

CHAPTER 12: TERRESTRIAL LAYERS



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Theme Description:

Land use corresponds to the socio-economic description (or functional dimension) of a given area. For example, areas used for residential, industrial or commercial purposes, for farming or forestry, for recreation or conservation purposes, etc. It may be possible to infer land use from land cover and vice versa. But situations are often complicated and the link is not always evident. Unlike land cover, land use is difficult to 'observe'. For example, it is often difficult to decide if grasslands are used for agricultural purposes or not. Often, there is overlap between these two themes. Distinctions between land use and land cover and their definition have impacts on the development of classification systems, data collection and information systems in general (European Environment Agency [EEA], 2003).

Land cover corresponds to a biophysical description of the earth's surface. In short, it is that which overlays or currently covers the ground. This description enables various biophysical categories to be distinguished such as areas of vegetation (e.g., trees, bushes, fields, lawns), bare soil, hard surfaces (e.g., rocks, buildings) and wet areas and bodies of water (e.g., watercourses, wetlands) (EEA 2003).

*Federal or State Listed Species*¹⁸ and *Habitat* correspond to any information regarding the status and location of rare, threatened, or endangered¹⁹ species and/or native natural communities. These locations are tracked throughout the state of Hawai'i for the purpose of providing the most comprehensive and up-to-date status information on rare species or native communities that are in danger of local extirpation or extinction (United States Fish and Wildlife Service [USFWS], 2003).

¹⁸ Listed species: A species, subspecies, or distinct vertebrate population segment that has been added to the Federal lists of Endangered and Threatened Wildlife and Plants as they appear in sections 17.11 and 17.12 of Title 50 of the Code of Federal Regulations (50 CFR 17.11 and 17.12). The State also has laws protecting species from island to island.

¹⁹ Endangered: The classification provided to an animal or plant in danger of extinction within the foreseeable future throughout all or a significant portion of its range.

Agricultural Land corresponds to those lands zoned as agricultural on which various crops, plantations, or trees are grown.

Invasive Species are introduced species that are harmful to Hawai'i's native ecosystems and species as well as agriculture and the general welfare of the economy.

Status:

Land use: There is only one land use layer that covers the 8 main islands in a uniform manner. A more detailed layer covers Oahu only. The details of these two layers follow:

The State Office of Planning (OP) has State Land Use District Boundaries for the 8 main Hawaiian Islands for the years 1991, 1993, 1995, and 2000. The layers depict areas as land use zones consisting of conservation, rural, agriculture, and urban. The layers were digitized from 1:24000 mylars obtained from the State Land Use Commission (LUC).

City and County of Honolulu (CCH) has detailed *land use* down to the parcel level in the zoning layer (Oahu only). It has attributes such as residential, commercial, neighborhood business, community business, agriculture, conservation, military, Federal, apartment, industrial, etc., as well as categories indicating degree of density, etc.

Land cover: There are a variety of sources of land cover data but few that cover the entire 8 main islands in a uniform manner. The National Oceanic and Atmospheric Administration (NOAA) Coastal Change Analysis Program (C-CAP) and the Hawai'i Gap Analysis Project (HI-GAP) both seek to do just that.

NOAA C-CAP created land cover layers for the 8 main islands using a nearly cloud free mosaic of NASA's Landsat 7 Enhanced Thematic Mapper (ETM) imagery.²⁰ The islands were broken into classes of major land cover features such as developed, cultivated land, grassland, forest, scrub lands, wetland, bare land, and water. The C-CAP land cover classification scheme can be seen in detail at http://www.csc.noaa.gov/crs/lca/tech_cls.html.

