PROJECT DOCUMENT

County of Hawai'i General Plan Comprehensive Review

# Analysis Documentation: Conservation & Urban Suitability Report

Date: February 20, 2020
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## Introduction

This technical report documents and describes a CommunityViz analysis built to assess areas of conservation value in the County of Hawaii (CoH). This assessment used best-available GIS information to represent diverse themes including native habitats, coastal resources, hazards, culture, history and agriculture. This resulted in a weighted score of conservation value. The conservation score was then compared with another scoring system that measured suitability for urban development. Areas that both had high conservation scores and high urban scores were then highlighted to identify areas of potential conflict.

## About the Suitability Tool

One of the most powerful applications of CommunityViz is the land suitability analysis: the process of determining which locations are best suited for certain uses. The CommunityViz Suitability Tool allows the user to set up a weighted suitability analysis (sometimes referred to as multivariate suitability). Suitability combines multiple factors having to do with location – such as proximity, overlap, slope, or value – and comes up with a combined rating or score for each place (feature) on the map. "Weighted" suitability analysis places more importance on some factors and less on others, so that the combined rating more fairly represents the relative importance of each location criterion. This technique was used for the CoH Conservation and Urban Suitability analyses.

To use the tool, the user specifies the factors they want to consider (for example, proximity to protected areas or overlap with floodplains) and the Suitability Tool sets up a complete analysis. Once the analysis has been created, the maps symbology can be set up according to which sites are most suitable, and the user can change the weighting of each factor and see the results. Once appropriately symbolized, the map looks like a "heat map" with warmer areas showing areas of great suitability and cooler areas showing areas of lower suitability.

There are two main parts to a suitability analysis. The first is the factor rating, in which features in your layer are rated according to their own attributes or to their relationship to other features or layers on the map. For example, in the conservation suitability analysis, the critical habitat factor is rated based on its overlap with the critical habitat layer. The more overlap with the critical habitat layer, the higher the factor value. This overlap value is then rescaled using a numerical formula and the result is that the grid cell with the most overlap receives the score of 100 and the least overlap receives a score of 0.

Other factors are similarly scaled 0-100 but may use other spatial operations, for example amount of distance to particular feature. The scaled scores for each factor in the analysis are then added together and again rescaled between 0-100.

The second part of a suitability analysis is weighting. Here the user can place more importance on some factors (e.g., proximity to wetlands) and less importance on others (e.g., proximity to streams). The Suitability Tool sets up variable assumptions that control the weight of each factor, typically between 0-10. Once the tool has been run, the user can change the variable assumptions to weigh some factors more than others.

A key component to a Suitability Analysis is the choice of analysis unit. Experience has shown that regular sized units (i.e., an analysis that uses units that are consistently the same size and shape), are superior to units that vary size and shape. Different options were considered including parcels and hexagons, before choosing square grid cells. The grid cell used for both the Conservation and Urban suitability analyses was 40 acres in size.

## Conservation Score

**Conservation Themes**
Working collaboratively, the consultant and CoH staff developed a list of data sources in Appendix 1 and organized them under different thematic areas. Each thematic area had a corresponding suitability analysis. Each suitability analysis had a final score that was an input to a composite suitability analysis.

- Protecting Native Habitats & Wildlife
- Coastal Resources, wetlands, streams, and watersheds
- Hazards & Climate Change
- Landscape, Culture and History
- Prioritizing Agriculture & Food Security

The composite analysis used the five scores from the theme-based suitability analyses listed above. This "nested" approach of developing thematic areas that roll up into a final score allowed planner to look at trends that might be apparent within a particular theme but also allow a simplified "big picture" of conservation priorities on the island.

