2009 Hawai‘i Conservation Conference

Hawai‘i in a Changing Climate: Ecological, Cultural, Economic, and Policy Challenges and Solutions

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Hawai‘i Convention Center, Honolulu, HI

ABSTRACTS

Hawai‘i Conservation Alliance
Hawai‘i Conservation Alliance Foundation

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ORAL PRESENTATION ABSTRACTS BY PRESENTING AUTHOR

CONCURRENT SESSION 1: JULY 28, 1 – 3 PM

Symposium: Global Climate Change Impacts in the United States

1-1 Climate and Ecosystems

Eileen Shea
U.S. Climate Change Science Program, Washington, DC

The natural functioning of the environment provides both goods—such as food and other products that are bought and sold—and services on which our society depends. For example, ecosystems store carbon in plants, animals, and soils; they regulate water flow and water quality; and they stabilize local climates. These services are not assigned a financial value, but society nonetheless depends on them. Ecosystem processes are the underpinning of these services: photosynthesis, the process by which plants capture carbon dioxide from the atmosphere and create new growth; the plant and soil processes that recycle nutrients from decomposing matter and maintain soil fertility; and the processes by which plants draw water from soils and return water to the atmosphere. These ecosystem processes are affected by climate and by the concentration of carbon dioxide in the atmosphere. The diversity of living things (biodiversity) in ecosystems is itself an important resource that maintains the ability of these systems to provide the services upon which society depends. Many factors affect biodiversity including: climatic conditions; the influences of competitors, predators, parasites, and disease; disturbances such as fire; and other physical factors. The Global Climatatic Data Center report finds that large-scale shifts have already occurred in the ranges of species, the timing of seasons, and animal migration, and further changes are projected. Human-induced climate change, in conjunction with other stresses, is exerting major influences on natural environments and biodiversity, and these influences are generally expected to grow with increased warming.

1-2 Climate and Water Resources

U.S. Climate Change Science Program, Washington, DC

The warming observed over the past several decades is consistently associated with changes in the water cycle, such as changes in precipitation patterns and intensity, incidence of drought, widespread melting of snow and ice, increasing atmospheric water vapor, increasing evaporation, increasing water temperatures, reductions in lake and river ice, and changes in soil moisture and runoff. Regional projections differ markedly. Climate change impacts include too little water, too much water, and degraded water quality. Water cycle changes are expected to continue and will adversely affect energy production and use, human health, transportation, agriculture, and ecosystems. Key findings in the The Global Climatic Data Center report on water resources include: climate change already has altered, and will continue to alter the water cycle, affecting where, when, and how much water is available; floods and droughts will become more common and more intense; precipitation and runoff are projected to increase in the Northeast and Midwest, while decreasing in the West, especially the Southwest; in mountain areas where snowpack dominates, the timing of runoff will shift to earlier in the spring and flows will be lower in late summer; surface water quality and groundwater quantity will be affected by a changing climate; climate change will place additional burdens on already stressed water systems; and the past century is no longer a reasonable guide to the future for water management.

1-3 Climate and Coasts

U.S. Climate Change Science Program, Washington, DC

More than one-third of all Americans live in counties immediately bordering the nation’s ocean coasts. In addition to accommodating major cities, the coasts and the exclusive economic zone extending 200 miles offshore provide enjoyment, recreation, seafood, transportation of goods, and energy. Coastal and ocean activities contribute more than $1 trillion to the nation's gross domestic product and the ecosystems hold rich biodiversity and provide invaluable services. However, intense human uses have taken a toll on coastal environments and their resources, and global climate change imposes additional stresses on coastal environments. Rising sea level is already eroding shorelines, drowning wetlands, and threatening the built environment. The destructive potential of Atlantic tropical storms and hurricanes has increased since 1970 in association with increasing Atlantic sea surface temperatures, and it is likely that hurricane rainfall and wind speeds will increase in response to global warming. Coastal water temperatures have risen by about 2°F in several regions, and the geographic distributions of marine species have shifted. Precipitation increases on land have increased river runoff, polluting coastal waters

with more nitrogen and phosphorous, sediments, and other contaminants. Furthermore, increasing acidification resulting from the uptake of carbon dioxide by ocean waters threatens corals, shellfish, and other living things that form their shells and skeletons from calcium carbonate. All of these forces converge and interact at the coasts, making these areas particularly sensitive to the impacts of climate change.

1-4 Climate Change Adaptation: A Response Strategy
U.S. Climate Change Science Program, Washington, DC

Responses to climate change fall into two broad categories. The first involves “mitigation” measures to reduce climate change by reducing emissions of heat-trapping gases and particles, or increasing removal of heat-trapping gases from the atmosphere. The second involves “adaptation” measures to improve our ability to cope with or avoid harmful impacts and take advantage of beneficial ones, now and in the future. Both of these are necessary elements of an effective response strategy. Adaptation options have the potential to moderate harmful impacts of current and future climate variability and change. A variety of actions are currently being pursued in various sectors and regions to address climate change, as well as other environmental problems that could be exacerbated by climate change such as urban air pollution and heat waves. In most cases, there is insufficient peer-reviewed information to evaluate the practicality, effectiveness, costs, or benefits of adaptation measures, highlighting a need for research in this area. In addition, it is clear that there are limits to how much adaptation can achieve. Humans have adapted to changing conditions in the past, but in the future, adaptations will be particularly challenging because society won't be adapting to a new steady state but rather to a moving target. Climate will be continually changing, moving at a relatively rapid rate, outside the range to which society has adapted. The precise amounts and timing of these changes will not be known with certainty.

Symposium: Carbon Sequestration in Hawai‘i—Importance and Current State of Knowledge

1-5 Measurement and Simulation of Carbon Sequestration in an Organically Managed Soil
Farhat Abbas, Ali Fares
University of Hawai‘i at Mānoa, Honolulu, HI

The regional carbon sequestration partnership program of the U.S. Department of Energy is the centerpiece of national efforts to validate and deploy carbon sequestration technologies. Carbon sequestration can be measured by determining soil organic carbon (SOC, Mg ha^{-1}) through chemical and/or physical methods. This study was conducted on Waimānalo research station of the University of Hawai‘i. Loss on ignition method was used to measure SOC, which was also simulated with Rothamsted carbon turnover model (RothC). SOC measurements were made in a soil organically managed with various types, rates, and levels of manure amendments and different tillage practices. CO_2 emission (Mg ha^{-1}) from above soil was simulated using RothC. The simulated and measured SOC reasonably agreed. Results revealed that SOC, CO_2 emissions, and saturated hydraulic conductivity of soil (K, m d^{-1}) increased, while bulk density (BD, g cm^{-3}) decreased with increasing manure application rates. There was no significant effect of manure type. There was a highly significant correlation between both measured and simulated SOC and the measured SOC and simulated CO_2 emissions. Values of BD and K significantly correlated with measured and simulated SOC and the simulated CO_2 emissions. Results revealed that carbon sequestration in this organically amended soil correlates with the soil’s physical and hydrological properties.

1-6 Carbon Sequestration in Kona Shade Coffee Farms
Travis Idol[1], Craig Elevitch[2], James B. Friday[1]
[1]*University of Hawai‘i at Mānoa, Honolulu, HI,* [2]*Permanent Agriculture Resources, Holualoa, HI*

Coffee production in Hawai‘i covers more than 2800 hectares and is growing statewide. Because coffee is compatible with shade, it provides opportunities to maintain or improve carbon sequestration in both soil organic matter and tree biomass. The potential trade-off is lower coffee yield. This trade-off may vary by tree species, however. We inventoried a range of shade coffee farms in the South Kona growing region to estimate biomass and shade level of several common shade tree species as well as coffee yield. On a subset of farms, we measured soil C in open and shaded areas. Shade had no overall effect on yield, but the highest yields were confined to areas with less than 50% shade. Carbon sequestration in tree biomass ranged widely depending upon tree density and farm size, but two farms growing coffee in mature ohia lehua forest averaged 400-800 Mg/ha. Soil C concentrations in these mostly young volcanic soils averaged 8%, but total soil C sequestration ranged

from 70-300 Mg/ha in the top 50 cm, depending upon the percentage of rock fragments in the soil. Tree cover did not have a consistent effect on soil C. Overall, Kona coffee farms have large stores of C sequestered in soil organic matter. Both monkeypod and avocado trees added significantly to overall C sequestration without measurable reductions in yield. The high biomass levels of intact ohia forests, however, did result in lower coffee yields.