HI-GAP, a consortium of public and private conservation organizations is working on a land cover layer derived from Landsat 7 Advanced Thematic Mapper (ETM) imagery. The data is being prepared and compiled in compliance with the United States Geological Survey (USGS) National Gap Program²¹ and is supported by local cooperators. Final products will be 5 hectare Minimum Mapping Units (MMU) in both raster and shape file formats. The land cover will be classified into ecological systems determined by a

²⁰ Landsat 7 Enhanced Thematic Mapper (ETM) imagery: An eight-band multispectral scanning radiometer onboard the Landsat 7 satellite that is capable of providing high-resolution imaging information of the Earth's surface (NASA Earth Observatory. 2003)

²¹ USGS National Gap Program seeks to provide regional assessments of the conservation status of native vertebrate species and natural land cover types and to facilitate the application of this information to land management activities. (see <http://www.gap.uidaho.edu>)

combination of factors such as elevation, precipitation, slope, aspect, and dominant and sub dominant vegetation types. HI-GAP statewide land cover datasets will be available in 2005. For more details contact the Hawai'i Natural Heritage Program (HINHP).

Federal or State Listed Species²² and Habitat: There are a variety of sources for statewide information pertaining to the status and location of listed species and rare and/or critical habitat. Although the data is statewide, the coverage is uneven both spatially, temporally, and taxonomically. Spatially, federal and state lands are the most well surveyed with many large privately owned tracts (and even some state and local government tracts) having never been surveyed. Temporally, species status on military training areas is probably the most up to date with many datasets being current as of 2003. However, many areas in the state haven't been surveyed specifically for rare species for 10 to 20 years or more. Taxonomically, forest birds are probably the best covered with yearly state organized forest bird surveys which attempt to revisit each transect every 5 years. Plants are well-inventoried on military lands but there is no systematic statewide survey for plants or invertebrates. The distribution and status of the Hawaiian hoary bat (the only land mammal in Hawai'i) is not well known and it has not been updated since the early 1990's.

HINHP, a program affiliated with the Center for Conservation, Research and Training (CCRT) at the University of Hawai'i (UH) has the largest statewide spatial dataset of *rare, threatened, and endangered plants, animals, and natural communities* in the state. HINHP's Natural Diversity Database and GIS Layers consist of information on the status and location of rare species and natural communities throughout the state. The data is provided primarily to government organizations and researchers in order to assist them in land use planning, natural resource management, and biological research. The data is restricted due to its sensitive nature; however it is available upon request for appropriate projects. The data covers all federally listed and state listed species as well as those classified as globally rare by NatureServe, an international organization comprised of 76 Heritage programs that tracks the worldwide status of at risk species. HINHP also has a dataset detailing remaining native vegetation communities for the 8 main islands based on elevation, rainfall, slope, aspect, and dominant and sub-dominant vegetation digitized at a 1:24,000 scale.

The US Fish and Wildlife Service, an agency of the Department of the Interior (DOI) has proposed *Critical Habitat* layers that demarcate "specific geographic areas, whether occupied by listed species or not, that are determined to be essential for the conservation and management of listed species, and that have been formally described in the Federal Register." The proposed critical habitat designations cover 47 plants for the Island of Hawai'i (Big Island), 83 plant species for Kauai and Niihau, 61 plant species for Maui and Kahoolawe, 46 plant species for Molokai, 32 for Lanai, 99 plant species for Oahu, and 5 plant species for the Northwestern Hawaiian Islands (USFWS, May 28, 2002). Contact USFWS at 808-541-3441 to check on availability of layers.

Agricultural Land: There are a variety of sources of data layers demarcating agricultural lands in the land cover category, however there are a few layers that specialize in issues of particular to agriculture such as crop type, soil type (see Chapter 10, Physical Environment and Natural Hazards), or productivity.

The Land Study Bureau of the University of Hawai'i prepared an inventory and evaluation of the State's land resources during the 1960's and 1970's. The inventory detailed agricultural land productivity ratings for Kauai, Oahu, Maui, Molokai, Lanai and Hawai'i. The Bureau grouped all lands in the State, except those in the urban district, into homogeneous units of land types. It described their condition and environment; rated the land on its over-all quality in terms of agricultural productivity; appraised its performance for selected alternative crops; and delineated the various land types and groupings based on soil properties and productive capabilities. Statewide data layers compiled from information gathered from 1965 to 1972 are complete. The data is publicly available.

