NATURAL AREA RESERVES SYSTEM HAWAI`I
NARS Enhancement Report: Analysis to Identify Biologically Important Areas
Draft September 2008

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Introduction

The Natural Area Reserves System Commission was formed in the early 1970s to recommend to the Governor and Department of Land and Natural Resources areas suitable for inclusion within the reserves system; on any matter relating to the preservation of Hawai`i's unique natural resources; and advise on the management of state-owned land or natural resources which are or may be appropriate for inclusion into the reserves system, among other duties (See HRS §195-7). This analysis builds on the previous work done by the Commission to fulfill these duties, with a compilation of comprehensive and up to date scientific data to fulfill the NARS' goal of representing the full range of Hawai`i's unique geology, plants, animals, and habitats.

This report explains the various methods used to measure the biological resource criteria for selecting natural areas (See Appendix 1). The methods selected to undertake this analysis were the result of discussions in various meetings among Commissioners, DOFAW staff, scientists, and land managers. In addition to the input received in those meetings, many others offered advice, recommendations, and contributed data to this analysis.


Sea Cave
Hono O Na Pali NAR

1973 – The first Reserve, `Ahihi-Kina`u, was added to the System. The next year, the Waiakea 1942 Lava Flow was included, followed by the addition of 17 more reserves in the 1980s. The most recent Reserve designated was Kanaio in 1991.

Those that have had an interest and input in this analysis are gratefully acknowledged in the "Mahalo" section.

Purpose

It is a large commitment to designate an area as a NAR and direct resources to the management of that area. In order to prioritize the numerous areas that have been proposed as NARS in the past, and identify new areas that are appropriate for conservation designation or management, the NARS Commission has spearheaded this analysis to systematically evaluate areas statewide for their biological and geological resources. This analysis was designed to be comprehensive so that the areas identified fit best within the entire statewide conservation picture.

This analysis is meant as a guide for the Commission and other conservation entities, and compiles data useful for planning, policymaking, research, and education. While the Commission has recommended and prioritized some of the areas for NARS designation, many of the areas that are listed in the Data section have not been presented to the Commission. These areas are labeled "Biologically Important Areas" because this analysis only focuses on the biological resources of areas and does not address the other criteria needed for NARS designation. Since this analysis is also meant to ensure that other areas that were not previously recommended are taken into account, the Commission requested that land managers and scientists give recommendations of biologically important areas, and many of the areas listed are results of that input. A multi-stage radial analysis survey method was used to gain input on areas and data sources that should be investigated.

This analysis is a preliminary step in a larger process of evaluating and gaining input about the designation of Hawai`i's native ecosystems. In the past few months, clarifications to the NARS Nomination process have been made (See Appendix 2), and the NARS has completed a Strategic Plan with goals that relate to filling ecosystem gaps in the NARS, as well as integration with other DLNR and DOFAW programs.

Most areas listed as biologically important have not had nominations developed or submitted to the NARS Commission, which is the first step towards NARS nomination. None of the areas listed have been officially recommended by the NARS Commission, with the exception of Poamoho, Hono O Na Pali Extension, and Kanaio Mauka Extension. These nominations have been undergoing public comment and BLNR and governor review. Throughout this process, DOFAW staff have met

Blue Hole, Kauai

"There is a generally agreed upon goal of 100 reserves with a mean acreage of 1,500 acres. These are to be selected as much as possible to lie in altitudinal belt transects to encompass a maximum of variation in vegetation and climate. Ideally, these belt-transects should be continuous from mountain tops to sea level." - *Conceptual Plan for the Natural Area Reserves System*, 1975

periodically to discuss individual nominations, as well as give input on the process and effects of the designation of new NARS.

Methods

A major objective of this analysis is to find gaps in the NARS: ecosystems not contained in the NARS or any other type of protective designation. Finding areas that contain rare species that are not protected in any other type of protective designation is another way to fill in the gaps. Finding viable, "relatively unmodified" examples of these ecosystems means targeting locations with the highest habitat quality, habitat contiguity, as well as areas nearby adjacent areas designated for conservation. This analysis measures these factors by drawing upon various data sources and analyses that have sought to find which native ecosystems are most imperiled, as well as intact.

The data sources used in this analysis were recommended by the NARS Commission in regular meetings as well as in meetings of the Subcommittee on Enhancement. In addition to a 2005 retreat where some areas suggested for NAR designation were roughly prioritized, there have been many previous meetings that led to the formulation of this analysis. Recent meetings that specifically addressed the content of NARS enhancement can be reviewed online[1].

This section quickly summarizes the categories used in the Part 2: Data section, where the recommended areas are listed in tables to determine their biological importance in flora, fauna and landscape categories. Following this list is a description of the data sources and their relevance to the analysis.

To establish a general standard of "NARS-Quality," existing Reserves are evaluated for comparison purposes.

FLORA

Total Plant Richness: Please see the summary of *Mapping Plant Species Ranges in the Hawaiian Islands: Developing a Methodology and Associated GIS Layers* (Price et al., 2007) for a more complete discussion on this measurement. This represents the highest concentration of all native vascular plant species' predicted ranges (potential species range that is still within a native-dominated ecosystem as projected by HI-GAP), from a low of 0 to a potential 331 overlapping species' ranges. These possible ranges were divided into even fifths – Very Low, Low, Medium, High, and Very High.

Endangered Plant Richness: Similar in methodology to the previous category, this represents the highest concentration of all endangered native vascular plant species' predicted ranges (potential species range that is still within a native-dominated ecosystem

[1] Minutes of the April 21 2008 Workshop on Enhancement:
http://hawaii.gov/dlnr/dofaw/nars/narsc/NARSC-Meeting-Workshop-4.21.08/DOC002.PDF/view

NARS Commission Submittal that summarized interviews with members of the Subcommittee on Enhancement in preparation for the June 30, 2008 Workshop:
http://hawaii.gov/dlnr/dofaw/nars/narsc/6.4.08/NARSC%20submittal%20Enhancement%20Discussion%20%205.22.08/view

Minutes of the June 30, 2008 Workshop on Enhancement:
http://hawaii.gov/dlnr/dofaw/nars/narsc/6.4.08/minutes%20workshop%20enhancement%206.4.08.pdf/view

as projected by HI-GAP), from a low of 0 to a potential richness of 48. These predicted overlapping ranges were divided into even fifths – Very Low, Low, Medium, High, and Very High.