1-7 Biomass and Soil Carbon Sequestration in a *Leucaena* Agroforestry System in Hawai'i

Adel Youkhana, Travis Idol
College of Tropical Agriculture and Human resources, University of Hawai'i at Mānoa, Honolulu, HI

Agroforestry helps carbon sequestration because of its potential to store carbon above and belowground. We quantified C sequestration in tree biomass and soil organic matter associated with a managed shade coffee agroforestry system in Hawai'i. We developed allometric models for *Leucaena leucocephala* x pallida var. KX2 trees after pollarding to predict aboveground and belowground biomass. Samples of representative trees were collected and weighed to develop an allometric equation for each tree component (main stem, roots, branches, leaves, seed pods) as functions of stem diameter at 50 cm, diameter and height of individual shoots, and coarse root diameter. Biomass data were analyzed to derive equations between yield and diameter ($y=a*D^b$) and height ($y=a*H^b$). Optimum prediction equations were decided on the basis of R^2 along with the significance of the regression and minimum standard error. Trees were pollarded 0, 1, or 2 times per year and the pruning residues were chipped and added back to plots as mulch. Soil organic C was measured after 2 years of mulch additions. Plant carbon sequestration in this system averaged 72.05, 37, and 26.21 Mg ha-1 in plots pollarded 0, 1, and 2 times per year. Mulch additions significantly increased soil C and N in the top 20 cm by 10.8 and 2.12 Mg ha^{-1}. *Leucaena* KX2 shows good promise for aboveground and belowground carbon sequestration and potential carbon credit to the farmers. Integrating agroforestry with C sequestration and C trading may help meet the CO2 emissions targets of Kyoto protocol and sustainable agricultural production.

1-8 Carbon Sequestration in Ocean Settings

Kathleen Ruttenberg
Oceanography Dept., and Geology and Geophysics Dept., University of Hawai'i, Honolulu, HI

Marine sediments constitute a large and relatively stable reservoir of stored carbon in the ocean. Carbon is delivered to oceanic sediments in both organic and inorganic form. Organic carbon deposition occurs as marine organisms die and sink to the bottom of the ocean, and as fecal pellets exported to and buried in sediments. Extent of preservation and long-term sequestration of this organic matter depends upon the characteristics of the depositional environment, and the inherent chemical lability of the organic material. Inorganic carbon is delivered to marine sediments principally as biogenically formed inorganic carbonate minerals. Extent of preservation of carbonate minerals is also controlled by both physical and biogeochemical aspects of the depositional environment. This presentation will describe the oceanic carbon cycle, including reservoir sizes, fluxes, and time scales over which carbon cycles between reservoirs. Building upon this foundation, we will: (i) explore different theories about environmental and biogeochemical controls on sediment organic carbon preservation; (ii) discuss the linkage between terrestrial and marine systems from the standpoint of nutrient supply to the coastal ocean, consequent coastal ocean productivity and carbon sedimentation, and fate of terrestrial organic matter exported to the coastal ocean; and (iii) discuss consequences of ocean acidification for carbonate mineral preservation in marine sediments.

1-9 Carbon Sequestration Possibilities in Koa Forest Restoration

James Friday[1], Travis Idol[1], Paul Scowcroft[2], Dean Meason[3], Rodolfo Martinez Morales[1]
[1]University of Hawai'i at Mānoa, Honolulu, HI, [2]USDA Forest Service, Hilo, HI, [3]Scion Research, Rotorua, NZ

Forest plantations can help mitigate climate change by sequestering carbon, but the fast-growing, exotic species usually chosen do little to promote biodiversity. Reforestation with the native tree *Acacia koa* is an option more landowners are pursuing as an alternative to plantations of non-native species. Koa not only grows rapidly on marginal sites in Hawai'i, but koa forests also provide habitat for native wildlife and ideal sites for underplanting other native plant species. We present data on the magnitude and rate of accumulation of aboveground woody biomass of natural koa stands and plantations of known age on sites along rainfall and elevation gradients on the islands of Hawai'i and Kaua'i. We developed species-specific allometric relationships for estimation of biomass. We discuss the use of satellite imagery to correlate stand structure with canopy reflectance in order to quantify

biomass of koa forests at the landscape level. Our results indicate that secondary koa stands can sequester significant amounts of carbon while providing other ecosystem services. Because large areas of land could be available for koa reforestation statewide, restored koa forests could play a small but significant role statewide in offsetting Hawai'i's carbon emissions.

Symposium: Sea Level Impacts in Hawai'i, Implications for the Natural and Built Environment

1-10 Global Sea-level Rise: Meeting the Challenge in Hawai'i

Chip Fletcher
University of Hawai'i at Mānoa, Honolulu, HI

Global mean sea level is rising (about 3 mm/yr) twice the rate of the 20th century (1.6 mm/yr). This is a result of atmospheric warming causing net melting in Antarctia, Greenland, among small ice caps, and in the world's mountain glaciers. Thermal expansion in warming oceans is also a major component (about half). Sea-level rise threatens coastal communities and ecosystems, and planners are engaged in assessing options for meeting this threat. Accordingly, it is essential to have an estimate of sea-level rise this century to properly design mitigation and adaptation strategies. Based on current scientific understanding, a global mean rise of approximately 1 m by the end of the century is likely and constitutes an appropriate planning target at this time. However, sea-level rise will have important local variability that planners should consider as knowledge of that variability improves. Global mean sea-level may rise significantly more than 1 m, but is unlikely to rise significantly less. Important questions remain regarding the melt-down rate of ice in West Antarctica and Southern Greenland. Also unknown are the actual levels of natural climate variability and greenhouse gas accumulation that will be reached later this century. However, even if atmospheric composition were stabilized today, sea-level rise several fold over the observed pattern of the 20th century is unavoidable. In Hawai'i, hundreds of thousands of people, numerous ecosystems, and abundant environmental services are located in the threatened area. Coastal erosion, wave inundation, and severe drainage problems are upon us now, and will worsen in the future.

1-11 Island Climate Adaptation and Policy: Diverse Risks and Interdisciplinary Solutions

Maxine Burkett
University of Hawai'i at Mānoa, Honolulu, HI

Hawai'i sits at the center of our Earth's climate crossroads. Since voyaging to the islands over 1,000 years ago, native Hawaiian culture has closely studied the flow of water, the patterns of waves and winds, the topography of the land, and the nature of our island climate. Using this knowledge, islanders adapted their use of the land and ocean to the perpetually changing conditions. However, climate challenges have shifted. Over the past half-century, unique data gathered in Hawai'i at Mauna Loa Observatory have documented increasing atmospheric concentrations of greenhouse gases. Climate change impacts are widespread and now islanders are faced with a new set of climate challenges. The distinctive combination of cutting-edge science and traditional knowledge highlights the strength of solutions that Hawai'i can bring to the uncertain future of small islands facing climate change. Toward the creation of those solutions, UH Sea Grant College Program's new Center for Island Climate Adaptation and Policy (ICAP) facilitates a sustainable, climate conscious future for Hawai'i, the Pacific, and global island communities. The Center produces innovative, interdisciplinary research and real-world solutions to island decision-makers in the public and private sectors. As a focal point for University of Hawai'i climate expertise, ICAP serves as a two-way conduit between the University and island communities to catalyze climate change adaptation and resiliency.

1-12 Managed Shoreline Retreat: A Framework for Private Property and Residential Neighborhoods

Makena Coffman
University of Hawai'i at Mānoa, Honolulu, HI

With better understanding of how sea level rise will affect our coastal communities and increasing urgency for improved shoreline management – one of Hawai'i's best options is to "retreat from the coast." This approach serves to protect communities from further property loss and restore healthy coastal areas. Particularly pertinent to privately-owned and residential properties, this study creates a framework to understand decisions to relocate infrastructure and, often, people. It proposes the use of hedonic pricing methods to assess the value of retreat versus inundation based on the expected rate of erosion, forecasts in sea level rise, assessment of nearby amenities and services, and property characteristics. As Hawai'i is but one island state around the Pacific and the

world that will be drastically affected by climate change, this framework can be applied for planning, management, and policy-making purposes for similar cases of shoreline degradation.