Invasive Species: The Coordinating Group on Alien Pest Species (CGAP)²³ oversees Invasive Species Committees (ISC) on Oahu, Maui, Molokai, Lanai, Kauai, and Hawai'i. Each ISC maps, monitors, and controls invasive weed and pest species on each island. Each ISC maps the location of serious invasive and/or incipient alien species specific to each island. They work closely with the Hawai'i Department of Agriculture as well, tracking down and killing the most noxious species. Data is in various states of completion and may or may not be readily available. This should change over the next year as the Hawai'i Natural Heritage Program works to compile all data into one format and make it available over the web under contract to the National Biological Information Infrastructure's (NBII) Pacific Basin Information Node (PBIN).

Data Source:

Land use:

State Office of Planning (OP), <http://www.hawaii.gov/dbedt/gis/download.htm>
City & County of Honolulu (CCH), <http://gis.hicentral.com>

Land cover:

State Office of Planning (OP), <http://www.hawaii.gov/dbedt/gis/download.htm>
NOAA Coastal Change Analysis Program (C-CAP),
http://www.csc.noaa.gov/crs/lca/m_eight.html
Hawai'i Gap Analysis Project (HI-GAP), <http://www2.hawaii.edu/~hinhp/>
Hawai'i Natural Heritage Program (HINHP), <http://www2.hawaii.edu/~hinhp/>

Federal or State Listed Species²⁴ and Habitat:

²³ The Coordinating Group on Alien Pest Species is a multi-agency partnership that seeks to coordinate more effective protection for Hawaii's economy, environment, health, and way of life from harmful alien pests. See <http://www.hear.org/cgaps/> for more information.

State Office of Planning (OP), <http://www.hawaii.gov/dbedt/gis/download.htm>
Hawai'i Natural Heritage Program (HINHP), <http://www2.hawaii.edu/~hinhp/>

Agricultural Land:

State Office of Planning (OP), <http://www.hawaii.gov/dbedt/gis/download.htm>

Invasive Species:

Maui Invasive Species Committee (MISC), <http://www.hear.org/misc>
Oahu Invasive Species Committee (OISC), <http://www.hear.org/oisc>
Big Island Invasive Species Committee (BIISC), <http://www.hear.org/bimac>
Molokai Invasive Species Committee (MoMISC), <http://www.hear.org/momisc>
Kauai Invasive Species Committee (KISC), <http://www.hear.org/kisc>
Lanai Invasive Species Committee (LanISC), <http://www.hear.org/cgaps> for now.
Hawai'i Natural Heritage Program (HINHP), <http://www2.hawaii.edu/~hinhp/>

Standards:

Land use:

State Office of Planning (OP), metadata associated with each file at
<http://www.hawaii.gov/dbedt/gis/download.htm>
City & County of Honolulu (CCH), <http://gis.hicentral.com>

Land cover:

State Office of Planning (OP), metadata is associated with each file at
<http://www.hawaii.gov/dbedt/gis/download.htm>
NOAA C-CAP, metadata associated with each file can be found at
http://www.csc.noaa.gov/crs/lca/m_eight.html
Hawai'i Gap Analysis Project (HI-GAP), National Gap Analysis Standards, Version
2.0.0. (February 16, 2000) at <http://www.gap.uidaho.edu/handbook/Standards/default.htm>

Federal or State Listed Species²⁵ and Habitat:

State Office of Planning (OP), <http://www.hawaii.gov/dbedt/gis/download.htm>
Hawai'i Natural Heritage Program (HINHP), information on standards and Heritage
mapping methodology can be found at the NatureServe web site at
<http://www.natureserve.org/prodServices/heritagemethodology.jsp>
U.S. Fish and Wildlife Service Endangered Species Program <http://endangered.fws.gov/>