FAUNA

Forest Bird Species: The number of native forest bird species with predicted habitat range in the area, including the ʻIo (*Buteo solitarius*), Pueo (*Asio flammeus sandwicensis*) and the Nene (*Branta sandvicensis*). Low = 0-3 species, Medium = 4-7 species, High = 8-11 species.

Endangered Forest Bird Species: The number of federally listed endangered forest bird species with predicted habitat range in the area, including the `Io (*Buteo solitarius*), and the Nene (*Branta sandvicensis*). Low = 0-1 species, Medium = 2-3 species, High = 4-5 species.

Aquatic Species Rating: *The Atlas of Hawaiian Watersheds and Aquatic Resources* gave watersheds a "Native Species Rating" based on the number of native species observed in the watershed, on a 0-10 scale. The native species rating was given to each recommended area with a ranked watershed. If the recommended area contained more than one watershed, the highest ranking watershed was recorded. Low = Areas with no streams or with a watershed with a native species rating of 0-3, Medium = areas with streams in watersheds with a native species rating of 4-7, High = native species rating of 8-10.

Anchialine Species Rating: This data and ranking system comes from an unreleased and still in development coastal addendum to *An Ecoregional Assessment of Biodiversity Conservation for the Hawaiian High Islands* (The Nature Conservancy Ecoregional Planning Team, 2006). A points system assigns different values to species found in these pools based on rarity.

1pt each - common shrimp (*H. rubra*, *P. debilis*, and *M. grandimanus*), eel, any amphipod, any isopod, any algae, Ruppia, any mollusc, and any grapsid crab

2 pt - *M. lohena*

3 pt - all rare shrimp

0 pt - all worms, insects, and sponges/coelenterates/other invertebrates

Halapepe, Kanaio NAR

2005 – A public hearing is held for the north/west extension of Kanaio NAR.

LANDSCAPE

Area: The relative size of the proposed area, based on the size distribution of existing NARS. Small = 0-1,100 acres, Medium = 1,101-3,748 acres, Large = 3,748 acres or more.

Habitat Diversity: The number of different habitat types found in the area, based on the nine types distinguished by bioclimactic and substrate factors in *Mapping Plant Species Ranges: Developing a Methodology and Associated GIS Layers* (Price et. al, 2007). These habitats were: Alpine, Subalpine, Montane Dry, Montane Mesic, Montane Wet,

Lowland Dry, Lowland Mesic, and Lowland Wet, and Pioneer (fresher lava flows). Low = 1-2 habitat types, Medium = 3-4, High = 4-9.

Priority Habitats: Similar in methodology to previous category. The number of different "priority" habitats found in the area, based on the three types that are relatively degraded and unprotected: Lowland Dry, Lowland Mesic, and Lowland Wet. Low = 0 priority habitat types, Medium = 1-2, High = 3.

Habitat Quality: The primary source for mapping this and the following two categories is the HI-GAP report (US Dept. of Interior, 2006). Areas with <25% of their landcover recorded as native dominated vegetation ranked Low, while areas with 25-50% of their landcover recorded as native-dominated=Medium, and areas with >75% native dominated landcover ranked High. HI-GAP had technical limitations in detecting native dominated landscapes in dryland and coastal areas.

Habitat Contiguity: This measures whether the area is adjacent to high-quality native habitat, so is part of a larger contiguous system, which increases its viability. Areas with areas with <25% adjacent native dominated vegetation=Low, areas with 25-50% connectivity with other native dominated vegetation=Medium, and areas with >75% of their boundaries adjacent to native-dominated vegetation=High.

Management Contiguity: This measures whether the adjacent lands have conservation management intent, based on HI GAP Management Intent Status 1 and 2. Areas with no adjacent connectivity= Low, areas with >0 but <50% connectivity=Medium, and areas with > 50% of their boundaries adjacent to these areas = High.

Ecosystems: Ecosystems that have less than 10% of their distribution the NARS are listed in yellow, of the 10 ecosystems distinguished in *An Ecoregional Assessment of Biodiversity Conservation for the Hawaiian High Islands* (The Nature Conservancy Ecoregional Planning Team, 2006). Ecosystems that have more than 10% of their range represented in a NAR are pink, ecosystems with less than 10% of their distribution in a NAR are yellow, and ecosystems with <10% in any Management Intent Status 1 or 2 (including NARS) are in green. Ecosystems designated as "Good" or "Very Good" viability are bolded.

Summary of Data Sources

A Biological Overview of the Natural Area Reserves System/Hawaiian Natural Community Classification System

Hawai`i Heritage Program, The Nature Conservancy of Hawai`i, 1987

In the late 1980s and early 90s, the Hawai`i Heritage Program released reports on the Hawaiian Natural Community Classification and tables which indicated whether these communities were represented in any NARS, National Parks, State Parks, FWS

Kalalau back pali

1987- A Biological Overview of the NARS is released, which includes lists of 49 native communities not included in designated areas, and lists 29 candidate reserves.

Refuges, other state lands, or county/privately owned lands. This classification system was further refined in later versions. Appendix 2 has a brief summary of the findings of the Protection Status of Hawaiian Natural Communities, and a link to that document.

In the most recent version of the Natural Communities Classification System, 108 terrestrial communities were included [2]. The most imperiled elevation-moisture types, as measured by the G1 rank of critically imperiled, without consideration of the protection status of the ecosystem were found in the Lowland Dry, Lowland Mesic, Subalpine Dry, Subalpine Mesic, Coastal Dry, Coastal Mesic, Montane Mesic, Montane Dry ecosystems.

NARS Commissioners and staff identified limitations for using the 1987 biological overview, including the need for a broader ecosystem classification system and the lack of comprehensive mapping of the location of these communities. While this data remains useful, Commissioners indicated that there were opportunities to use more recent data sources. One source mentioned was the GAP Analysis.