1-13 Keys to Implementing Science to Address Sea Level Rise and Other Hazards
Dennis Hwang
University of Hawai'i, Honolulu, HI

Based on concepts developed in Hawai'i Coastal Hazard Mitigation Guidebook (University of Hawai'i Sea Grant College Program), a flexible approach to implementing a program for sea level rise is based on knowledge, planning information, guidance, policy, industry standards, existing authority and new regulations. Recognizing that these elements of implementation create a sliding scale, or continuum, can offer a jurisdiction more flexibility and an endless array of options. This basic concept can be used for any governmental program, whether it is for implementing a hazard program for sea-level rise or to address conservation issues such as groundwater purity or biodiversity. More specifically, with regard to hazards, three other concepts are introduced, including: the hazard forces in Hawai'i; the stages of development; and the weighting considerations by government agencies and the courts. How these concepts are implemented is shown for two case studies that address sea level rise: (i) the new shoreline setback rules for Kaua'i County and (ii) the handling of future shoreline movements in the Kapoho area by the Hawai'i County Planning Department. The concepts are universal and have been applied throughout Hawai'i, in the mainland United States and internationally.

CONCURRENT SESSION 2: JULY 28, 3:20 – 5:20 PM

Symposium: Climate Change Impacts in Hawai'i and Island Communities

2-1 Evidence of Decreasing Rainfall and Ground-Water Storage during the 20th Century
Delwyn Oki, Gordon Tribble
USGS, Honolulu, HI

Records of streamflow from seven gaging stations operated in Hawai'i by the USGS from 1913 through 2002 show that the base flow (groundwater discharge to streams) at all of the stations declined significantly during this period. Streamflows measured by these gaging stations are not affected by upstream diversion of surface water or nearby groundwater withdrawals; therefore the declining base-flow trends indicate a decrease in groundwater recharge and storage over this period. This change may have a long-term effect on the sustainability of water resources. Streams from the islands of Kaua'i, O'ahu, Moloka'i, and Maui in a range of climatic settings were represented, indicating that the trend of reduced flow affected most of the State. Mean annual rainfall on the drainage basins above these gaging stations ranges from about 80 to 250 inches. Trends in streamflows generally reflect statewide trends in rainfall. Of 71 rain gages with sufficient data during 1913 to 2001, 17 showed statistically significant downward trends, which is consistent with the streamflow trends during that period. Three of the rain gages had upward trends. If the rainfall analysis is extended back to 1893, significant trends in annual rainfall were detected at only three of the 23 rain gages evaluated. Thus, although rainfall trends commonly were downward during the 89-year period from 1913 to 2001, over the 109-year period 1893 to 2001, significant trends were much less common. Additional analysis is needed to determine if the streamflow declines are a permanent shift or are part of a long-term cycle.

2-2 Climate Change Monitoring in Hawai'i—From Regionalization to Local Extremes
Henry Diaz[1], Thomas Giambelluca[2], Jon Eischeid[1]
[1]*University of Colorado, Boulder, CO,* [2]*University of Hawai'i at Mānoa, Honolulu, HI*

We describe efforts to develop regional units for the major Hawaiian Islands in order to study secular changes in Hawai'i's climate in the instrumental record. Our approach to regionalization is to consider the amplitude and phase of the annual cycle of monthly mean rainfall in the Islands using a relatively large number of climate stations (N>300). We show how this regionalization results in 7 subregions—a reasonable number that balances the need to retain enough spatial information, while restricting the number of such groupings to a reasonable size. We will discuss the observed changes in mean temperature and precipitation for the State and its climate subregions. We will also examine changes in the distribution of daily values of temperature and precipitation for the past 60 years to ascertain if there have been significant changes in the frequency of occurrence of specific quantiles. We will also consider other climate monitoring indices such as changes in the number of days certain

type events occur during the period of record (for example, the number of days with daily rainfall total exceeding 2 inches).

2-3 Climate Change and Fisheries

Jeff Polovina
National Oceanic and Atmospheric Administration, Honolulu, HI

We have observed an increase in the area of the least productive waters in the central North Pacific, those defined as not exceeding 0.07 mg•m3, from 1998 to 2006, of about 2 percent per year coherent with increases in sea surface temperature. There has been an eastward expansion of the area of low surface chlorophyll waters between the beginning and end of the time series that now extends into Hawaiian waters. A similar areal expansion of low surface chlorophyll waters has been documented in the South Pacific, North Atlantic, and the South Atlantic, at rates ranging from 1-4% per year. The expansion of low surface chlorophyll waters is consistent with a global warming scenario of increased vertical stratification but the rates we observe already exceed long term model predictions. This observed change suggests that a response from global warming in Hawaiian waters will be a decrease in the carrying capacity of the pelagic ecosystem.

2-4 Climate Variability and Change and Human Health in Island Communities

Nancy Lewis
East-West Center, Honolulu, HI

Climate variability and change present challenges for the health of humans across the globe. The challenges faced by island communities are shaped by the unique nature of islands, their typically small size, their oceanic location and relative isolation. The effects of climate change on health are both direct and indirect and they interact with impacts on water availability, biodiversity, coral reefs, agriculture, etc. to affect human well being and the quality of life. In the extreme, with sea level rise, entire communities can be threatened, creating environmental refugees. Increasingly severe weather events, which may occur in the Pacific, pose particular health risks for island coastal communities. El Niño events may strengthen short-term and interannual climate variations. Options for adaptation must be seriously addressed. A robust public health infrastructure can help to lessen the negative health impacts of climate change. Issues and concerns in Hawai‘i and the Pacific will be discussed as well as the recommendations from three workshops in which the author was involved on climate variability and change in small island states organized by the World Health Organization in partnership with the World Meteorological Organization and the United Nations Environment Programme.

2-5 Utilizing Coastal Zone Management and the Hawai‘i Ocean Resources Management Plan as a Foundation for Adapting to Climate Change in the Islands

Douglas Tom, Melissa Iwamoto, Marnie Meyer
Hawai‘i Coastal Zone Management Program, State of Hawai‘i

Before identifying and addressing the impacts of climate change in Hawai‘i and the Pacific Islands, it is essential to ground efforts in a shared concept that is useful for all manners of research, planning, and implementation. Coastal Zone Management, or CZM, provides a context that is designed to be broad enough to encompass the issues faced in natural and cultural resource management and conservation while simultaneously addressing the needs for economic development. Brief background information on Hawai‘i’s CZM Program will lead into an overview of the program’s flagship project, the 2006 Hawai‘i Ocean Resources Management Plan (ORMP). The ORMP is the first step towards a comprehensive plan that provides guiding perspectives to address the vast challenges before us. Emphasizing the interconnections between land and sea, the importance of our ocean heritage, and the necessity of collaborative governance and stewardship, the ORMP lays a foundation from which state, county, and federal agencies are collaborating to increase the state’s capacity to address the local impacts of climate change. To cultivate collaboration and implementation of the ORMP, the Hawai‘i CZM Program established an executive-level Policy Group and a manager/staff-level Working Group. Members represent federal, state, and county partners, citizen groups, and the University of Hawai‘i. The presentation will conclude with an overview of the ongoing and planned efforts of the ORMP Policy and Working Groups to develop and implement an operational planning framework to foster adaptation to climate change impacts in Hawai‘i.

Symposium: Ecological Restoration in a Changing World

2-6 Expecting the Unexpected: Ecological Restoration in the Face of Changing Climate, Biological Invasion and Economic Crisis

David Burney
National Tropical Botanical Garden, Kalāheo, HI

Consensus among climate models is that greenhouse gas-driven change will result in warming of mid-Pacific islands, sea-level rise, and probably increased dryness in the lowlands and a decreased area of high rainfall on mountains. Successful plant reintroduction strategies need to take into account the likely need for buffering against climate uncertainty through use of micro-irrigation techniques, creation of new populations in suitable habitat, and possibly assisted migration strategies. Meanwhile, the ever-present and ever-changing challenges of biological invasions can be expected to increase and diversify under future climate scenarios. Added to the negative synergy of climate change and biological invasion is the onward march of development in whatever forms may emerge under the current and near-future circumstances of economic decline, energy shortage, and sustainability issues. Clearly, if biodiversity itself is to survive under these combined threats, innovative strategies are needed that provide maximum flexibility and affordability while saving as many species and ecological functions as possible. Baseline studies, including drawing on information from longer time series provided by paleoecology, archaeology, history, and oral tradition, are essential to good decision-making. Conservation dollars, hours, and acres should be deployed on a long front that includes a wide range of in situ techniques as well as strong back-ups provided by ex situ institutions such as botanical gardens, seed banks, and micropropagation laboratories. Between these two there is a broad “third front” for Hawaiian plant conservation, offered by flexible, affordable methodologies grouped under the term inter situ. Examples will be discussed.