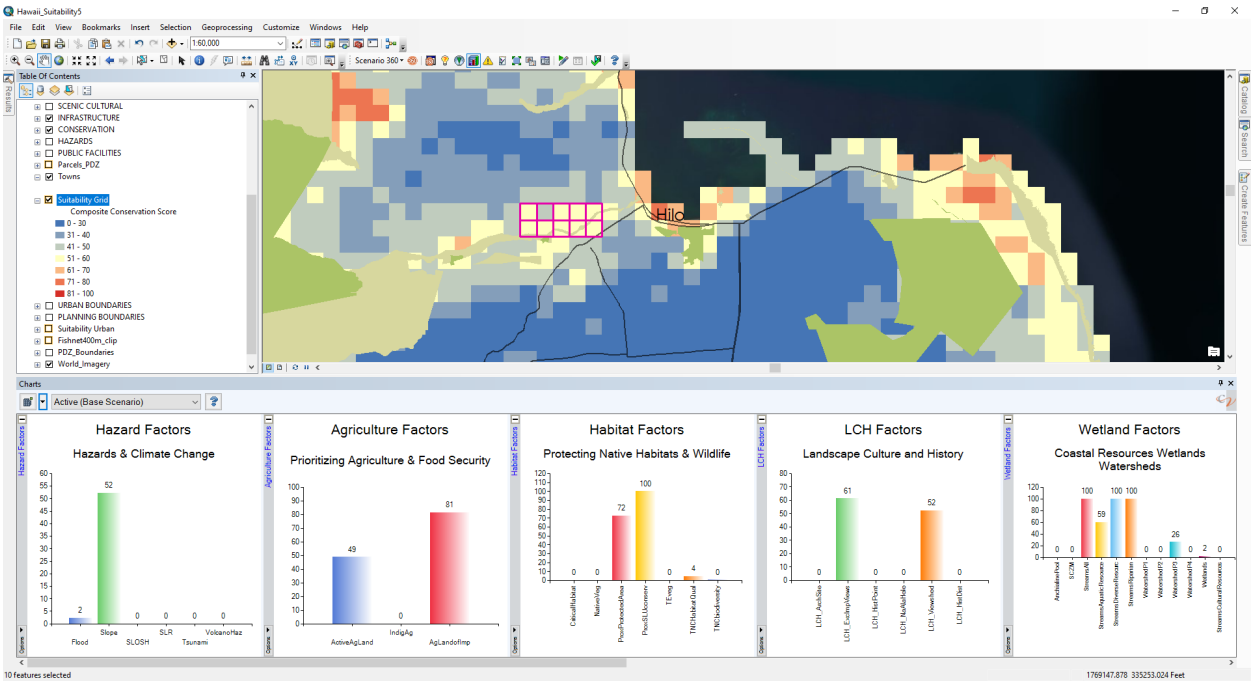
During the development of the analysis, the consultant and planners modified the suitability grid cells, removing grid cells that fell entirely within a permanent protected area (national or state parks) or areas designated for conservation under the State Land Use system (many privately, owned but unlikely to develop significantly under state law). This removed areas which were already conserved and put the emphasis on finding areas that had a greater potential to be developed in the future.

Upon opening the analysis, the user has the option of choosing various "Saved Views" which set up the ArcMap/CommunityViz interface. Saved Views assist users by arranging the screen display to match an arrangement, appearance and map symbology. The saved views included in the analysis allowed the user to examine the final results of each thematic area and the final composite score. The analysis lets a user find specific information about suitability scores by querying one or more grid cells. CommunityViz

has a set of functions that provide an easy way for a user to select a feature and get set of metrics, displayed in either a table or chart. In this analysis, the metrics are displayed as indicators in a chart or alternatively in a list. The image below illustrates how this process works.

In the example below, the user has selected an area west of Hilo (note pink highlighted grid cells). The grid cells are showing the Composite Conservation Score on a scale from 0-100. Warmer colors represent areas with higher scores. After running the "Update IsSelected Formulas" button on the CommunityViz Scenario 360 Toolbar, the tool updates the indicator metrics shown in the charts. Each chart contains the factors belonging to a particular theme, the bar graphs showing the average score between 0-100 for each factor. Using this system, the user can identify what factors are contributing to the conservation scores of any area of the island.

Figure 1 Screenshot of the Conservation Composite Scores in the CommunityViz analysis




## Weighting the Suitability Analysis

By default, CommunityViz assigns a weight of five to all factors that are created with the tool. After the development of a draft version, the consultant met with County planners to discuss potential criteria that could influence weighting. The factors discussed included:

- Legal Criteria – What resources are protected by federal, state or county law? Criteria considered included:
    - Threatened and endangered species
    - State land use system
    - Coastal zone management
    - State water code
    - Historic Preservation Laws
    - Important agricultural lands
- Data Quality

  - Scale. Data mapped at a coarser scale should be weighed less.
  - Origin. Data that has been modeled or remotely sensed (e.g., mapped via satellite) typically has a lower value than data mapped in person, in the field.
  - Age. Older data should have a lower value compared to data that is more recent.
- Ecosystem Service Criteria. Ecosystem services is a concept that recognizes that natural resources and healthy ecosystems provide benefits to people. While understood implicitly by native people for millennia, modern societies have recognized the importance of ecosystem services relatively recently. Ecosystem services can be classified using the following:
  - Provisioning services are services that provide benefits such as food or raw materials.
  - Regulating services regulate climate, cycle nutrients, and sequester carbon, among other benefits.
  - Habitat services provide habitat for migratory and resident species.
  - Cultural services provide spiritual, recreational, scientific and educational benefits.
- Strategic Conservation Criteria
  - Protected areas benefit from connectivity and buffering from intense human activities
  - Conservation efforts in absence of complete information generally emphasize protecting areas where the greatest diversity and abundance of species exist.
  - Species imperilment is a key criterion to the protection of natural resources. Conservation efforts should factor in concepts like rarity, endemism, and the threats from long-term trends such as climate change and habitat loss. Resources with lower levels of imperilment should receive lower weighting.