Invasive Species Distribution: The various ISC's map alien species locations using
1:24000 USGS Quadrangles and/or a combination of Global Positioning Systems (GPS).
Maui Invasive Species Committee (MISC)
Oahu Invasive Species Committee (OISC)
Big Island Invasive Species Committee (BIISC)
Molokai Invasive Species Committee (MoMISC)
Kauai Invasive Species Committee (KISC)

Lanai Invasive Species Committee (LanISC)
Hawai'i Natural Heritage Program (HINHP), <http://www2.hawaii.edu/~hinhp>

Priorities

The Terrestrial layers were selected by the Hawai'i GIS community as a set of framework data layers. While not one of the original FGDC layers, they make up a crucial component in analyzing the condition and stresses on the natural environment. These layers are each important in combination with other spatial data layers in comprehensive planning for the Hawaiian Islands. It will take a combination of data organization and new purchases to achieve the goals in this chapter. Layers such as land use and agriculture need a coordinated data management plan. Land cover requires a high-resolution imagery product for analysis. Species and Habitat data efforts will include funding to database existing records as well as cooperation between the Hawai'i Natural Heritage Program and the Bishop Museum, an effort currently underway.

Estimated total investment in this theme:

Land use:

State Office of Planning (OP): unknown
City & County of Honolulu (CCH): unknown

Land cover:

State Office of Planning (OP): unknown
NOAA Coastal Change Analysis Program (C-CAP): unknown
Hawai'i Gap Analysis Project (HI-GAP), \$100,000

Federal or State Listed Species and Habitat:

Hawai'i Natural Heritage Program (HINHP) has invested a total of \$10,000,000 to \$15,000,000 over an 18 year period.

Agricultural land: unknown

Invasive species: Costs associated with this collecting data and mapping this theme total in the millions if you look at the number of agencies involved with managing various invasive species.

Estimated current state and local contributions:

Land use:

Office of Planning (OP): unknown
City and County of Honolulu (CCH): unknown

Land cover:

Hawai'i Gap Analysis Project (HI-GAP): \$250,000

Federal or State Listed Species and Habitat:

Hawai'i Natural Heritage Program (HINHP): \$50,000 annually

Agricultural land: unknown

Invasive species: unknown

What is needed:

Land use: The state needs an up-to-date land use map that is uniform throughout the islands and more detailed and accurate than current land use maps. The OP and the LUC could perhaps work with the Counties and CCH to come up with a standard set of land use classifications which best suit the needs of all through a series of workshops and focused meetings.

Land cover: The ability to update land cover is based on the availability of current remotely sensed imagery. We need complete statewide datasets of remotely sensed data on which to base our land cover classification (see details of imagery costs in Chapter 3, Imagery). Previous work on land cover classification using Landsat 7 ETM data has shown that 30 meter pixels are just too coarse for most land cover classification needs. Higher resolution data such as Space Imaging's IKONOS²⁶ imagery or Digital Globe's Quickbird²⁷ imagery are needed. Imagery must be orthorectified to better than National Map Accuracy Standards (NMAS 1:12,000 CE 90%) and the land cover should be created using imagery of this caliber as the base layer. The state needs a uniform statewide land cover data layer in order to monitor watershed, forest, and stream health to name but a few. A good land cover layer can also help managers protect the ocean by showing areas of barren ground that are susceptible to erosion. It is well documented that what happens on the land effects the near shore marine ecosystems.

Federal or State Listed Species and Habitat: The state needs a uniform and up-to-date source of information on the status and location of rare, threatened, and endangered species and natural communities. Currently, there is a lot of duplication of effort with many organizations mapping species information already mapped by others, sometimes 3 times over. These datasets often end up being combined at some point, which causes data confusion that requires still more effort. By organizing mapping efforts, pooling resources, and/or storing data under one roof in a clearinghouse for all, we could increase efficiency, eliminate duplication of effort, and do a better job protecting the unique plants