2-7 Using Dense Outplantings of Select Native Species to Overcome Invasive Plant Competition in Limahuli Preserve, Kauaʻi

Emory Griffin-Noyes, David Burney
National Tropical Botanical Garden, Kalāheo, HI

Conservationists at the National Tropical Botanical Garden have undertaken the daunting task of restoring a weedy forest in Limahuli Preserve to an almost completely native system, from the tree canopy down to the groundcovers and ferns. The goal is to create a patch of native forest that is so thick and diverse that it will actively compete with invasive alien species that are taking over surrounding areas. We have field-tested various methods to remove invasive species and then fill in open spaces by planting diverse native plants at higher than customary densities. It is clear from our preliminary results that the species composition used in the restoration process is critical to success. I will examine what species when planted together are the most effective at competing with weeds as well as being dense enough to exclude weeds from re-establishing within the restoration. One of the most important benefits of this kind of restoration is that it can be used as a tool to educate the community about native plants and conservation. Considerable forethought is necessary to ensure that the public will be positively involved in this type of conservation effort. By involving the community in the restoration process people will leave the site knowing more about native plants and be inspired knowing that they made a positive impact on the area around them. By involving children we can instill the values of protecting and conserving what is around today for those who will follow.

2-8 Diversified Plant Reintroductions at Larger Scale in Hawaiian Dry Forest

Lida Pigott Burney
Makauwahi Cave Reserve, Kalāheo, HI

Experimentation and monitoring at Makauwahi Cave Reserve and other sites on Kauaʻi has shown that highly flexible and affordable methodologies for native plant reforestation on abandoned farmland can benefit greatly from strategies borrowed from agriculture. High variance in annual rainfall and uncertainties in monthly distribution pose a great challenge to survival of greenhouse-raised native plants, but microirrigation during establishment can largely ameliorate this limitation. Biological invasions, both highly aggressive weed competition and some disease and insect challenges, can be addressed through a program of conservation tillage, mulching, ground cover planting, and integrated pest management. Experiments at medium scale show that plant survival, propagule generation, and natural recruitment can all be enhanced with a “phased withdrawal” form of adaptive management. Volunteers can hand-weed around plants, and by combining with rotary tillage in

the lanes between plants, it is feasible to give outplanted natives a head start. Choice of soil amendments and the positioning and timing of administration can be critical. Inoculation with mycorrhizal associates can also help. To address the weeding challenges cost-effectively, use of large well-organized groups of volunteers, including school groups, is essential. Selection of species from multiple criteria, including historic or late prehistoric occurrence on the site can make a critical difference and suggest many species that otherwise would have been left out. Preservation of genetic diversity may require creative thinking and innovative strategies to avoid population bottlenecks. Automation of ecological measurements, periodic census taking, and repeat photography from ground and air can assist with tracking success.

2-9 Cyberinfrastructure for Monitoring Environmental Change in Hawaiian "Mountain-to-Sea" Environments

Mike Kido
University of Hawai'i, Honolulu, HI

Humans through their degradative impacts on global ecosystems and nonsustainable use of natural resources have created serious challenges for social-ecological systems worldwide from the likes of emerging infectious diseases, the cascading effects of climate change, loss of biocomplexity, and over-demand for natural resources such as water. Continuous monitoring of environmental change occurring within the complex relationships and feedbacks of ecosystems confounded by these large-scale forces, is essential to effectively understand and deal with the escalating impacts of expanding human populations globally on watersheds. Realistically, ecological restoration attempted in this new age of rapid change will only be successful within the context of robust local-scale environmental monitoring which can be linked to global data resources and the advanced computing required to integrate, model, and simulate data. For this purpose, an advanced cyberinfrastructure for environmental monitoring is being developed at the University of Hawai'i which already has successfully merged the use of wireless sensor technologies, Grid computing with 3D geospatial data visualization / exploration, and a secured Internet portal user interface. This technology is being used to monitor and understand change occurring in mountain-to-sea environments across the Hawaiian Islands. Use-case examples will be discussed.

2-10 Genetic Considerations in Ecological Restoration

Jennifer Ramp Neale[1], Tom Ranker[2], Cliff Morden[2]
[1]Denver Botanic Gardens, Denver, CO, [2]University of Hawai'i at Mānoa, Honolulu, HI

Restoration of habitat for endangered species often involves translocation of seeds or individuals from source populations to an area targeted for restoration. Long-term persistence of a species is dependent on the maintenance of sufficient genetic variation within and among populations. Thus, knowledge and maintenance of genetic variability within rare or endangered species is essential for developing effective conservation and restoration strategies. Genetic monitoring of both natural and restored populations can provide an assessment of restoration protocol success in establishing populations that maintain levels of genetic diversity similar to those in natural populations. In terms of genetic considerations, restorationists should consider inbreeding depression, reproductive viability, local adaptation, and evolutionary potential of translocated populations.

2-11 Culturally-Based Solutions for a Multiplicity of Issues in a Changing Climate: Ahupua'a Lessons for Ecological, Agricultural, Fishery and Community Restoration

Kawika Winter
National Tropical Botanical Garden, Kalāheo*, HI*

For at least a millennium the ahupua'a system of resource management sustainably provided the needs of the inhabitants of these islands while maintaining the integrity of watersheds and ecosystems. Following changes in the ecological, economic and cultural climates of Hawai'i the ecosystem services that the ahupua'a system once provided no longer exist. Limahuli Garden and Preserve's ongoing Hā'ena Ahupua'a Project has worked for more than 15 years to be an example of how the ahupua'a system of resource management can provide lessons and guidance in the areas of ecological restoration, sustainable agriculture, fisheries management, community development and more. We will share our challenges and our successes in our aim to beneficially manage for both sides of the social-ecological system of Hā'ena, Kaua'i.

CONCURRENT SESSION 3: JULY 29, 10AM – 12PM

Symposium: Building Scientific and Management Tools to Address Climate Change in the NWHI (Session 1)

3-1 The Effect of Thermal History on the Diversity of Coral Endosymbionts (*Symbiodinium* ssp.) Harbored by *Montipora capitata* and *Porites lobata* in the Northwestern Hawaiian Islands Monument, Papahānaumokuākea

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Predicting the resilience of coral reefs to increased sea surface temperature, as an outcome of global climate change, is an important focus of coral reef research and conservation. Our understanding of the adaptive capacity of corals with respect to environmental change is poor and as a result, models that predict impacts under various scenarios of climate change are hindered by a lack of understanding dynamic aspects of coral biology. Reef building corals form intimate associations with endosymbiotic dinoflagellates in the genus *Symbiodinium* and the physiological scope afforded by these unions underpins the economic and ecological success of the group. The chimeric nature of corals may also provide an opportunity for environmental flexibility and the capacity to optimize thermal tolerance by modifying the composition of their endosymbiotic dinoflagellate communities. Here we evaluate this hypothesis by characterizing the endosymbiotic communities in Montipora capitata and Porites lobata sampled in areas of the Northwestern Hawaiian Islands that have different thermal histories between 1985 and 2005.

3-2 Microbes in the Monument: Using Bacterial Community Assessments to Monitor Coral Health

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Corals are essential biological and structural components of the reef framework which are under immediate threat from human impacts at local and global scales. Mitigating stressors at the local level may add a protective buffer that effectively reduces the impacts of global climate change, specifically ocean acidification and elevated temperatures, on coral communities. Developing new tools to measure and monitor the effects of local stressors on corals is essential to their conservation. Here, we explore the use of coral-associated bacterial community assessments to monitor coral health in the Hawaiian Islands. We have developed and optimized molecular techniques to characterize the diversity and abundance of bacteria associated with different coral species across broad geographic scales and under gradients of environmental stress in the field and in aquarium experiments. A 2005 - 2006 field survey of non-diseased *Porites lobata* corals in the Papahānaumokuākea Marine National Monument revealed that bacterial communities associated with this reef-building coral exhibited geographic-specific distributions. We are identifying the bacterial species that are contributing to the observed differences between islands and atolls and determining if these differences are correlated with specific environmental variables. We have also employed our molecular techniques to determine if coral associated microbial communities change in response to seasonally and diurnally-driven sediment resuspension on the reefs of southern Moloka'i. Ultimately, we aim to identify key bacterial species that can serve as indicators of environmental degradation and/or a decline in coral health before the visual onset of disease occurs.