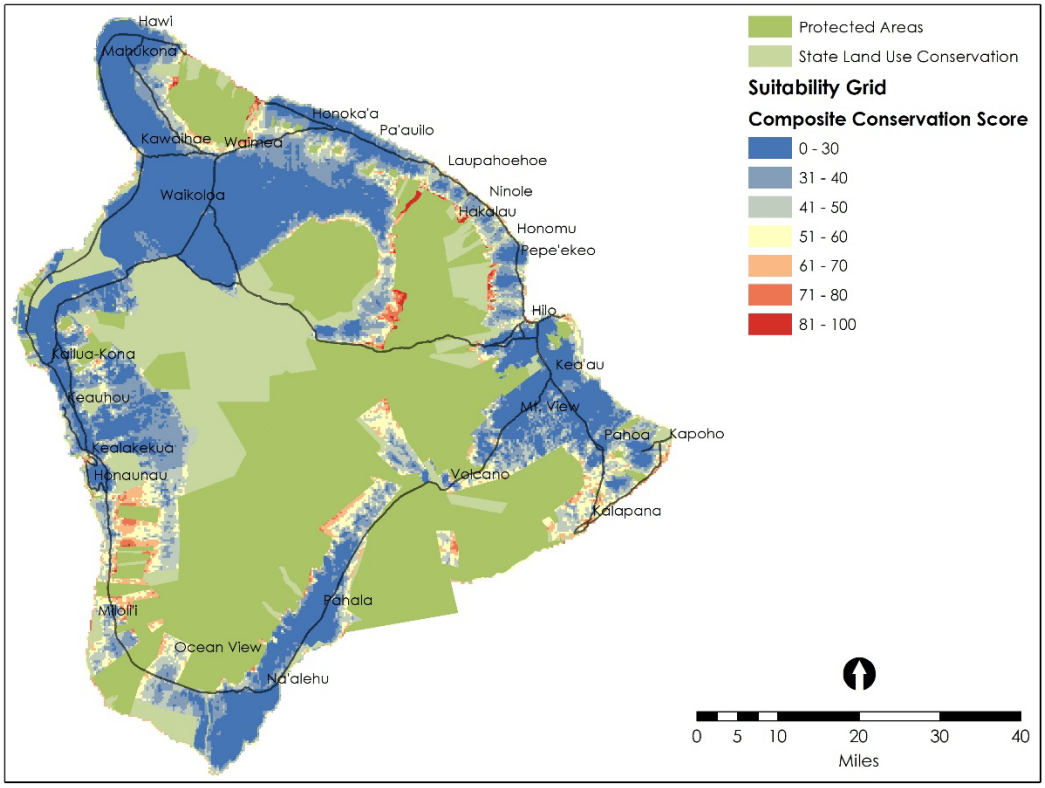
After meeting internally and some initial revisions, county planners proposed the weighting system included in the table below. The analysis called, "Hawaii_Suitability6.mxd" was provided to county planners. The analysis was built on CommunityViz 5.2 for ArcGIS 10.4 but will work with the current production version of ArcGIS 10.7 as of this writing. A more complete version of the table below is included in Appendix 2.

| Suitability | Factor Name | Weight |
|---|---|---|
| Protecting Native Habitats & Wildlife | Nature Conservancy Assessment of Habitat Quality | 10 |
| | Nature Conservancy Assessment of Biodiversity | 10 |
| | Native Vegetation | 8 |
| | Proximity to Protected Areas | 6 |
| | Proximity to State Land Use Designated Conservation Areas | 5 |
| | Critical Habitat | 3 |
| | Threatened and endangered plant species | 2 |
| Coastal Resources, wetlands, streams, and watersheds | Anchialine pools | 10 |
| | Watersheds Priority 3 | 9 |
| | Watersheds Priority 4 | 8 |
| | Watersheds Priority 1 | 7 |
| | Watersheds Priority 2 | 6 |

| | | |
|---|---|---|
| | Streams Diverse Resources | 5.5 |
| | Streams Riparian Resources | 5 |
| | Streams Aquatic Resources | 4.5 |
| | Streams with Cultural Resources | 4 |
| | All streams (complements the other stream assessment layers) | 3 |
| | State Coastal Management Zone | 2 |
| | USGS Wetlands | 1 |
| Hazards & Climate Change | USGS volcano hazard areas | 10 |
| | Tsunami risk areas | 8.5 |
| | Sea, Lake and Overland Surges from Hurricanes (SLOSH) | 7 |
| | Sea level rise areas | 5 |
| | Wildfire risk | 4 |
| | Steep slopes | 3 |
| | FEMA flood areas | 1 |
| Landscape, Culture and History | Exceptional and Important Views | 10 |
| | Important Viewsheds | 8 |
| | Na Ala Hele Trails | 6 |
| | Archaeology Polygon | 4 |
| | Historic Sites | 2 |
| | Historic Districts | 1 |
| Prioritizing Agriculture & Food Security | Active Agricultural Land | 10 |
| | Indigenous agricultural lands | 7 |
| | Agricultural land of importance | 4 |
| Composite Score | Protecting Native Habitats & Wildlife | 10 |
| | Coastal Resources, wetlands, streams, and watersheds | 8 |
| | Hazards & Climate Change | 6 |
| | Landscape, Culture and History | 4 |
| | Prioritizing Agriculture & Food Security | 2 |