A GAP Analysis of Hawai`i
U.S. Dept. Interior, USGS, 2006
http://www.higap.org

The GAP Analysis of Hawai`i (HI-GAP) sought to spatially demonstrate and identify "the degree to which native animal species and natural communities are represented in our present-day mix of conservation lands" (US Dept. of Interior, 2006). Using satellite data, landcover was mapped into different classes which could be classified as native, mixed native and alien species, alien-dominated cover, and completely converted areas. The landcover was then compared against the existing land stewardship of areas. The level of stewardship was determined by National GAP standards, and then modified to reflect Hawai`i-specific considerations – named the Management Intent Status (MIS). For purposes of this NARS analysis, Management Intent Status 1 and 2 will be used as indicators of conservation management. The definitions of these designations are:

Management Intent Status 1: An area having designated protection from conversion of natural land cover and a mandated management plan in operation to maintain or restore to a natural state.

Management Intent Status 2: An area having designated protection from conversion of natural land cover and a mandated management plan in operation to maintain a primarily natural state, but which may receive use or management practices that degrade the quality of existing natural communities (US Dept. of Interior, 2006).

Please refer to the Hawai`i GAP Analysis (http://higap.org) for more details about the land stewardship analysis and how it compares to the mapped land cover. The measurement of MIS is used extensively in Part 2 to determine whether ecosystems are within other protective designations than NARS. Appendix 4 has a list of the individual island land cover classes that had less than 10% of their range in a MIS 1 or 2 area. Throughout this report, an arbitrary goal of 10% of ecosystem coverage is used as a measure of representation, in lieu of the NARS Commission defining "representation" as

[2] Association for Biodiversity Information, Ecology Group and Network of Natural Heritage Program Ecologists. 2000. International classification of ecological communities: Terrestrial vegetation of the United States. Hawai'i Subset. Association for Biodiversity Information, Arlington, VA and Dr. Sam Gon, The Nature Conservancy of Hawai'i, Honolulu.

a percentage or acreage of an ecosystem protected. A short discussion of the ramifications of this goal is included in the "Next Steps" section of this report.

For an example of these HI-GAP ecosystems, the HI-GAP statewide native landcover classes with less than 10% of their ranges in MIS 1 or 2 are:

A`ali`i Shrubland
Closed Hala Forest
Closed Pouteria Forest
Native Wet Forest and Shrubland
Open Koa-Mamane Forest

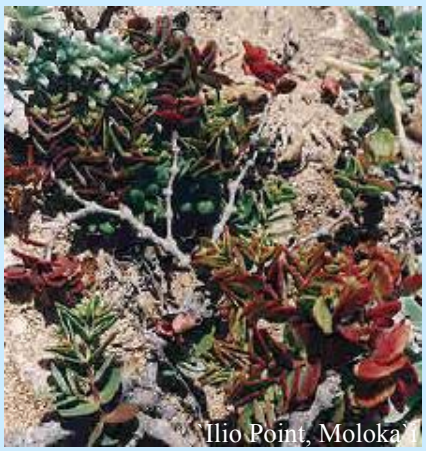
Appendix 4 contains lists of landcover classes, including native statewide landcover classes that have fewer than 500 acres in MIS 1 or 2, and island-specific landcover classes that have <10% of their existing ranges in MIS 1 or 2.

It is noted in Part 2 whether any of the biologically important areas that were recommended contain these types of ecosystems in the "**HI-GAP Priority**" column of the landscape section.

A benefit to this analysis is that these areas are spatially represented and comprehensive. However, HI-GAP was technically limited and it is noted that some areas that contained native dry forest and coastal ecosystems were not recorded.

This analysis also uses HI-GAP data to determine the columns of "**Habitat Quality**" and "**Habitat Contiguity**," used in Part 2, although the limitations for dry forest and coastal areas must again be noted.

HI-GAP also mapped the predicted ranges of forest bird species, which was used in this model to determine whether the biologically important areas provided habitat for bird species. The **"Forest Bird Species,"** and **"Endangered Forest Bird Species"** categories drew upon these predicted range maps.


Ilio Point, Moloka'i

"A good natural area system should have samples of all principal ecosystems that belong to the geographic network under consideration. There is no limit on the number of areas to be considered. At least each bioclimactic zone should contain an example of the zonal vegetation." - Mueller-Dombois, D. 1973. *Island Ecosystems Integrated Research Program. Technical Report No. 26*. Natural Area System Development for the Pacific Region, a Concept and Symposium.

Atlas of Hawaiian Watersheds and their Aquatic Resources
Parham et. al., 2008
http://www.hawaiiwatershedatlas.com

This atlas, which describes and ranks 430 watersheds across the state, contains a native species rating for aquatic species. "This rating counts the number of common native fishes and macro-invertebrates that are likely seen in most surveys. These nine species include the fishes *Awaous guamensis, Eleotris sandwicensis, Kuhlia xenura* (or

Kuhlia sp. prior to name change), *Lentipes concolor, Sicyopterus stimpsoni, Stenogobius hawaiiensis*, the crustaceans *Atyoida bisulcata, Macrobrachium grandimanus,* and the mollusk *Neritina granosa*. Watersheds without survey efforts are unranked" (Parham, J. et al., 2008). The **"Aquatic Species Rating"** column in the "Fauna" spreadsheet of Part 2 records the level of biological diversity the stream resources of the recommended areas that contained streams that were part of rated watersheds.

An Ecoregional Assessment of Biological Conservation for the Hawaiian High Islands
The Nature Conservancy Ecoregional Planning Team, 2006
http://www.hawaiiecoregionalplan.info

This assessment done by The Nature Conservancy distinguished 10 types of terrestrial ecosystems (excluding coastal) based on bioclimactic differences. This assessment divided the island chain into 15 stratification units to reflect the geographic zones of Hawai`i. This addresses the fact that a montane mesic ecosystem on Kaua`i is very different in species composition from one in Ka`u. Viability, determined by the size, condition, and landscape context was also derived from the Ecoregional Plan, which rated each ecosystem in each stratification unit as "Very Good," "Good," "Fair," or "Poor."

In April 2008, Theresa Menard, GIS Specialist at The Nature Conservancy gave a powerpoint presentation during a NARS Commission meeting that demonstrated which of Hawai`i's ecosystems are represented in the NARS, using the categories delineated in the *Ecoregional Assessment*.