3-3 Reefs Under a Microscope: Micro-spatial Genetic and Thermal Architecture of Hawaiian Coral Reefs

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Coral reefs cover a small fraction of the world's surface (~284,300 km2) but nonetheless are economically and biologically critically important. In Hawai'i, coastal ecosystem use adds ~$364 million annually to the local economy. Coral reefs are called rainforests of the sea because they support similarly high species diversity and are disappearing at alarming rates. The health of coral, and therefore coral reefs, is dependent on a variety of factors including temperature, solar irradiance, terrestrial runoff, pollution, water movement, etc. Water

temperature is one factor that has clearly been associated with reductions in coral health and increases in the incidence of coral bleaching. Less well known, however, is the role genotype plays in coral colony health and persistence. Furthermore, microspatial (i.e., centimeter scale) heterogeneity in habitat, health, and settlement are commonplace on reefs. Since 2006, we have recorded temperature every 50 minutes at 85 locations on a 4-meter grid covering an entire reef in Kāneʻohe Bay, HI. Every colony of *Pocillopora damicornis* on the reef also was mapped and genotyped. We detected widespread, stable microspatial variation in temperature. Deep locations, as well as shallow, consistently (i.e., ≥ 50% of the time) experience temperatures more than one standard deviation above the mean temperature across the reef. Several shallow locations (as well as deep) are similarly cold. Genetic variability is high and genotypes and genetic relatedness are uniformly distributed across the reef. Here, we present these analyses in reference to coral health, reef conservation, global warming, and the Papahānaumokuākea Marine National Monument.

3-4 Climate Change and Coral Health in the Northwestern Hawaiian Islands

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Coral reefs are under threat from global climate change with increased sea surface temperatures and ocean acidification predicted to result in increases in coral bleaching, disease and a decline in reef resilience. To maintain reef resources in the face of changing climatic conditions we have been conducting disease surveys and investigating diseases of concern in the Northwestern Hawaiian Islands (NWHI) since 2002. Baseline disease surveys revealed 10 coral diseases and one disease of crustose coralline algae on the reefs of the NWHI. Annual monitoring surveys are following disease levels through time so increases in disease can be acted upon quickly. Distribution and prevalence of diseases varied among islands with French Frigate Shoals currently showing the highest level of coral mortality from disease. Diseases varied in their degree of harm to the coral host (virulence) with diseases causing tissue loss (white syndromes) resulting in the highest coral mortality. Coral genera differ in disease susceptibility with *Acropora* having the highest prevalence and rate of mortality. Reefs dominated by *Acropora* should be monitored closely for disease. The backreefs of Pearl and Hermes, Midway and Kure are prone to temperature stress with bleaching events occurring in 2002 and 2004. Environmental stressors are known to affect disease prevalence and so these sites should also be monitored. The backreefs dominated by *Montipora* are vulnerable to disease outbreaks as studies have shown that, *Montipora* white syndrome can cause a significant coral mortality. Currently, modeling techniques are being used to understand drivers of coral disease in Hawaiʻi.

3-5 Impact of Ocean Acidification on Hawaiian Coral Reefs in the 21st Century

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Levels of ocean acidification at twice present day pCO_2 will occur during this century unless extreme measures are taken to reduce fossil fuel combustion. The environmental consequences to Hawaiian coral reefs have been demonstrated experimentally. At this level, recruitment and growth of coralline algae (CCA) will be reduced by up to 80-90% and calcifying communities will undergo net dissolution caused by initial loss of the more soluble high magnesium carbonate component. Coral calcification will decrease by 15% to 30% under acidified conditions. Skeletal formation in corals is impaired, but other functions such as coral spawning and coral settlement show little or no difference. The impact of ocean acidification is insidious and is not marked by the dramatic and highly visible mortality events such as occurs with temperature-induced coral bleaching. Rather, ocean acidification leads to decreasing resilience and structural collapse of reefs communities. Quantitative models show that increasing frequency and intensity of bleaching events due to global warming during mid-century will be the dominant cause of reef decline, but ocean acidification becomes increasingly important near the end of the century. Corals in certain geographic regions can tolerate much higher temperatures than Hawaiian corals, so natural selection and genetic adaptation to higher temperature does occur over evolutionary time scales. However, observations on the chemical requirements for calcification indicate that adaptation to levels of increased ocean acidification is not possible.

Symposium: Integration of Native Hawaiian and Western Sciences to Understand the Environment of Hawai‘i: Lessons from the Ku‘ula Class at UH Hilo

3-6 Ko Kua Uka, Ko Kua Kai (Those Of The Land, Those Of The Sea)

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Through generations of observation, Hawaiians developed connections among natural occurrences in the sky, on land, and in the sea. "Pala ka hala, momona ka hā‘uke‘uke", this ‘olelo no‘eau, or wise saying, was used to pass on the knowledge that ripening hala (*Pandanus*) fruit on land is an indicator of the optimal time of year for harvesting hā‘uke‘uke (*Colobocentrotus atratus*) from the intertidal zone. The intent of this study was to record this seasonal occurrence by quantitative means. Six sites containing hā‘uke‘uke and hala were sampled on the island of Hawai‘i from October to December 2008. Number of fruits (female) and flowers (male) were recorded for each hala tree. Up to five specimens of hā‘uke‘uke from two size categories (large, medium) were collected from each site. Test diameter and height were measured (to 0.05cm accuracy) and gonad tissue was weighed (g). Pearson’s correlation did not reveal a linear relationship between average number of fruits/flowers per hala and average weight of gonad tissue. Monthly mean comparisons of fruits/flowers did not change over the sampling period (one-way Analysis of Variance, $p>0.05$). Average weight of gonad tissue was also relatively constant (3.7-4.5g). Data indicate a consistent relationship between fruits/flowers of hala and weight of urchin gonads over the three-month sampling period. However, additional sampling across seasons is underway to further study this example of how Hawaiians integrated traditional ecological knowledge into their resource management practices.

3-7 Hinahele: Coral Reef Zonations

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Coral reef zonations as understood by Native Hawaiians were studied along an age gradient presented at Moku o Keawae (Hawai‘i Island), and Pihemanu (Midway) Hawai‘i, during fall 2008. Substrate ages ranged from 400 to 30,000,000 years before present (y b.p.). Results indicate that there was a significant positive linear relationship between substrate age and the length of the one (sand) and kohola (reef flat). While not significant, trends of positive relationships were also found between substrate age and length of the kai he‘e ku (reef slope) and kai he‘e nalu (reef crest where surf breaks) zones. In general, the longest zones occurred in areas of oldest substrate age, and the shortest zones occurred in areas of youngest substrate age. Naming of physical components of coral reefs in a Hawaiian system is consistent with the geologically based reef zonation system. However, the Hawaiian names of reef zonations also indicate their specific ties to resources, deities, and activities done. Our review of literature and interviews with traditional reef users suggests the resource use and potentially the social characteristics of the culture may differ along the age gradient of of nā moku o Hawai‘i (all islands).

3-8 What a Traditional Hawaiian Legend has to Teach Us about Reef Fish Management Today: Comparing Uhu (*Scaridae*) Age-Structure and Abundance between Midway Atoll and Puako, West Hawai‘i

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Key fish species, such as uhu (*Scaridae*) may serve as an indicator for overall reef community resilience. During our study (April 2007 – December 2008) abundances of uhu populations were assessed and compared between a populated and fished Main Hawaiian Island site (Puako, West Hawai‘i), and a protected, lightly populated Northwestern Hawaiian Island site (Midway Atoll). The age-structure distribution was also noted, given their hermaphrodidic (initial female to terminal male) life history and sequential color change with age. *Scaridae* abundance data was collected by visual census and compared by a student’s T-Test. Midway had a significantly higher uhu density ($p=0.001$). There was a higher male to female ratio in Midway (65:35) than Hawai‘i Island sites, indicating an abundance of larger, reproductively mature fish. The decreased uhu population and age-structure differential in Puako may be indicative of an overall loss of resilience for this population. A traditional Hawaiian story about the legendary fisher Puniakai‘a reinforces what current biological literature suggests in regard to effective reef fish management: that by protecting the larger-sized individual (more fecund) reef fish, the resilience of the entire population may increase exponentially while medium-sized fish may still be taken for food protein in this important fishery.