²⁶ Space Imaging Corp's IKONOS Pro imagery, both 1 and 4-meter products are the highest accuracy orthorectified products derived from IKONOS imagery that do not require ground control. Consistent 10-meter CE90 product accuracy provides global access to 1:12,000 National Map Accuracy Standards (NMAS). <http://www.spaceimaging.com/products/IKONOS/pro.htm>

²⁷ Digital Globe's Quickbird ortho imagery, both 70cm and 2.8-meter products are the highest accuracy orthorectified products derived from Quickbird imagery that do not require ground control. Consistent 10.2-meter CE90 product accuracy over USA only at 1:12,000 NMAS. See details at <http://www.digitalglobe.com/products/ortho.shtml>

and animals of Hawai'i. Data and mapping standards need to be created so that these datasets can be pulled together more easily for storage, analysis, and dissemination.

Agricultural land: The state needs a uniform and up-to-date source of information on the status, type, and location of crops and plantations in Hawai'i. Data and mapping standards need to be created so that these datasets can be pulled together for storage, analysis, and dissemination.

Invasive species: A uniform and up-to date-source of information on the status and location of invasive species is needed. Currently these datasets are dispersed and stored in disparate databases. Data and mapping standards need to be created so that these datasets can be compiled for storage, analysis, and dissemination. By organizing mapping efforts, pooling resources, and/or storing data under one roof in a clearinghouse for all, we could increase efficiency, eliminate duplication of effort, and do a better job managing our natural resources and protecting public health, the economy, and tourism.

What is a likely source:

Land use: The Department of Land and Natural Resources (DLNR), CCH, the LUC, the Counties, and the Military all have information on land use. A combined effort and/or workshops could help to bring these datasets together in a uniform way.

Land cover: Funding for imagery is likely come from a consortium of federal, state, local, and private organizations. The Hawai'i IKONOS Consortium is currently receiving orders from over half a dozen public and private organizations who are working together to create a common imagery dataset that can be used for land use and land cover mapping (see the Chapter 2, Imagery). The Military services, the National Park Service (NPS), the CCH, DLNR, and many others have mandates to track land cover. If these groups pulled resources they could eliminate duplication of effort and complete a set of data that benefits all parties.

Federal or State Listed Species and Habitat: The USFWS, NPS, The Nature Conservancy of Hawai'i (TNCH), US Army, Maui Pineapple Company's Puu Kukui Preserve, DLNR Division of Forestry and Wildlife (DOFAW) and Division of Aquatic Resources (DAR), Bishop Museum, National Tropical Botanical Garden (NTBG), Pelea Pacifica, USGS Biological Resource Division (BRD), and many others all have information on the location of rare species and habitat. All these organizations and many more need to track rare and legally protected species. By organizing efforts, pooling resources, and storing data under one roof in a clearinghouse for all, we could increase efficiency, reduce or eliminate duplication of effort, and do a better job protecting resources.

Agriculture land: The United States Department of Agriculture's (USDA) Farm Service Agency (FSA) and the Natural Resource Conservation Service (NRCS), and the Hawai'i Department of Agriculture (HDOA) as well as the big private agricultural concerns all have data on the location of crops, plantations, and forestry operations.

Invasive species: The ISCs, USDA Forestry, TNCH, Maui Pineapple Company, US Army, NPS, DLNR, UH, HDOA, USDA FSA, Bishop Museum, and others, all have data on the location of invasive species.

Estimated total investment to complete this theme:

Land use:

State Office of Planning (OP): unknown

City & County of Honolulu (CCH): unknown

Land cover:

State Office of Planning (OP): unknown

Hawai'i Gap Analysis Project (HI-GAP): \$200,000

Federal or State Listed Species and Habitat: The backlog of data at the HINHP would take 5 years to map and input. Estimated cost to update the database with existing data could run up to \$5,000,000 with an estimated \$1,000,000 annually to maintain the data.

Agricultural land: Unknown

Invasive species: There is currently a backlog of data that may take a year to clean up and input, estimate of \$100,000 needed.