This powerpoint presentation, titled "Native Hawaiian Ecosystems Represented in Natural Area Reserves" is available at:
http://hawaii.gov/dlnr/dofaw/nars/NARsAnalysisApr2008%20-%20JYS-TCM.ppt/view

The presentation focused on the Representativeness and Scientific Value criteria to determine which existing and viable native-dominated ecosystems in Hawai`i were not represented in the NARS. This showed that each of the ten statewide ecosystems were represented in the NARS, and in some of the stratification units – Kaua`i, Waianae, West Maui, and the Kohalas, the NARS represent portions of most of the existing native ecosystems of that area. However, when taking into account the acreages of the representation, it is shown that across all the islands, Dry Cliff, Wet Cliff, Montane Dry, Montane Mesic, Subalpine, and Alpine all have fewer than 5,000 acres represented in the NARS.

The data also highlighted which stratification units were least represented in the NARS – Ni`ihau, the Ko`olaus, Lana`i, Kaho`olawe, Ka`u-Kapapala, and Pohakuloa-Pu`uwa`awa`a. Of these, the two latter ecosystems contain large areas that are of high viability, and ecosystem types that are not protected by any MIS 1 or 2. Another way to look at the acreage factor is to determine the percentage of the ecosystem that the NARS contain, in each of the stratification units. In the **"Ecosystems"** column in Part 2, ecosystems found in the biologically important areas that have less than 10% of their distribution in a NAR are listed and labeled yellow. Instances where this occurs and there is still good or very good ecosystem viability are italicized. Refer to Appendix 5, List A, for a list of these ecosystems. One limitation of this approach is that some of these areas, such as in Mauna Kea and Kona, have thousands of acres of the montane ecosystems in NARS, yet the NARS are shown to represent fewer than 10% of the ecosystem because the range of these ecosystems are so large, while the percentage found in the NARS is

small. However, most of the other ecosystems that are shown to have small percentages represented have correspondingly small acreages.

After a consideration of ecosystems lacking in the NARS, it is important to widen the scope of the analysis to look at sizable amounts of conservation management from other entities in areas that have good or very good viability (See Appendix 5, List B).

The ecosystems left – ones with less than 10% of their distribution in the NARS or other MIS 1 or 2, are listed and labeled green in the "**Ecosystems"** column, and italicized if they are of "Good" or "Very Good" viability (See Appendix 5, List C).


T. macrostachys, Poamoho

2001 – The NARSC recommends Poamoho to the governor and DLNR. In 2003, they recommend Hono O Na Pali Ext., and Kanaio Mauka Ext.

While these results show gaps in the Representativeness criteria (both within NARS and in areas with MIS 1 and 2), the NARS Commission has often discussed the need for large-scale protection of the remaining native ecosystems. This is especially needed for the continued survival of faunal species. Additionally, the benefits of situating a NAR adjacent to areas managed for conservation include leveraged resources and replicable management methods. In the long term, the viability of the area in the landscape context could be dependent on surrounding management. With these considerations in mind, part of the NARS conservation strategy could be to find opportunities that are near managed areas, even if those ecosystems are already protected. Appendix 5 has lists of ecosystems that are of "Good" or "Very Good" viability and are bounded by areas with MIS 1 or 2 (List D), and which ecosystems of those have less than 10% of their distribution represented in a NAR. The "**Management Contiguity**" column indicates the extent to which the recommended areas are bounded by MIS 1 or 2 areas.

In the tables in Part 2, the "**Ecosystems**" column notes whether the recommended area contains ecosystems that have less than 10% in NARS, even if they are of "Fair" or "Poor" viability. Areas that are of "Good" or "Very Good" viability were bolded, to differentiate them from the less viable areas.

Staff at The Nature Conservancy are developing coastal and marine addendums to the *Ecoregional Assessment.* For the purposes of this report, this preliminary and unreleased data regarding **"Anchialine Species Rating"** provides the information and ranking system used in this analysis. Maciolek & Brock's 1974 *Aquatic Survey of the Kona Coast Ponds, Hawaii Island* as well as species accounts from Mike Yamamoto and Tommy Iwai from the Division of Aquatic Resources were data sources, though not all anchialine pools have been studied.

Mapping Plant Species Ranges in the Hawaiian Islands: Developing a Methodology and Associated GIS Layers
Price et. al. 2007
http://www.uhh.hawaii.edu/hcsu/documents/HCSUTR-008PlantMappingPriceetalFinal.pdf

This report delineated predicted geographic ranges of native vascular plant species by developing GIS layers of substrate type, climate, biogeographic regions of islands, overlaid on maps of human-caused disturbance of native ecosystems. In the report, the GIS layers were analyzed based on these factors to determine whether individual species could be predicted to have lived in that area, and whether they still might be found there based on the amount of disturbance to their previous habitat. This data was used to populate the "**Total Plant Richness**," and "**Endangered Plant Richness**," categories.

This report maps all of these predicted plant species ranges that overlap, to determine point data of species richness. When analyzing the biologically important areas, this measurement does not necessarily correspond to the total amount of biodiversity within the boundaries of the area, but instead indicates the points within the given boundary with the highest overlap in predicted ranges. Work is underway to create models that can compute total predicted species lists for an area.

The bioclimactic and substrate age layers that this report distinguished to create habitat types was also used in this analysis to determine the "**Habitat Diversity**" category.

Preliminary Results

These results assume that each of the categories and sub-categories such as habitat contiguity, forest bird habitat, aquatic species, etc., had similar weight. The "Next Steps" section calls for more discussion about the relative importance of these categories.

Flora: In general, areas on older islands, such as Kaua`i, O`ahu, Moloka`i, and West Maui had more predicted biodiversity as well as endangered species concentrations, although the Hanawi West and Waiho`i Crater Bog areas on windward Haleakala were also notable in the "Total Plant Richness" category. Coastal, Alpine, and Subalpine areas had the least amount of species concentrations, according to this model.

Fauna: The "Fauna" category highlighted almost opposite areas than the "Flora" category, with the younger islands such as Maui and the Big Island having much more bird diversity, and coastal areas having important anchialine pool resources. However, many areas on Kauai also proved to have high forest bird resources, and contained streams in watersheds with a high native species ranking.