3-9 Nā ʻOpihi o Hawaiʻi Nei: A Study of ʻOpihi, an Endemic Hawaiian Limpet (*Cellana spp.*) In the Hawaiian Archipelago

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ʻOpihi (*Cellana spp*.) are one of the most prized species harvested in Hawaiʻi, due to their cultural significance to Hawaiians and their high economic value. In Hawaiʻi, ʻopihi are considered the fish of death because they are located in the inter-tidal zone with large wave action, so people risk their lives while harvesting ʻopihi. ʻOpihi are also an important source of protein, vitamins A & D, phosphorous and iron, before foodstuff began to be imported. There are three endemic *Cellana* species, *C. exarata* (makaiauli), *C. sandwicensis* (ʻālinalina), and *C. talcosa* (kōʻele), distributed throughout Hawaiʻi**.** We investigated the distribution and density of ʻopihi during various lunar phases on Hawaiʻi Island and on Pihemanu (Midway Atoll) in the Northwestern Hawaiian Islands to better understand ʻopihi ecology across the Hawaiian archipelago from a cultural perspective. The alongshore transect survey at Puhi Bay, Hilo, Hawaiʻi revealed that ʻālinalina are larger than makaiauli but exhibit lower densities during all three moon phases. ʻĀlinalina are favored over makaiauli, so their lower densities may be attributed to higher fishing pressure of this species. No true ʻopihi were found on Pihemanu and may be due to the lack of connectivity with other populations. This research provided data on previously poorly studied population dynamics and ecology of ʻopihi which are model species for culturally appropriate conservation efforts in Hawaiʻi for their cultural and economic importance. Further investigation on harvesting pressures of ʻopihi in correlation to their densities, at Kalaupapa National Historic Park, Molokaʻi is underway.

3-10 Native Plants of Pihemanu: Observations from a Hawaiian Perspective

Nakoa Goo
University of Hawaiʻi at Hilo, Hilo, HI

Pihemanu also known as Midway Atoll is home to a variety of native plant species well adapted to an environment with limited natural resources. Many of these species hold significant importance in Hawaiian culture. The history of human disturbance on Pihemanu has significantly altered the atoll's natural environment and the current native plant distribution. During the World War II era, the land mass of Sand Island was increased by 230% through dredging and introduction of imported soil. Such disturbances have led to the introduction of over 250 non-native species which compete with native species. Observations were made of the habitats plants occupied, location on the atoll, and interactions between native plants with terrestrial fauna. A total of 13 native species were observed on the atoll, some of which are human introductions. Distribution of native species was highly dependent on substrate type. Spatial dominant native species were observed in different habitat types. ʻEmaloa (*Eragostris variabilis*) and makaloa (*Cyperus laevigatus*) were of major importance to a variety of bird species on the atoll providing foraging habitat and shelter. This study was conducted from a Hawaiian perspective in that interactions among species, habitats, and physical environments were focused and that observations were interpreted through incorporation of oral history, proverbs, and other facets of indigenous knowledge related to native plants on Pihemanu. Through observing environments and their inhabitants from the knowledge base that has evolved in Hawaiʻi, we can gain inferences into how native plants may respond to natural and anthroprogenic environmental changes.

3-11 ʻŌlelo Noʻeau: Pili iā Pihemanu a Collection of Wise or Entertaining Proverbs on the Subject of Midway Atoll

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Traditional knowledge systems often employ multifaceted approaches to understanding the workings of natural systems. Hawaiian traditional knowledge is based on observation, is generational, and is place-specific. Through being aware of one's surrounding in life, observations were made over thousands of years and the collective knowledge was passed on from one generation to the next. The applications of this knowledge over generations fine-tuned and modified it to fit the specific location of residence. The relationships between various elements of natural systems and their corresponding activities were observed in resourceful ways by our kupuna and orally passed down to what we know them as today: ʻŌlelo Noʻeau translated as wise or entertaining proverbs or sayings. These ʻōlelo noʻeau function as a rhyme or jargon, in that through its phrasing, helps us remember and pass on certain information. Our project at Pihemanu was to duplicate this process of observing, making connections and producing ʻōlelo noʻeau that would help us to remember the collected information. Bringing with

us our past experiences, we made an effort to be aware of the activities around us: in the air, on land and in the ocean to develop relationships between these observed activities. We collectively composed a series of our own ʻōlelo noʻeau pertinent to our experiences on Pihemanu, relationships we found, and relationships in comparison to our own experiences on broader Hawaiian Islands. These ʻōlelo noʻeau are our attempt to pass on our observations as well as honor our kupuna by continuing the practice of composition.

Session: Huihuina: A Mixture of Hawaiian Conservation Issues

3-12 How Well Is Climate Change Addressed in U.S. Recovery Plans for Hawaiian Species?

Tony Povilitis
Life Net Nature, Makawao, HI

Federal recovery plans are a primary tool for guiding the conservation of endangered and threatened species in Hawaiʻi and the U.S. However, less than 10% of 356 Hawaiian species with recovery plans at the end of 2008 had plans that addressed climate change threats, and few plans, all published since 2003, provided significant climate-related analysis and discussion. Most vertebrates (59%), few plants (4%), and no invertebrates had plans addressing climate change threats. Specific concerns in Hawaiian recovery plans related to climate change included disease impacts on forest birds, adverse local climatic effects on plants, and sea level rise, altered oceanographic patterns, food chain disruptions, loss of near-shore habitat, and heightened storm events for marine and coastal animals. Specific measures to counter climate change impacts were prescribed in only two recovery plans, and addressed the need to curtail greenhouse gas emissions and manage disease (forest birds plan), and to establish additional populations (Laysan duck plan). Hawaiian recovery plans should be revised in response to current scientific information on climate change effects on species and ecosystems. Examples of recovery plans needing to address climate change threats and suggestions for improving plans are provided. Plan updates would improve conservation prospects for individual species, provide information for a more comprehensive statewide response to threats posed by climate change, and help underscore the magnitude of the effort needed to recover endangered species in a climatically challenged world.

3-13 Does Size Matter? Human Perceptions of Species Endangerment

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Species become endangered due to a number of factors, ranging from habitat loss to economic development. However, the process of listing species as endangered is governed not only by causal factors, but also by human perception. Considering that human perception is important in species detection, we hypothesized that there would be observable changes over time in two perception indicators, body mass and geographic range. Based upon this hypothesis, we predicted a negative correlation between the two indicators and time of detection (i.e. year a species was listed as endangered) would exist. We tested our hypothesis on U.S. endangered species listed from 1967-1999, with consideration of taxonomic grouping and island/mainland context. As new species were listed over the thirty-year period, they decreased in body mass and geographic range, with distinctions among taxonomic groups and island/mainland context. Specifically, all taxonomic groups exhibited negative relationships with body mass, but three exhibited positive relationships with geographic range. Overall, our results strongly suggest that human perception has changed over time, with smaller species being listed more recently compared to larger species. These findings indicate that we have moved away from listing large cosmopolitan species towards local endemics, and that future listings and conservation efforts may increasingly be directed towards small species.

3-14 Challenges Associated with Assessing the Impacts of Near-shore Fisheries on Hawaiʻi's Protected Species, and Proposed Solutions

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With technical assistance from NOAA Fisheries (NMFS), the Hawaiʻi State Department of Land and Natural Resources (DLNR) is developing a Habitat Conservation Plan (HCP), as required for an Incidental Take Permit (ITP) application under Section 10 of the Endangered Species Act (ESA) for near-shore State managed fisheries

that interact with ESA-listed species including threatened green turtles, endangered hawksbill turtles, and endangered Hawaiian monk seals. The HCP should: provide an estimate of the baseline rate of take that is occurring, describe mitigation measures intended to reduce take, and outline a monitoring system that will be implemented to ensure the level of authorized take is not exceeded. Hawai'i's deep cultural ties to fishing and protected species, the open-access nature of its recreational fisheries, and distrust between the fishing community and regulatory agencies pose some unique challenges to collecting necessary baseline information on current levels of take. The ultimate goal of the HCP is to benefit both protected species and fisheries by bringing them into compliance with the ESA. The HCP will be informed by data from NOAA's Pacific Islands Fisheries Science Center stranding databases and by information collected through community outreach and capacity building activities. Outreach efforts will include attending fishing tournaments, holding public meetings and workshops, and disseminating anonymous postcards for near-shore fishers to report in situ turtle and seal observations. Here we present and describe challenges encountered thus far and propose methods for building a mutually beneficial and trusting relationship between the fishing community and regulatory agencies.

3-15 The Effects of Native Forest and Working Pasture on Rainfall Partitioning and Groundwater Recharge in Kona, Hawai'i

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Vegetation can play a major role in ecosystem service tradeoffs that result from land use change by affecting the volume of rain water that reaches the ground surface and is thus available for water supply. We collected micrometeorological and vegetation data at two sites on leeward Hawai'i Island for 20 months to look at rainfall, cloud interception, and evapotranspiration in native forest and working pasture. Rainfall rates are low and canopy interception of rainfall is high – only 65% of rainfall reaches the forest floor at one of the sites. Cloud interception is an additional source of water input: at the second site throughfall is 120% of rainfall. Using a water balance approach, we estimate groundwater recharge under each land cover type. Taller trees and higher forest density are the most plausible explanations for increased cloud water input at the second site. At the first site, where throughfall is lower, the forest is shorter and more open, likely the result of cattle grazing. The dramatic decrease in throughfall at the grazed site suggests that mixed use of native Hawaiian forest for cattle grazing could decrease downstream water supply. If rainfall decreases but cloudiness persists under future climate regimes, our findings suggest that maintaining healthy forest that can effectively intercept cloud water may be one way to help ensure adequate downstream water supply.