The conservation score analysis reveals various conservation hotspots across the island. Many of these areas are proximate to the County's existing conservation areas and coastline. The importance of the island's perennial streams and wetland areas is also apparent. Forest areas, in particular areas with high ratios of native species to non-native species appear in the wetter windward sides of the island (Hamakua, Hilo, Kau and Puna) as well as the highlands of South Kona.

Figure 2 Conservation Scores map




## Urban Score

The Urban Suitability Analysis was developed as part of an earlier technical task that focused on identifying areas that would be most suitable for future urban growth. This is documented in the Alternative Future Scenarios Technical Report. This task culminated in the creation of the Priority Development Zone (PDZ) future growth scenario. The scenario tested the potential of shifting urban growth to areas in and around existing villages, towns and urban clusters. The development of the Urban Score helped planners identify the boundaries of the PDZs and was employed again here for the purpose of identifying potential conflicts between areas that are appropriate for future urban growth and areas with a high conservation value.

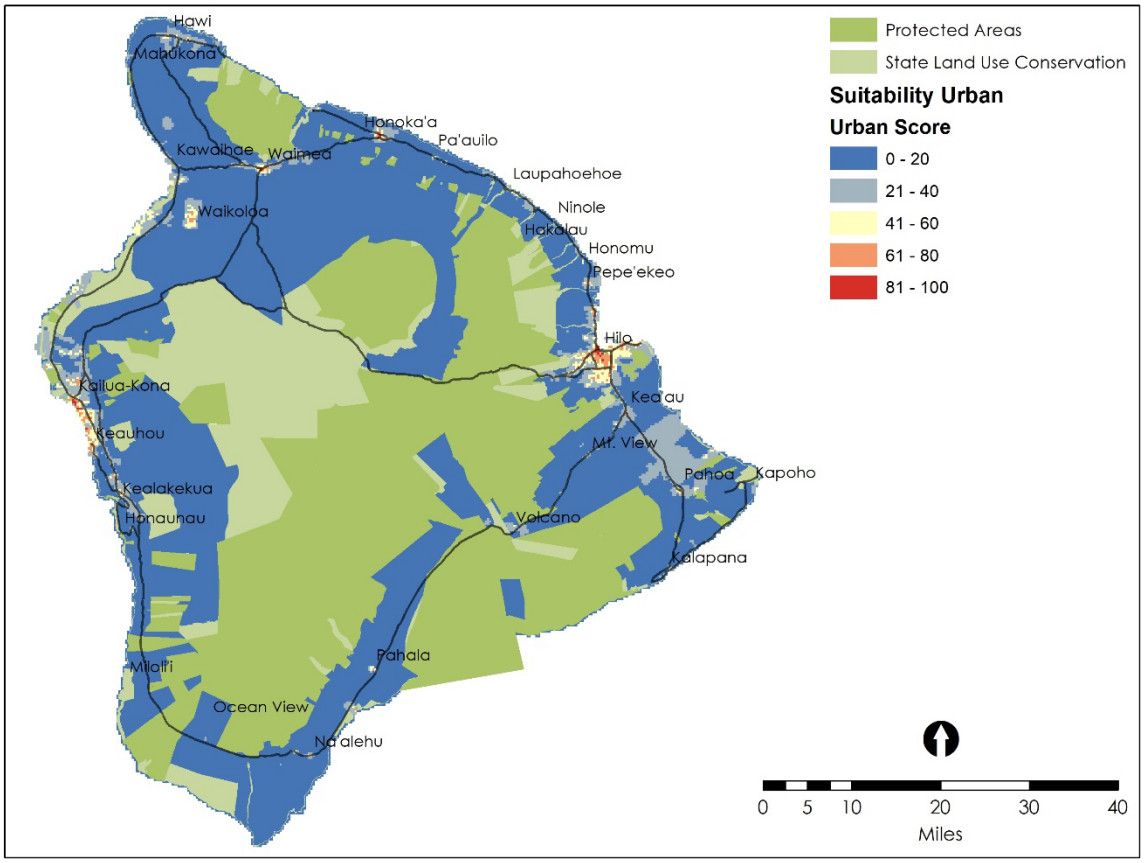
The urban score was developed using eight factors described below. No weighting was assigned and the default score of 5 assigned by CommunityViz was maintained.