Landscape: If an arbitrary point system was created where every category of landscape was weighted equally, with Low (pink) entries scoring 0 points, Medium (yellow) scoring 1 and High (green) Scoring 2, and each entry in the "Ecosystems" category scoring .25 points extra if they are also "good" or "very good" viability, areas that stood out as having the highest ecosystem viability and/or filled in ecosystem gaps in the NARS (with 10 or more points) were:

Kuia North Extension
Kalalau Back Pali
Upper Koaie Canyon
Namolokama
Hanawi West Extension
Lana`ihale
Pohakuloa Gulch Extension
Mauna Loa Mosaic –1942 Extension

Waihaka
Ka`u

As the methods of this favored the larger areas, it is interesting to note the small areas with relatively high landscape value despite their small size: Kamakou and Blue Hole. These areas had relatively large amounts of Landscape value in less area.

Overall:

Kauai: According to the models used in this analysis, almost all of the Kaua`i areas proved to be very biologically important. If all categories are weighted roughly equally, the Kuia North Extension, Hono O Na Pali Ext, Kalalau Back Pali, Upper Koa`ie Canyon, Namolokama, and Blue Hole are on par with the most biologically important existing reserves.

O`ahu: Kaluanui contained the highest amount of unrepresented ecosystems on O`ahu, as well as an excellent aquatic species rating. Poamoho was very similar to Manana, except it contained higher habitat quality according to these models, which results from the fact that Manana contains lower elevation ecosystems which are more degraded, while Poamoho's boundaries cut off the lower elevations.

Moloka`i: Wailau Back Pali had the high habitat quality, and a highly-rated stream as well. Adjacent Kamakou also had very high viability, while Upper Kawela was more degraded but contained ecosystems not protected in the Moloka`i NARS.

Lana`i: Lana`ihale contained many ecosystems not represented in the NARS, and high habitat quality and plant richness, though very little habitat or management contiguity, or fauna value[3].

Maui: Both Hanawi West and Waiho`i Crater Bog were high in total plant, forest bird, endangered forest bird, and viability categories, though Hanawi West also had high aquatic resource value as well as more unrepresented ecosystems.

Hawai`i: The Mauna Kea Ice Age Ext area, which includes the Mauna Kea North Slope, and Pohakuloa Gulch Ext all had very high forest bird and habitat quality values, although these values are mostly found on a much smaller portion of the very large areas. The Mauna Loa Mosaic also contained these values, as well as unrepresented ecosystems and plant values. Similar to the Mauna Kea areas, most of the plant values in the Mauna Loa Mosaic were found in a smaller makai portion of the vast subalpine area. Kulani, Waihaka, and Ka`u also had incredible bird value and a high quality native habitat, although the lower portions of Ka`u were not as native-dominated. Waihaka and Ka`u are especially notable for containing many high viability unrepresented ecosystems.

Next Steps

The Commission has indicated that this process should not wait for the development of new data sources or studies, and instead should move forward with existing data in this preliminary analysis to see which areas might be pursued for conservation designation. However, it is important to note the limitations of the data, as well as the omissions, and brainstorm how to deal with the missing information while prioritizing. Some omissions are: marine, geological, terrestrial invertebrate, seabird,

[3] This highlights a limitation of this report, which does not contain data on seabird nesting areas, or native snails, which are fauna values found in Lana`ihale, as well as many other of the biologically important areas, due to lack of comprehensive statewide data. As some of these areas are researched further, area-specific data will be recorded.

waterbird, and nonvascular plant data. Also, the data that attempts to capture remaining native ecosystems and the ranges of certain species has limitations, especially in capturing dryland and coastal ecosystems.

Some of the areas identified as biologically important or fill gaps in the NARS may not be recommended for designation because this analysis only focuses on the "Representativeness" and "Scientific Value" criteria. Other criteria used to evaluate NARS proposals such as Administrative, Size, Number, and Ownership factors have not been taken into consideration in this analysis. Instead, other types of conservation management might be more appropriate.

After this analysis has identified and prioritized areas that contain biological resources that would add to the System, the NARS Commission, with the input of DOFAW staff and others interested in this process, will be responsible for analyzing whether these areas fit the other criteria as well. The public, the Board of Land and Natural Resources, as well as the Governor also will be involved in this process (See Appendix 2).

Another item to further discuss is whether the NARS should focus on keeping areas that have been relatively unmodified in that more native-dominated state, or on restoring ecosystems that are not represented, but more degraded. In the latter case, we must especially rely on the recommendations from experts to determine where are the most intact locations of these overall more modified ecosystems. In many instances, changing the boundaries of these biologically important areas to only include the native dominated areas would increase their habitat quality and contiguity value, but decrease their rating on "Priority Habitats" and in the "Ecosystems" categories.

This issue closely ties with the "Size of Areas" discussion, since many of the more viable areas identified as biologically important are adjacent to existing NARS or NAPs, and in many cases contain the similar types of ecosystems. The "Criteria for Selecting Natural Areas" states that "A desired size is that which will provide essentially unmodified conditions in the interior portion," which raises the question of what sort of size or management actions will lead to minimal changes in the interior of the Reserve. This is further complicated by the fact that many of the interior portions of these areas are completely different habitat types than the ecosystems around the edges, so if only the middle portions remain in the future, many ecosystems in the reserve will be lost.

Another way to address this question is to define what percentage or acreage of an ecosystem or species range is needed to sufficiently represent that resource. *An Ecoregional Assessment of Biodiversity Conservation for the Hawaiian High Islands* (The Nature Conservancy Ecoregional Planning Team, 2006) sought to determine the size an ecosystem needed to be to be viable, and that information is embedded in this analysis. However, if for instance the Commission decided that this analysis should focus on ecosystems as defined in the *Ecoregional Assessment* that had less than 5% of its range represented in the NARS, rather than the 10% goal used in this analysis, there would be 56 ecological systems that qualify as unrepresented, rather than the 68 that this report identifies. This question could be complicated by other factors, such as the viability of that ecosystem or species, or their range needs. In a Commission meeting it was suggested that if the purpose of the Reserve was to protect the plant components of an ecosystem, a smaller Reserve may be sufficient, while if the area is important forest bird habitat, a much larger area must be conserved in order for the forest birds to survive

in the long term. While these ideas help in prioritization, more discussion is needed on this vital issue.

Prioritizing areas for their biological value is a difficult task, but a necessary first step towards systematically and comprehensively evaluating areas in order to fulfill the goals of the NARS to preserve these ecosystems.