Estimated current allocations of funding:

Land use:

State Office of Planning (OP): unknown

City & County of Honolulu (CCH): unknown

Land cover:

State Office of Planning (OP): unknown

Hawai'i Gap Analysis Project (HI-GAP): \$200,000

Federal or State Listed Species and Habitat:

Hawai'i Natural Heritage Program (HINHP): \$50,000 annually

Agricultural land: unknown

Invasive species: unknown

Estimated budget shortfall:

Land use: unknown

Land cover: \$250,000

Federal or State Listed Species and Habitat: \$950,000

Agricultural land: unknown

Invasive species: \$250,000

Possible ways to overcome this gap:

Land use:

State Office of Planning (OP): Legislative action both at the State and Federal levels.

City & County of Honolulu (CCH): unknown

Land cover:

State Office of Planning (OP): Federal, State, or private grants or funds as well as public and private partnerships could best support the creation and maintenance of this layer

Hawai'i Gap Analysis Project (HI-GAP): has no budget shortfall at this time.

Federal or State Listed Species and Habitat: In the long run, the theme would best be supported by a consortium of federal, state, local, and private organizations that pooled resources, supplemented by contracts and grants to help pay for the management and maintenance of this important data layer.

Agricultural land: Federal, State, or private grants or funds as well as public and private partnerships could best support the creation and maintenance of this layer.

Invasive species: Federal, State, or private grants or funds as well as public and private partnerships could best support the creation and maintenance of this layer.

Most appropriate data steward:

Land use: It could be OP or another clearinghouse yet to be established.

Land cover: It could be OP or another clearinghouse yet to be established. The HINHP under a contract from NBII's PBIN will be acting as a clearinghouse for biological datasets and the HI-GAP land cover dataset as well as other framework datasets will be disseminated on this web site.

Federal or State Listed Species and Habitat: HINHP is the likely steward as they all ready maintain the most comprehensive database and GIS repository of endangered species observation data since 1985.

Agricultural land: It could be OP or another clearinghouse yet to be established or USDA's FSA or other.

Invasive species: The HINHP will be acting as a clearinghouse for biological datasets including invasive species under a contract from NBII's PBIN.

Maintenance Process:

Land use: Land use should be updated on at least a five year cycle and use a repeatable method so that change detection and/or other spatial analyses can be conducted and rates or extent of change can be quantified. This would require the constant acquisition of high-resolution orthoimagery as well as image classification and ground verification on a cyclical basis. Areas of high or rapid change may require more frequent updates.

Land cover: Land cover should be updated on a five year cycle and use a repeatable method so that change detection and/or other spatial analyses can be conducted and rates or extent of change can be quantified. This would require the constant acquisition of high-resolution orthoimagery as well as image classification and ground verification on a cyclical basis. Areas of high or rapid change may require more frequent updates.

Federal or State Listed Species and Habitat: Develop partnerships and facilitate database integration and update between USFWS, DLNR, DOD, NPS, TNCH, Bishop Museum, and others who manage rare native species across the state. This would reduce or eliminate duplication of effort, thus increasing efficiency across all agencies.

Agricultural land: Agricultural lands should also be inventoried on a regular basis in order to assess the amount of land under cultivation as well as the types of crops being grown. This would require the constant acquisition of high-resolution imagery and image classification on a cyclical basis as well as ground verification.

Invasive species: Invasive species should be mapped on a regular basis as crews work to eradicate them. Large scale mapping of invasive species can occur in conjunction with the land cover mapping updated on a five year cycle using a repeatable method in order to conduct change analysis so that patterns and rates of change in the landscape can be quantified. Again, this would require the constant acquisition of high-resolution imagery and image classification on a cyclical basis as well as ground verification.

Estimated maintenance cost:

Land use: \$500,000

Land cover: \$250,000

Federal or State Listed Species and Habitat: \$1,000,000

Agricultural land: \$100,000

Invasive species: \$250,000

Reference List

United States Fish and Wildlife Service, (2003). Glossary. Retrieved June 3, 2003, from <http://midwest.fws.gov/endangered/glossary/index.html>

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