3-16 The Maui Conservation Data Hui, Adventures in Interagency Collaboration

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Over the last two years, members of conservation groups on Maui have met to create an integrated Natural Resource Database System (NRDS). For West Maui we integrated management datasets from nearly 50,000 acres of watershed. The purpose of this project is to effectively communicate goals and accomplishments from a comprehensive conservation landscape managed by multiple organizations, while providing useful tools to direct on-the-ground managers. The database we have developed utilizes ESRI's ArcGIS and a Microsoft Access database to provide instantly updated field maps for on-the-ground resource management crews, interactive scheduling tools for supervisors and managers, and reports for funders. To date we have standardized our fence and ungulate control data and are working to develop an island-wide data standard for other types of information. Ultimately, the goal of the system is to measure the effectiveness of our conservation management strategies using real-time management and monitoring data from multiple sources and multiple agencies across the landscape. Sharing compatible data provides such benefits as better communication between partners, prioritization of resources, and improved accountability. In this presentation, we will share some products of our database, discuss the benefits and limitations of our system, and present the lessons learned through collaborative data management efforts.

3-17 Ha‘ahonua: A Methodology of the Spirit

Matthews Hamabata[1], Kekuhi Kealiikanaka‘oleohailani[2], Jordan Henk[3], Karen Kemp[1]
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“…not science, not religion, not culture…just a way to converse about what needs to be done with the deepest respect and no compromise.” Kekuhi Kealiikanaka‘oleohaililani

We will explore how a diverse team of scholars, scientists, technologists and indigenous practitioners gathered to build the foundation for a “geocollaboratory” that could bring together indigenous Hawaiian knowledge with Western research science on Hawai‘i Island. Immersion learning in indigenous knowledge systems enabled Western scientists to see how Hawaiian knowledge systems could be synthesized with their own disciplines. Hawai‘i knowledge practitioners saw how Geographic Information Science (GIS) could provide a common basis for interpreting the essential ‘aina relationships that drive Hawaiian life and practice. True to the transformative power of Hawai‘i, the team outgrew their initial concepts and committed to Ha‘ahonua, a revised collaborative vision to weave a unifying theme among a variety of community programs and research projects on Hawai‘i Island. Led by The Kohala Center (TKC) the Edith Kanaka‘ole Foundation (EKF), and the Redlands Institute, Ha‘ahonua is now actively bringing together indigenous Hawaiian and Western knowledge; building GIS tools for conservation and management; and working to demonstrate practical alternatives to facilitate the revitalization of Hawai‘i Island as a self-reliant, sustainable system. Ha‘ahonua is being realized by connecting community members, researchers, scholars and indigenous practitioners on projects such as the Ala Kahakai National Historic Trail (National Park Service), an Agricultural Suitability Application (County of Hawai‘i), Papaku Makawalu at Kahalu‘u Bay (TKC, EKF and Kamehameha Investment Corporation), and others.

Symposium: Statewide Assessment of Forest Resources for Hawai‘i (SWARS)

3-18 Introduction to Statewide Assessment of Forest Conditions and Statewide Resource Strategy (SWARS)

Ronald Cannarella
Hawai‘i Department of Land and Natural Resources

The speaker will introduce the legal requirements, milestones, and due-dates for the Hawai‘i SWARS. He will put this planning effort in a historic context, and will touch upon some of the unique qualities of the Hawai‘i SWARS. He will then introduce the other panelists, who will elaborate on various aspects of the Statewide Assessment of Forest Conditions. Note: This session will focus on the first of two documents comprising the SWARS; the first document of the SWARS is the Statewide Assessment of Forest Conditions. The second document of the SWARS is the Statewide Resource Strategy.

3-19 Sustainability Science for Watershed Management: A Systems Approach to Efficient Conservation

Kimberly Burnett
University of Hawai‘i Economic Research Organization, Honolulu, HI

In contrast to multidisciplinary research, which delivers largely separate analyses on the same subject matter, sustainability science is transdisciplinary, organizing research to deliver meaningful contributions to critical issues of resource management and public policy. Our approach aims to provide immediate recommendations for groundwater management and watershed conservation investments and a management framework that allows for changes in climate, ecology, and public policies. By quantifying the linkages between conservation, water balance, and ecosystem services, the framework can identify priority watersheds for initiatives such as the federally-mandated Hawai‘i Assessment of Forest Conditions and Resource Strategy. Climate change and damages to the watershed (e.g. feral ungulates, fire, invasive plant species, and human impacts) change both the amounts and distribution of rainfall into runoff, recharge to the aquifer, and evapotranspiration, in turn changing aquifer head levels, erosion levels, and ecosystem characteristics. Efficient management of the watershed system requires addressing the threats through implementation of conservation instruments. It is the quantity and timing of these instruments that will determine the ultimate consequences and direct conservation funds towards the activities that will reap the highest net benefit.

3-20 Statewide Assessment and Resource Strategy (SWARS)—Urban and Community Forestry Perspective

Teresa Truman-Madriaga
Kaulunani Urban & Community Forestry Program, Honolulu, HI

In her presentation, Ms. Truman-Madriaga will address many of our critical issues through the lens of urban forestry. In Hawai'i, as in other tropical islands, the Urban and Community Forest is situated in the densely populated areas between the forest reserves in the mountains, the recreation zone at our beaches, and the highy productive and protective reef zone. The Kaulunani Urban and Community Forestry Council suggest IslandAbility as the overarching theme for the urban portion of the Hawai'i SWARS. Using the national 2008 Farm Bill objectives of Conserve Working Forests, Protect Forests from Harm, and Enhance Public Benefits from Trees and Forests, the Urban Forestry Committee has identified key GIS layers for Hawai'i and other tropical islands addressing tourism, economics, land use zoning, development and recreation for visitors and residents; canopy cover, open spaces, and impervious surfaces; climate change, coastal tree and heat islands; culture, education, quality of life, social environments, and livability; and research, inventories, best management practices and education.

3-21 Application of LANDFIRE Spatial Data in Hawai'i Statewide Forest Resource Assessment

Darren Johnson[1], Ronald Cannarella[2], Kurtis Nelson[3]
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LANDFIRE, also known as the Landscape Fire and Resource Management Planning Tools Project, is a five-year, multi-partner project producing consistent and comprehensive maps and data describing vegetation, wildland fuel, and fire regimes across the United States. As a partner in this project The Nature Conservancy's Global Fire Team is promoting the use of LANDFIRE products both spatial and non-spatial to assist conservation, forest and fire managers across the United States and globally. This presentation will highlight a case study demonstrating how LANDFIRE spatial data is being used by the Hawai'i Division of Forestry and Wildlife (DOFAW) to complete its Statewide Forest Resource Assessment. Specifically, the Existing Vegetation Type (EVT) layer including vegetation cover and height developed by LANDFIRE for the 8 main islands will be used to develop statewide maps of canopy closure, density and height in order to consider the current and projected condition of Hawai'i's primary forest types. In addition, other spatial products such as the Biophysical Systems (BpS) layer which describes pre-European settlement vegetation conditions can be used to determine ecological departure for existing forest types in terms of vegetation composition and structure across the archipelago.

3-22 Statewide Assessment and Resource Strategies: Minimizing Wildland Fire Impacts to Hawai'i's Natural Resources

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The Statewide Assessment and Resource Strategies planning efforts are providing new tools for the design and prioritization of measures to minimize fire threat to Hawai'i's rich cultural and natural resources. The State Assessment includes compilations of fire history data in addition to LANDFIRE's statewide 30-meter resolution maps of fuel model, existing vegetation type, and condition class. These new statewide GIS layers were produced by Natureserve, The Nature Conservancy, and The U.S. Geological Service's Earth Resources Observation and Science (EROS), with local assistance from many contributors including USGS Biological Resources Division, Hawai'i Department of Land and Natural Resources, U.S. Fish and Wildlife Service, the U.S. Department of Agriculture (USDA) Natural Resource Conservation Service, USDA Farm Service Agency, the Pacific Disaster Center, the U.S. Forest Service, and the University of Hawai'i, and Sanborn. This conference officially kicks off an interagency effort to design high-priority fuel management, fire prevention, and fire preparedness projects for inclusion in Resource Strategies planning documents. USDA project funding will be prioritized on local, regional, and national levels, based on fire threat, value of the resources at risk of burning, and the long-term impact of fire to those resources. Many very high priority projects have already been identified and we appreciate the continued assistance of the many partners who are contributing to this important planning effort.