Appendices

1. Process for Designation of Natural Area Reserves
2. Natural Area Reserves System (NARS) Nomination/Modification Process
3. Summary of unrepresented communities identified in *A Biological Overview of Hawaii's Natural Area Reserves System*
4. Summary of data used in this analysis from *A GAP Analysis of Hawai`i*
5. Summary of data used in this analysis from *An Ecoregional Assessment of Biodiversity Conservation for the Hawaiian High Islands*

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APPENDIX 1

PROCESS FOR DESIGNATION OF NATURAL AREA RESERVES

BACKGROUND

The Natural Area Reserves System Commission is responsible for establishing criteria for selecting Natural Area Reserves. The Commission acts in an **advisory** capacity to the Board of Land and Natural Resources, which makes the actual designations, followed by an Executive Order (EO) signed by the Governor to officially add the reserve to the system. In doing this, the Commission must interpret the purposes of Chapter 195 that establishes the Natural Area Reserves System.

CHAPTER 195-1 Findings and declaration of necessity. The legislature finds and declares that (1) the State of Hawaii possesses unique natural resources, such as geological and volcanological features and distinctive marine and terrestrial plants and animals, many of which occur nowhere else in the world, that are highly vulnerable to loss by the growth of population and technology; (2) these unique natural assets should be protected and preserved, both for the enjoyment of future generations, and to provide base lines against which changes which are being made in the environments of Hawaii can be measured; (3) in order to accomplish these purposes the present system of preserves, sanctuaries and refuges must be strengthened, and additional areas of land and shoreline suitable for preservation should be set aside and administered solely and specifically for the aforesaid purposes; and (4) that a statewide natural area reserves system should be established to preserve in perpetuity specific land and water areas which support communities, as relatively unmodified as possible, of the natural flora and fauna, as well as geological sites, of Hawaii.

There are currently 19 Natural Area Reserves protecting approximately 110,000 acres of Hawaii's most valuable natural heritage. The first, Ahihi-Kinau on Maui was designated in 1973; the latest, Kanaio, also on the island of Maui, was designated in 1991.

CRITERIA FOR SELECTING NATURAL AREAS

Adopted by Natural Area Reserves System Commission February 25, 1971.

The Commission asserts that the word "enjoyment" used in the act does not mean on site recreation use, but does mean cultural or scientific enrichment or satisfaction. The Commission has determined that the Natural Area Reserves System shall have the objective of preserving in as natural a condition as practicable, and in perpetuity, areas of land and/or water in the State of Hawaii which (1) form representative units of ecosystems containing the diversity of terrestrial or aquatic biota of the islands, (2) have unique geologic or physiographic significance, or (3) are necessary for preserving endangered species of Hawaiian fauna or flora. Such areas are to be used, as feasible for research in natural sciences, as teaching laboratories, for reservoirs of natural genetic materials (gene pools), or for preserving valuable illustrations of original natural heritage. Resources within Natural Areas are not to be subjected to consumptive use or to experimentation

other than that specifically approved and judged not to be deleterious to the area.

The following criteria are adopted as important guides for the Commission in selecting areas for the Natural Area Reserves System. However, the Commission shall exercise its prerogative of judgment with regard to these criteria and other criteria in selecting and recommending areas to be included in the Natural Area Reserves System.

Representativeness: Each selected Natural Area shall be representative of one or more major, natural, relatively unmodified ecosystems, geologic or physiographic features, or habitats containing endangered species of fauna or flora. The description of a proposed area shall include details of the features that make the area distinctive, unique, significant, or representative. The term representative as applied to ecosystems, shall be interpreted in relation to macroclimatic zonation to ensure a balanced geographic distribution of natural areas as representative ecosystems.

Scientific Value: Each Natural Area shall have significant potential for scientific study, for teaching, for preservation of distinctive biota or other natural features, or for preserving natural genetic material. The description of a proposed area shall include details of the scientific attributes of the area.

Administrative: Each Natural Area shall be identifiable on maps and on the ground. It should be reasonably protectable from pests and from physical damage and, legally, from encroachment. Access to the area should be in conformance with the nature and purpose of the area. Utilities, communication facilities, and other right of way developments should be avoided as much as possible. Administrative or management factors should be detailed in the description of each proposed area.

Size of Areas: Each Natural Area shall be large enough, but no larger than necessary, to accomplish the particular purpose of establishing that Natural Area. A desired size is that which will provide essentially unmodified conditions in the interior portion. The cost and feasibility of protecting the area will have a bearing on the size. Some areas may be less than an acre while others may exceed 10,000 acres, where a special need is demonstrated.

Number of Areas: As many as possible of the major terrestrial and aquatic plant and animal communities and distinctive geologic features on each island should be represented in the Natural Area Reserves System. However, the Natural Area Reserves System shall not include unnecessary duplications of ecosystems or geologic features already protected in Federal Wildlife Refuges, National Parks, or private conservation groups.

Ownership: Natural Areas shall be composed of lands owned or legally controlled by the State in perpetuity. Privately owned areas desired for the Natural Area Reserves System may be obtained by gift, devise, purchase, or eminent domain as specified in the Act. Federal lands shall not be designated as Natural Areas under Act 139.

APPENDIX 2

Natural Area Reserves System (NARS) Nomination/Modification Process

1. Anyone (public or private) may submit a nomination to the Natural Area Reserves System Commission for consideration at any time. The Commission itself may prepare site nominations.
2. These nominations are presented at regular (public) meetings of the Commission. These meetings are open to the public, where comments may be received in regards to these nominations.
3. The NARS Commission forwards the proposals to the Division of Forestry and Wildlife (DOFAW) Administrator for staff review and comments.
4. DOFAW will respond to the NARS Commission with a recommendation or comments within 90 days. If no recommendation is received within the allotted time period, the Commission will proceed with the review process.
5. After receiving recommendations from DOFAW, if any, the Commission makes a decision as to whether to recommend to the governor and the department the proposal for inclusion of suitable areas within the reserves system. The Commission may decide to hold a public meeting on the island of the proposal to solicit public comment prior to making its recommendation.
6. Upon recommendation by the Commission, staff prepares the nomination for public hearing. Staff publishes required legal notices in newspapers and circulates the nomination to interested parties. This phase may include an on-site visit to the proposed area by staff.
7. A public hearing is held, preferably on the particular island where the proposed expansion area is located.
8. Following the public hearing, comments are compiled and the nomination is prepared for submission to the Board.
9. The nomination then goes before the Board of Land and Natural Resources for a resolution to designate the proposed area into the reserves system.
10. Upon resolution by the Board of Land and Natural Resources, the proposed new Natural Area goes to the Governor for set aside by Executive Order into the Natural Area Reserves System.

