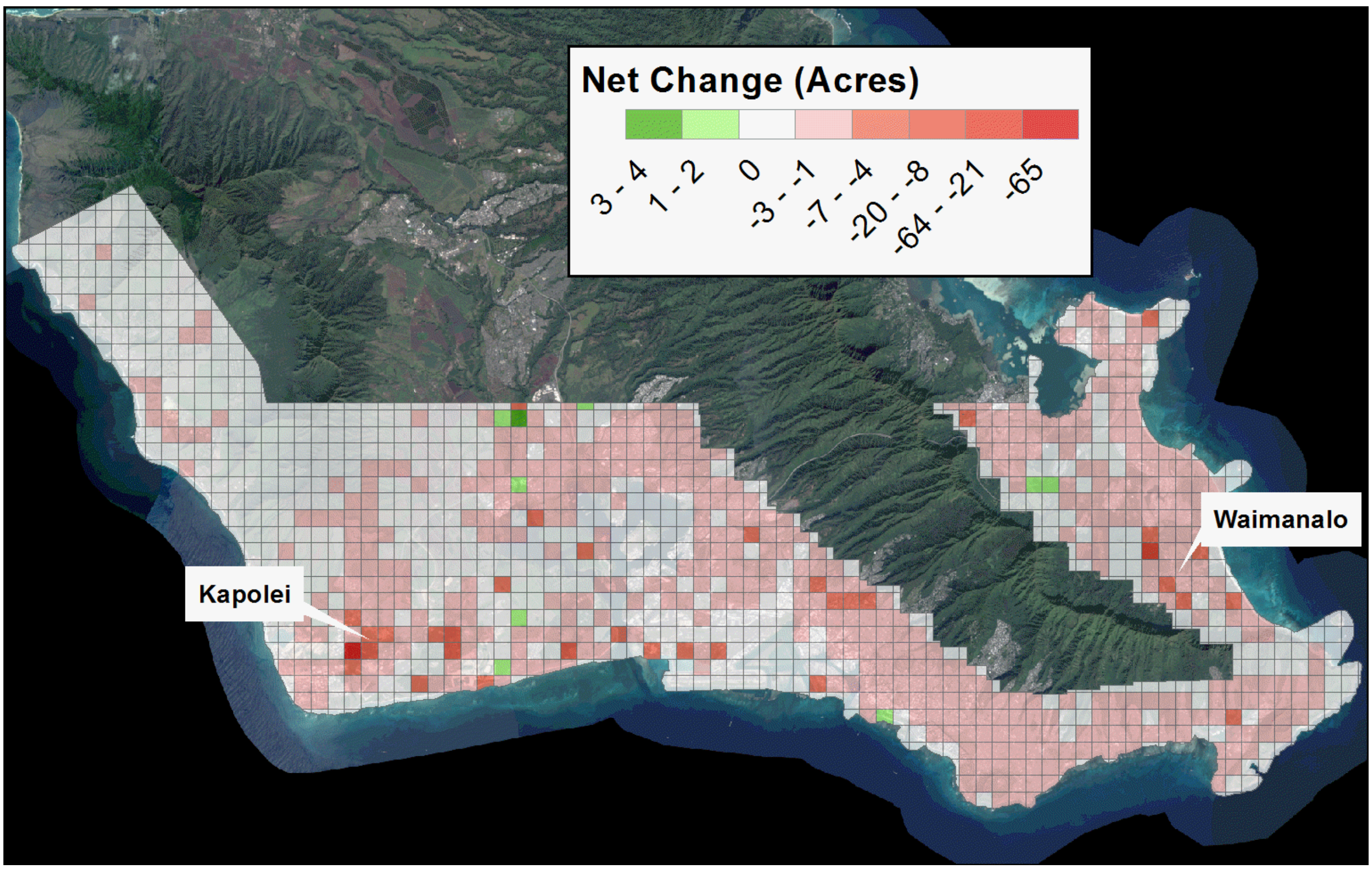

Figure 16: Net change in tree canopy area (acres) during the period 2010-2013, as calculated for a grid network with 750x750-meter cells.

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Additional Information

Funding for the project was provided by the USDA Forest Service. More information on Tree Canopy Assessments can be found at the following websites:

http://nrs.fs.fed.us/urban/utc/
http://smarttreespacific.org/

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