| Suitability | Factor Name | Weight |
|---|---|---|
| Urban Score | Density of Existing Commercial Development | 5 |
| | Density of Existing Residential Development | 5 |
| | Proximity to Existing Facilities (school, park, or community center) | 5 |
| | Proximity to Existing Utilities (Water, Wastewater) | 5 |
| | Intersection Density | 5 |

| | | |
|---|---|---|
| | Road Density | 5 |
| | Mixed Use Score (An assessment of the existing mix of housing and nonresidential activities) | 5 |
| | US Census Defined Urban Area | 5 |
| | Overlap with County Zoning allowing Urban Uses | 5 |

The urban score reveals a handful of hotspots on the island. This reflects the predominantly rural nature of development in CoH. The analysis confirms that there are just a few places on the island that are truly urbanized and have utilities to support dense urban growth: Hilo, Honoka'a, Kailua-Kona, Keauhou, Waikoloa, and Waimea.

Figure 3 Urban Scores map



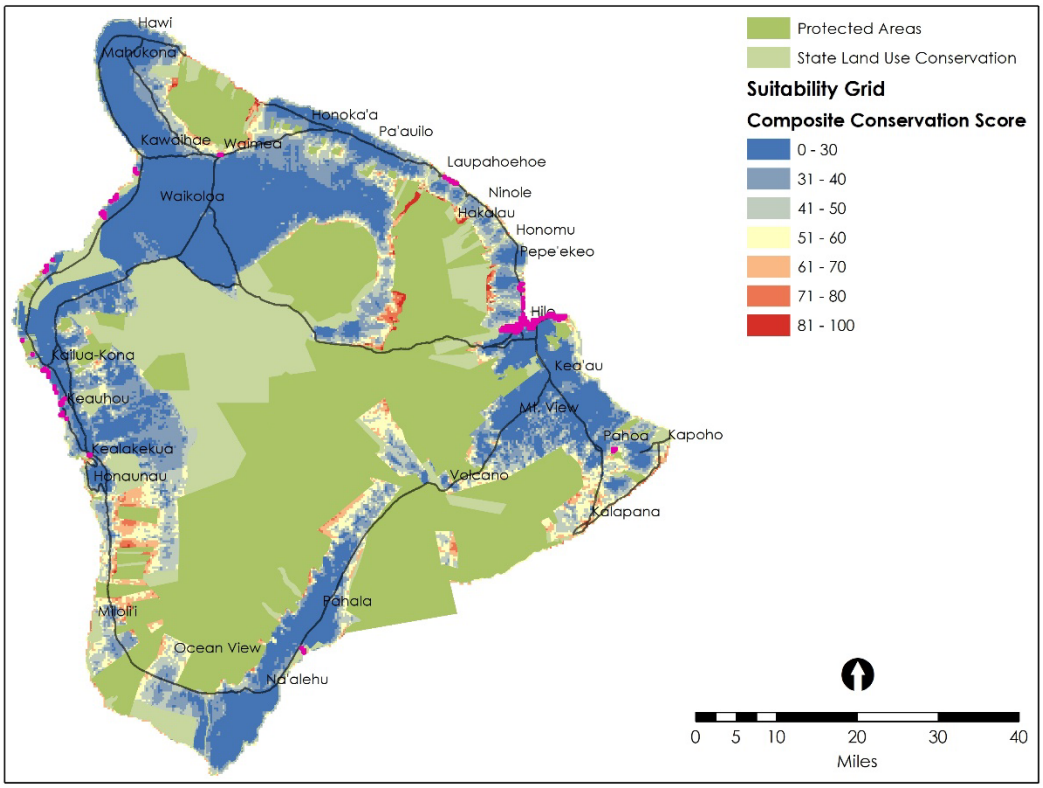

## Comparing Urban Score and Conservation Score

If the urban score suggests where future growth might most appropriately be located, what conflicts might arise with areas that also have high conservation value? This was the question that CoH Planners wanted to address as the final step of the analysis process. To address this, the analysis then compared areas with both high conservation and urban scores by adding one score to the other to create a "conflict score". After a few iterations of the process, the consultant and planners agreed that only

areas with scores higher than 40 should be added to each other. This removed areas with relatively low scores in both assessments. This set a minimum score of 80 and theoretical maximum score of 200 (each score being on a scale of 1-100). The Conflict Score can be revisited by changing the formula in the "SuitabilityCompositeConflict" attribute in the Suitability Grid layer (e.g., choose a higher threshold than 40).