Any changes to a Reserve, such as revocation or modification of the executive order that set aside lands for the reserves system also require a public hearing process before any action is taken.

APPENDIX 3

Summary of unrepresented communities identified in "Biological Overview of Hawaii's Natural Area Reserves System"
Hawai`i Heritage Program
The Nature Conservancy of Hawai`i - 1987
Appendices – Current Status of Biological Protection in Hawai`i

View the document:
http://hawaii.gov/dlnr/dofaw/nars/biological%20overview%20of%20NARS.pdf/view

This list, taken from the "Biological Overview of Hawai`i's NARS" was based on the Hawai`i Natural Community Classification System, which at the time published contained 5 elevation zones, 3 moisture zones, with 6 physiognomic types. Aquatic and Subterranean ecosystems were added to the list, which totaled 180 communities. Tables in the document indicated whether the community was known to exist in any NARS, State Sanctuary, Other State Land, National Park, Fish and Wildlife Service Refuge, Other Federal Land, Private Nature Preserve, or Other Private/County Land. Rarity of the communities was also measured.

Summary of communities not represented in NARS, State Sanctuary, National Park, Fish and Wildlife Service Refuge, or Preserves of The Nature Conservancy

Aquatic Ecosystems
COASTAL ZONE
High Salinity Lava Tube Anchialine Pool
Low Salinity Lava Tube Anchialine Pool
Low Salinity Limestone Anchialine Pool

LOWLAND ZONE
Lowland Freshwater Lake

Subterranean Ecosystems
LOWALND ZONE
Blind Hunting Spider Cave
Lowland Dry Limestone Cave
MONTANE ZONE
Blind Cricket Montane Cave
Montane Koa `Ohi`a Lava Tube
Montane Wet Piping Cave

Terrestrial Ecosystems
COASTAL ZONE
Coastal Dry Shrubland:
- Ma`o Coastal Dry Shrubland
- `Anaunau Coastal Dry Shrubland

`Iliahi Coastal Dry Shrubland
Ma`oli`oli Coastal Dry Shrubland
`Ilima/Nehe (Lipochaeta rockii) Coastal Dry Shrubland
`Ilima/Puapilo/Nehe Coastal Dry Shrubland

LOWLAND ZONE
Lowland Dry Shrubland:
Ko`oko`olau (Bidens menziesii) Lowland Dry Shrubland
Ko`oko`olau/`Aweoweo Lowland Dry Shrubland
`A`ali`i /Nehe (Lipochaeta lavarum) Lowland Dry Shrubland
`A`ali`i/Na`ena`e (Dubautia linearis) Lowland Dry Shrubland
Lowland Dry Forest:
Koa Lowland Dry Forest
Lama/Kauila Lowland Dry Forest
Olopua/Lama Lowland Dry Forest
Lowland Mesic Shrubland:
`Ulei Lowland Mesic Shrubland
`Iliau (Wilkesia gymnoxiphium)/`A`ali`i Lowland Mesic Shrubland
`Iliau (Wilkesia hobdyi) Mixed Shrub Lowland Mesic Cliffs
Lowland Mesic Forest:
Koa Lowland Mesic Forest
Koa/`Ohi`a Lowland Mesic Forest
Lanai Diverse Lowland Mesic Forest
`Ohi`a/Mixed Shrub Lowland Mesic Forest
Olopua/Halapepe Mixed Lowland Mesic Forest
Loulu (Pritchardia kaalae) Lowland Mesic Forest
Lowland Wet Grassland:
Kawelu Lowland Wet Grassland
Lowland Wet Mixed:
`Ohi`a/Kuolohia/Uluhe Lowland Mixed Semi-Bog
Lowland Wet Shrubland:
`Ohi`a/Uluhe Lowland Wet Shrubland
Lowland Wet Forest:
`Ohi`a Mixed Lowland Wet Forest
`Ohi`a Mixed Shrub Lowland Wet Forest
`Ohi`a/Hala Lowland Wet Forest
Loulu (Pritchardia hardyi) Lowland Wet Forest
Loulu (Pritchardia martii) Lowland Wet Forest

MONTANE ZONE
Montane Dry Grassland:
Deschamspia australis Montane Dry Grassland
Montane Dry Forest:
`Akoko (Chamaesyce olowaluana) Montane Dry Forest
Montane Mesic Forest:
Koa/`Iliahi Montane Mesic Forest

Maui Diverse Montane Mesic Forest
Olopua Mixed Montane Mesic Forest

Montane Wet Herbland:

Racomitrium Moss Montane Bog

Montane Wet Mixed:

`Ohi`a/`Ohelo/`Uki (Machaerina angustifolia) Mixed Montane Bog

SUBALPINE ZONE:

Subalpine Dry Grassland:

Kawelu/Kakonakona (Panicum tenuifolium) Subalpine Dry Grassland

Subalpine Dry Shrubland:

`Aweoweo Subalpine Dry Shrubland
`A`ali`i/Na`ena`e/Ko`oko`olau/Naio Subalpine Dry Shrubland

APPENDIX 4

Summary of data used in this analysis from "A GAP Analysis of Hawai`i"
http://www.higap.org
U.S. Dept of the Interior, US Geological Survey. A Gap Analysis of Hawai`i, Final Report. 2006

HI-GAP Statewide native landcover classes with <10% in MIS 1 or 2:

`A`ali`i Shrubland
Closed Hala Forest
Closed Pouteria Forest
Native Wet Forest and Shrubland
Open Koa-Mamane Forest

HI GAP Statewide native landcover classes with <500 acres in MI 1 or 2:

Deschampsia Grassland (260.2 acres in MI 1 or 2)
`A`ali`i Shrubland (83.8 acres)
Bog Vegetation (356.9 acres)
Native Coastal Vegetation (45.7 acres)
Native Dry Cliff Vegetation (294.3 acres)
Open Mao Shrubland (51.0 acres)
Closed Hala Forest (4.3 acres)
Closed Pouteria Forest (0 acres)
Koa Forest (235.6 acres)
Native Mesic to Dry Forest Shrubland (236.1 acres)
Olopua-Lama Forest (50.5 acres)