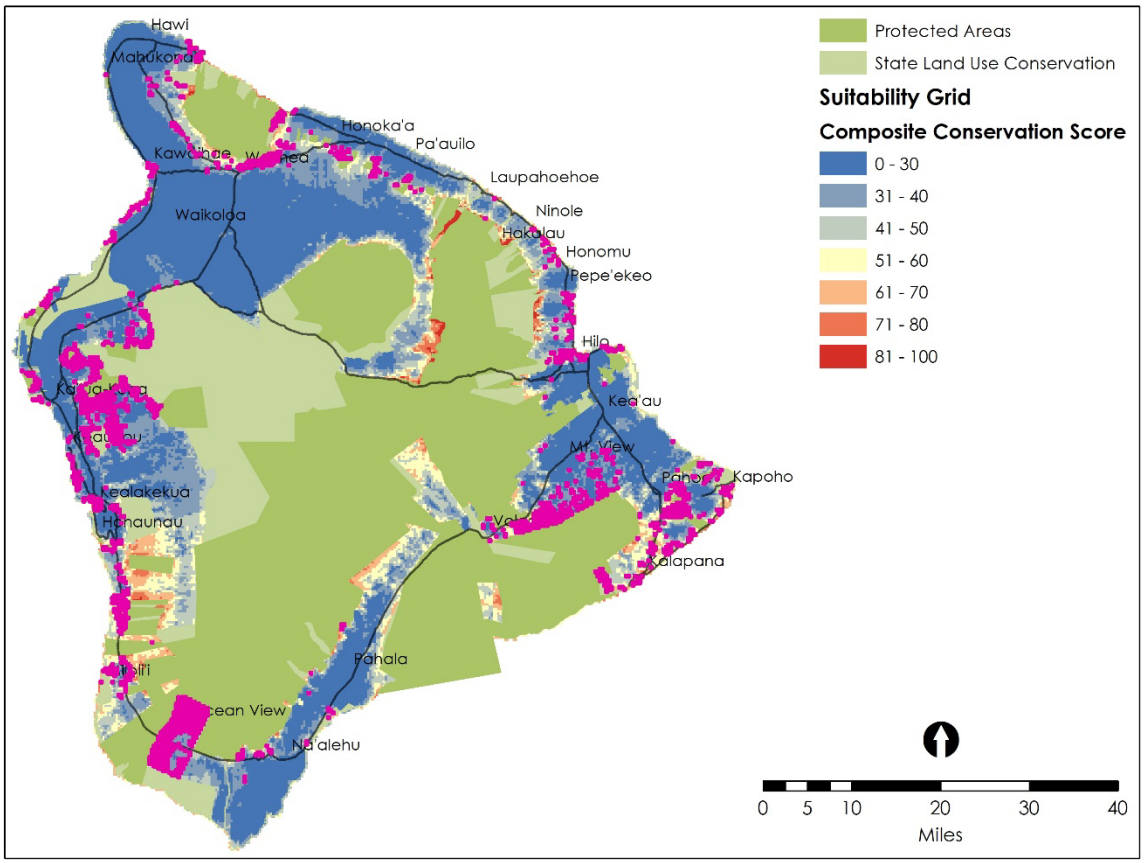
The result of this step reveals that are a limited number of areas (144 grid cells or about 5,760 acres) where high urban scores and conservation score coexist. The largest of these areas is an area in Hilo that includes the waterfront and a forested corridor along the Wailuku River surrounding upland (mauka) areas, west of the city. One of the highly ranked themes in the Conservation Score includes Hazards & Climate Change. The Hilo waterfront is an extremely vulnerable place with a tragic history of tsunami inundations. Upland areas to the west may be slightly less vulnerable but steep slopes and high conservation values imply incompatibility with future urban growth. Other areas that have high conflict scores include coastal areas near Kailua-Kona, South Kohala Beach Areas, and Laupahoehoe. These areas have similar profiles in conservation and conflict: high vulnerability to hazards and proximity to fragile coastal resources while having high suitability for urban development due to the presence of existing towns and villages and their services. That many of the most urban areas have relatively low conservation scores makes sense, these areas having been developed and most of their conservation value reduced.

**Figure 4 Conservation Score map, with highlights in pink showing areas with both high Conservation Score and Urban Scores**



This map is interesting to contrast against a similar analysis of conflict using an alternative to the Urban Score. The Trend Growth Scenario also used the CommunityViz suitability tool to guide the location of future residential growth as has been occurring according to recent trends. Informed by a statistical analysis and described in greater detail in the Trend Scenario and Land Use Allocation Technical Report, the Trend Residential Suitability was used to orient residential growth in the Trend Scenario (nonresidential growth was guided by a separate suitability analysis). The Trend Scenario showed a much more dispersed growth pattern, in particular orienting growth into rural and undeveloped areas of Puna, North and South Kona, Kau and South Kohala. As with the other suitability scores, the Trend Residential Growth was on a scale of 0-100. Using this score instead of the Urban Score results in a much larger areas of conflict (2,091 grid cells or 83,640 acres). Large areas in Ocean View, Puna, North and South Kona. While the Urban Score and Conservation Conflict areas are limited to a few coastal areas, many areas of the county's interior show conflict in this assessment.

**Figure 5 Conservation Score map, with highlights in pink showing areas with both high Conservation Score and Trend Suitability Scores**



# Appendix 1

**Data Used or Considered For Conservation Analysis**

- Hawaii Statewide Assessment of Forest Conditions and Resource Strategy (2010). Biodiversity/Habitat Quality summaries completed by The Nature Conservancy
- Carbon Assessment of Hawaii Land Cover Map 2015 (CAH Land Cover)
- Protected Areas (PAD US 2015)
- Hawaii State Land Use
- USFWS Critical Habitat
- Threatened and endangered plant species (1992)
- Anchialine Pool Sites
- Thermal Springs
- USGS Volcano Hazard Zones
- NOAA Tsunami risk areas
- NOAA Sea, Lake and Overland Surges from Hurricanes (SLOSH)
- SLR-XA 3.2 feet
- Wildfire Hazard
- Digital Elevation Model derived steep slopes (slope as percent) (Placeways 2015)
- Exceptional and Important View Areas  Point Locations (2014)
- Viewsheds (Placeways 2015)
- Streams with Assessed Resources (cultural/diverse/riparian/aquatic) layer
- USGS Streams layer (all streams)
- State Coastal Management Areas
- Watershed Priority Areas (I, II, III, IV)
- Impaired marine waters
- Restricted Watersheds
- GW Recharge (optional?)
- NWI Wetlands
- FEMA Coastal V-zones (coastal waters)
- Sensitive Ecological Areas
- Scenic Beauty Sites/Viewsheds?
- Na ala Hele Trail
- University of Hawaii Hilo Agriculture Assessment (2015)
- The potential of indigenous agricultural food production under climate change in Hawai'i (2019) Modeled layers representing areas with potential for different methods of indigenous agriculture: dryland, loi and agroforestry
- Agricultural Lands of Importance.

Additional Location Sensitive Data

- Archeological Points/polygons
- Historic Object/Buildings/structures
- Historic Districts
- T&E Plant species

# Appendix 2

### Theme, Factor and Data Matrix for Conservation Score Suitability Analysis

This matrix contains all of the factors created for Conservation Score Suitability Analysis, including the CoH assigned rank, CommunityViz assumption weight (0-10), the name of the assumption in the CommunityViz analysis and the GIS layer name that the factor is based on.

| Suitability | Factor Name | Rank | CommunityViz Model Weight | CommunityViz Assumption Name | Layer Name |
|---|---|---|---|---|---|
| Protecting Native Habitats & Wildlife | TNC Habitat Quality | 1 | 10 | HAB_TNCHabQual | hi_hq_combo_int_prj_clip_reclass.tif |
| Protecting Native Habitats & Wildlife | TNC Biodiversity | 1 | 10 | HAB_TNCBiodiv | hi_biodiv2010_int_prj_clip_reclass.tif |
| Protecting Native Habitats & Wildlife | Native Vegetation | 2 | 8 | HAB_NativeVeg Weight | CAH_HabStatusPrj2clip.tif |
| Protecting Native Habitats & Wildlife | Proximity to Protected Areas | 3 | 6 | HAB_ProxProtectedArea Weight | PADUS_CoH_Protected |
| Protecting Native Habitats & Wildlife | Proximity to SLU Conservation Areas | 4 | 5 | HAB_ProxSLUconserv Weight | SLU_Conservation |
| Protecting Native Habitats & Wildlife | Critical Habitat | 5 | 3 | Hab_CriticalHabitat | CriticalHabitat |
| Protecting Native Habitats & Wildlife | Threatened and endangered plant species | 6 | 2 | HAB_TEveg Weight | teplant_n83_prj |
| | | | | | |
| Coastal Resources, Wetlands, Streams, and Watersheds | Anchialine pools | 1 | 10 | WET_Anchialine Weight | AnchialinePoolsPrj |
| Coastal Resources, Wetlands, Streams, and Watersheds | Watershed Priority 3 | 2 | 9 | WET_WatershedP3 Weight | Watersheds |
| Coastal Resources, Wetlands, Streams, and Watersheds | Watershed Priority 4 | 2 | 8 | WET_WatershedP4 Weight | Watersheds |
| Coastal Resources, Wetlands, Streams, and Watersheds | Watershed Priority 1 | 2 | 7 | WET_WatershedP1 Weight | Watersheds |
| Coastal Resources, Wetlands, Streams, and Watersheds | Watershed Priority 2 | 2 | 6 | WET_WatershedP2 Weight | Watersheds |
| Coastal Resources, Wetlands, Streams, and Watersheds | Streams Diverse Resources | 3 | 5.5 | WET_StreamsDiverse Weight | StreamsDiverseResources_strmsdiv_n83_prj |
| Coastal Resources, Wetlands, Streams, and Watersheds | Streams Riparian Resources | 4 | 5 | WET_StreamsRiparian Weight | strmsrip_n83_prj |