HI GAP Individual island native landcover classes with <10% in MIS 1 or 2:

HAWAII – BIG ISLAND
Native wet cliff vegetation
Uluhe Shrubland
Open koa-mamane forest (mixed grasses)
Open koa `ohi`a forest (uluhe)
Open `ohi`a forest mixed grasses

KAUAI
Native wet cliff vegetation
Uluhe shrubland
Open koa `ohi`a

LANAI
`A`ali`i shrubland
Closed pouteria forest (native trees)
Open `ohi`a forest (uluhe)

MAUI
Closed hala forest
Open koa `ohi`a forest (native shrubs)

OAHU
Native wet cliff veg
Uluhe shrubland
`Ohi`a forest (native shrubs and uluhe)
Open koa `ohi`a forest (uluhe)

APPENDIX 5

Summary of data used in this analysis from "An Ecoregional Assessment of Biodiversity Conservation for the Hawaiian High Islands"
The Nature Conservancy Ecoregional Planning Team, 2006
Analysis with data from Ecoregional Assessment used in *"Native Hawaiian Ecosystems Represented in Natural Area Reserves"*
Theresa Menard GIS Specialist, The Nature Conservancy 2008
http://hawaii.gov/dlnr/dofaw/nars/NARsAnalysisApr2008%20-%20JYS-TCM.ppt/view

LIST A:
Ecosystems with <10% in NARS with "Good" or "Very Good" Viability:

Kaua`i: Montane Wet and Wet Cliff
East Moloka`i: Wet Cliff
East Maui: Alpine and Subalpine
Mauna Kea: Montane Wet
Ka`u-Kapapala: Alpine, Subalpine, Montane Dry, Montane Mesic, Montane Wet
Kona: Alpine, Subalpine, Montane Dry, Montane Mesic, Montane Wet
Pohakuloa-Pu`uwa`awa`a: Alpine, Subalpine, Montane Dry

Some of these areas, such as in Mauna Kea and Kona have thousands of acres of the montane ecosystems in NARS, yet because the range of these ecosystems are so large, the percentage found in the NARS is small.

LIST B:
Ecosystems with >10% representation in MIS 1 or 2 (Excluding NARS):

**Kaua`i**: Montane Wet (Alaka`i Wilderness Preserve)
Moloka`i: Wet Cliff (Kamakou and Pelekunu NAP)
East Maui: Alpine and Subalpine (Haleakala National Park)
Mauna Kea: Montane Wet (Hakalau Refuge of the U.S. Fish and Wildlife Service)
**Ka`u-Kapapala**: Alpine, Subalpine, Montane Dry, Montane Mesic (Hawai`i Volcanoes National Park)
Kona: Alpine, Subalpine, (Hawai`i Volcanoes National Park), Montane Mesic (The Nature Conservancy Kona Hema Preserve and the U.S. Fish and Wildlife Service's Kona Unit of the Hakalau Refuge), Montane Wet (U.S. Fish and Wildlife Service's Kona Unit of the Hakalau Refuge)
Pohakuloa-Pu`uwa`awa`a: Subalpine, Montane Dry

LIST C:
Ecosystems with <10% in MIS 1 or 2 with "Good" or "Very Good" Viability:

Kaua`i: Wet Cliff
Ka`u Kapapala: Montane Wet
Kona: Montane Dry

Poakuloa-Pu`uwa`awa`a: Subalpine, Montane Dry

LIST D:
Ecosystems with "Good" or "Very Good" Viability bounded by MIS 1 or 2 areas:

**Kaua`i**: Montane Wet (bordering Hono O Na Pali NAR and the Alaka`i Wilderness Preserve) and Wet Cliff (bordering the Alaka`i Wilderness Preserve).
**Moloka`i**: Wet cliffs (bordering Oloku`i and Pu`u Ali`i NARS), Montane Wet (East and West of Kamakou NAP)
West Maui: Montane Wet (between Kapunakea NAP and West Maui Panaewa NAR), Wet Cliff (East of Pu`u Kukui NAP and South of West Maui Panaewa NAR)
East Maui: Alpine and Subalpine (West and South of Haleakala National Park), Montane Wet (East and West of Hanawi NAR)
Kohala: Montane Wet (Expanding mauka portion of Pu`u O `Umi NAR)
Mauna Kea: Alpine (Expanding Mauna Kea Ice Age NAR West, North and East), Montane Wet (Areas to the North and South of Laupahoehoe NAR and the Hakalau Forest and Wildlife Refuge)
Windward Mauna Loa: Montane Wet (South and West of Pu`u Maka`ala and Kahauale`a NARs and portions of Hawai`i Volcanoes National Park)
**Ka`u- Kapapala**: Alpine, Subalpine, Montane Dry, Montane Mesic and Montane Wet (Adjacent to Hawai`i Volcanoes National Park)
Kona: Subalpine (West of Hawai`i Volcanoes National Park), Montane Dry (North of Hawai`i Volcanoes National Park and mauka of Kona Unit of the Hakalau FWS Refuge), Montane Mesic and Wet (North and South of Kona Hema Preserve, Kipahoehoe NAR, and Kona Unit of the Hakalau FWS Refuge)
**Pohakuloa-Pu`uwa`awa`a**: Alpine (North of Hawai`i Volcanoes National Park)

Areas in both List "A" and "D": Ecosystems with <10% in NARS with "Good" or "Very Good" Viability, and are bounded by areas with MIS 1 or 2:

Kaua`i: Montane Wet, Wet Cliff
East Moloka`i: Wet Cliff
East Maui: Alpine and Subalpine
Mauna Kea: Montane Wet
Ka`u Kapapala: Alpine, Subalpine, Montane Dry, Montane Mesic, Montane Wet,
Kona: Subalpine, Montane Dry, Montane Mesic, Montane Wet
Pohakuloa-Pu`uwa`awa`a: Alpine

Areas in both List "C" and "D": Ecosystems with <10% in MIS 1 or 2 with "Good" or "Very Good" Viability, and are bounded by areas with MIS 1 or 2:

Kaua`i: Wet Cliff
Ka`u Kapapala: Montane Wet
Kona: Montane Dry