| | | | | | |
|---|---|---|---|---|---|
| Coastal Resources, Wetlands, Streams, and Watersheds | Streams Aquatic Resources | 5 | 4.5 | WET_StreamsAquatic Weight | StreamsAquaticResources_strmsaq_n83_prj |
| Coastal Resources, Wetlands, Streams, and Watersheds | Streams with Cultural Resources | 6 | 4 | WET_StreamsCultural Weight | StreamsDiverseResources_strmsdiv_n83_prj (where resource is cultural) |
| Coastal Resources, Wetlands, Streams, and Watersheds | All streams (complements the other stream assessement layers) | 7 | 3 | WET_StreamsAll Weight | Streams_All_DARprj |
| Coastal Resources, Wetlands, Streams, and Watersheds | State Coastal Management Zone | 8 | 2 | WET_SCZM Weight | StateCoastalZoneManagement |
| Coastal Resources, Wetlands, Streams, and Watersheds | Thermal Springs | X | X | WET_ThermalSpr Weight | ThermalSpringsPrj_Buffer |
| Coastal Resources, Wetlands, Streams, and Watersheds | USGS Wetlands | 10 | 1 | WET_Wetlands Weight | HI_WetlandsPrj |
| | | | | | |
| Hazards & Climate Change | USGS volcano hazard areas | 1 | 10 | HAZ_VolcanoHaz Weight | VolcanoHazardZones |
| Hazards & Climate Change | Volcano buffer area | X | X | HAZ_VolcanoBuf Weight | volbndbuf_n83 |
| Hazards & Climate Change | Tsunami risk areas | 3 | 8.5 | HAZ_Tsunami Weight | Hawaii_Tsunami_Prj |
| Hazards & Climate Change | Sea, Lake and Overland Surges from Hurricanes (SLOSH) | 4 | 7 | HAZ_SLOSH Weight | HI_Cat4_SLOSH_HiTidePrj6.tif |
| Hazards & Climate Change | Sea level rise areas | 5 | 5 | HAZ_SLR Weight | slr_exposure_area_3_pt_2_ft_prj2 |
| Hazards & Climate Change | Wildfire risk | 6 | 4 | HAZ_WildfireHaz Weight | WildfireRisk_WHA2015_prj2 |
| Hazards & Climate Change | Steep slopes | 7 | 3 | HAZ_Slope Weight | HawaiiSlopePerc |
| Hazards & Climate Change | FEMA flood areas | 8 | 1 | HAZ_Flood Weight | Flood_Zones |
| Hazards & Climate Change | Marine waters | X | X | HAZ_MarineWaters Weight | |
| | | | | | |
| Landscape, Culture and History | Exceptional And Important Views | 1 | 10 | LCH_ExcImpViews Weight | ExceptionalAndImportantViews |
| Landscape, Culture and History | Important Viewsheds | 2 | 8 | LCH_Viewshed Weight | ViewshedMaxValue |
| Landscape, Culture and History | Na Ala Hele Trails | 3 | 6 | LCH_NaAlaHele Weight | NaAlaHeleTrailsPrj |
| Landscape, Culture and History | Archaeology Polygon | 4 | 4 | LCH_ArchSite Weight | Archaeology Polygon |
| Landscape, Culture and History | Historic sites | 5 | 2 | LCH_HistPoint Weight | Historic Object Point, Historic Structure Point, Historic Building Point |

| | | | | | |
|---|---|---|---|---|---|
| Landscape, Culture and History | historic districts | 6 | 1 | LCH_HistDist Weight | Historic District Polygon |
| Landscape, Culture and History | Natural Beauty Sites | X | X | LCH_NatBeautySite Weight | Natural Beauty SitesPrj |
| | | | | | |
| Prioritizing Agriculture & Food Security | Active Agricultural Land | 1 | 10 | AG_ActiveAg Weight | 2015AgBaseline_Prj2 |
| Prioritizing Agriculture & Food Security | Indigenous agricultural lands | 2 | 7 | AG_IndigAg Weight | Hawaii_Agro_Final10prj_Rcls3.tif , Hawaii_Dry_Final10prj_Rcls3.tif, Hawaii_Loi_Final10prj_Rcls3.tif |
| Prioritizing Agriculture & Food Security | Agricultural land of importance | 3 | 4 | AG_AgLandofImp Weight | AgLandofImportance |
| | | | | | |
| Composite Suitability | Protecting Native Habitats & Wildlife | 1 | 10 | HAB_CompWeight | Protecting Native Habitats & Wildlife |
| Composite Suitability | Coastal Resources, wetlands, streams, and watersheds | 2 | 8 | WET_CompWeight | Coastal Resources, wetlands, streams, and watersheds |
| Composite Suitability | Hazards & Climate Change | 3 | 6 | HAZ_CompWeight | Hazards & Climate Change |
| Composite Suitability | Landscape, Culture and History | 4 | 4 | LCH_CompWeight | Landscape, Culture and History |
| Composite Suitability | Prioritizing Agriculture & Food Security | 5 | 2 | AG_CompWeight | Prioritizing Agriculture & Food Security |