CONCURRENT SESSION 4: JULY 29, 1 – 3PM

Symposium: Building Scientific and Management Tools to Address Climate Change in the NWHI (Session 2)

4-1 Putting Climate Change on the Map: A Spatial Assessment of Climate Change in the Context of Cumulative Human Impacts in Papahānaumokuākea

Kimberly A. Selkoe[1], Benjamin S. Halpern[2], Colin M. Ebert[2], Erik C. Franklin[1], Elizabeth R. Selig[3], Kenneth S. Casey[4], John Bruno[5], Robert J. Toonen[1]

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Although anthropogenic climate change effects are now ubiquitous, they are often overlooked because impacts are gradual and hard to monitor, especially in a vast area like Papahānaumokuākea Marine National Monument. In our recent cumulative impact assessment of 14 anthropogenic threats affecting the Monument, disease-related ocean warming was found to have the highest expected impact overall, followed closely by the other climate-related threats, reinforcing climate change as a top management concern. We present here four remotely-sensed spatial datasets of climate change effects to date across the Monument: 1) increase in ultraviolet (UV) radiation, 2) seawater acidification, and the number of warm ocean temperature anomalies relevant to 3) disease outbreaks and 4) coral bleaching. These maps show that disease-related warming is most intense at the northwest end of the chain, coral bleaching probabilities peaks at both ends of the chain and both increased UV radiation and seawater acidification tended to have high values at the center of the chain. Of the shallow reefs, Pearl and Hermes stands out as having the highest exposure to disease and bleaching according to our metrics. All banks, and Nīhoa, Necker and Gardner should have lower impact from climate change threats because they are dominated by deep water areas with lower vulnerability. We highlight where our data suggest climate change impacts are joined by multiple other human impacts creating possible synergisms. Ongoing comparison of these remotely-sensed data with in situ data on bleaching, disease and acidification will aid in groundtruthing this descriptive work at smaller scales and determining true impacts.

4-2 Modeled Changes in Coral Growth and Mortality over the Next 100 Years in the Hawaiian Archipelago

Ronald Hoeke[1], Paul Jokiel[2], Robert Buddemeier[3]

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Climate changes currently underway affect coral population dynamics through broad-scale mortality resulting from increasingly frequent high temperature events (coral bleaching) and through decreased calcification rates due to increasing atmospheric carbon dioxide/decreasing aragonite saturation state in surface waters (ocean acidification). Associated changes in mean temperatures will also affect mean calcification rates, e.g. in some situations, corals may see an overall increase in calcification rates with warming temperatures, particularly at higher latitudes. In this work, the synergistic effects of ocean temperatures and aragonite saturation on coral growth and mortality are modeled in the Hawaiian Archipelago, defined here to include the Northwestern Hawaiian Islands and Johnston Atoll. Overall large scale changes in coral cover for the next 100 years are projected, based on a synthesis of predicted sea surface temperature (SST) and atmospheric carbon dioxide rise, observed coral growth rates, and observations of mass coral bleaching episodes. Temperature and aragonite saturation predictions are derived from Intergovernmental Panel on Climate Change (IPCC) 4th Assessment Report scenarios using the output from multiple general circulation models (GCMs). A probability analysis of these predictions suggests substantially different patterns of change in coral growth and mortality throughout the Hawaiian archipelago over this century. For example, some regions have higher probabilities of frequent bleaching events, while other regions may have faster rates of subsequent recovery. This suggests spatial patterns of risk and refugia in an overall archipelago wide decline in coral cover by the end of the 21st century.

4-3 Characterizing Patterns of Connectivity in the Hawaiian Archipelago in the Face of Global Climate Change

Rob Toonen[1], Chris Bird[1], Don Kobayashi[2], Brian Bowen[1]
[1]Hawai'i Insititute of Marine Biology, University of Hawai'i, Kāne'ohe, HI, [2]Pacific Islands Fisheries Science Center, National Marine Fisheries Service, Honolulu, HI

Over the past five years, we have been working to survey population genetic structure of a broad range of fish and invertebrate species to understand connectivity patterns throughout the Hawaiian Archipelago. By overlaying the shared genetic breaks in many species, we have determined four primary areas of restricted gene flow within the Hawaiian Archipelago. These previously unknown barriers are being used to ground-truth conflicting models of larval dispersal in the Hawaiian Archipelago to better understand connectivity to guide management and conservation efforts. Although we have made considerable progress in understanding existing patterns of connectivity across the Archipelago, what effect will global climate change have on the patterns of exchange that we have discovered to date? Laboratory experiments have begun to demonstrate how global climate change is expected to alter larval life-history, development times, and swimming abilities. Based on these changes, some recent work has predicted dramatic changes to the expected patterns of connectivity for marine organisms. We will discuss what is currently known about patterns of connectivity in Hawai'i and outline plans for research to predict future patterns of connectivity in the face of changes to global climate expected over the next century.

4-4 To Bleach or Not to Bleach: Integrating Research and Monitoring to Inform Management Response to Climate-induced Increases in Sea Surface Temperatures

Corinne Kane[1], Ann Mooney[2], Angela Anders[3], Randall Kosaki[2]
[1]Hawai'i Department of Land and Natural Resources, Honolulu, HI, [2]NOAA Office of National Marine Sanctuaries, Honolulu, HI, [3]Clancy Environmental Consultants, Honolulu, HI

Increased sea surface temperatures are known to be the primary proximate cause of mass coral bleaching events, and sea surface temperatures are predicted to exceed bleaching thresholds in many areas of the world over the next two decades. Within Papahānaumokuākea Marine National Monument the future condition of specific coral reefs will depend upon two main factors: the extent of sea surface temperature increases, and the resilience of coral reefs to bleaching events. With the remote nature of the Monument and limited occupancy, Monument management must undertake a multi-faceted approach to detect and respond to climate-induced changes of its coral reefs. As such, a coral bleaching response plan is under development to aid in prediction, assessment, response and analysis of bleaching events and subsequent effects. Results of this work will help to further identify and monitor mass coral bleaching events within the Monument and may contribute to a greater understanding of climate impacts on coral reefs throughout the Pacific region.

4-5 Climate Research in the Monument and the Need to Synthesize Research Findings to Formulate Management Strategies: A Manager's Perspective

'Aulani Wilhelm, Randall Kosaki
Papahānaumokuākea Marine National Monument, Honolulu, HI

Climate change poses a serious long-term threat to marine ecosystems worldwide and is a priority concern for marine managers. Higher temperatures, increases in sea level, changes in ocean chemistry, and more frequent and intense storms associated with global warming directly impact ecosystems, but also indirectly affect communities through changes in trophic interactions, increases in disease, and changes in population spatial distribution. Here we will discuss how the remote location, comparatively healthy marine ecosystems and relative absence of human activity in the Papahānaumokuākea Marine National Monument provide a unique opportunity to assess direct and indirect impacts of global climate change. While significant effort has been focused on forecasting global, large-scale ocean impacts of climate change and acidification, the Monument can serve as an important monitoring station to assess potential climate change impacts on populations and communities using a finer-scale investigation of local conditions. This presentation will highlight how Monument managers are working with scientists to identify the management implications of their findings, synthesize relevant research findings to better forecast climate change impacts, and develop appropriate monitoring and adaptation strategies in the Monument. Based on the scientific information collected to date in the Monument, it is likely that the diverse marine ecosystems, including the nearshore coral reef ecosystems surrounding the atolls and low-lying islands, and the apex predator dominated ecosystems found in deep water habitats, may be differentially affected by climate change at multiple temporal and spatial scales.

Session: Hawaiian Avifauna

4-6 Changes in Prevalence of Avian Malaria on the Alakaʻi Plateau – an Early Signal for Global Climate Change in Hawaiʻi?

Carter Atkinson[1], Ruth Utzurrum[2], Pauline Roberts[3], Lucas Behnke[3], Jeremy Russell[3]
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Many species of Hawaiian honeycreepers have persisted into the 20th century because high elevation montane rain forests on the islands of Kauaʻi, Maui, and Hawaiʻi are cool enough to limit transmission of introduced avian malaria and pox virus. Malaria transmission is tied closely to the effects of temperature on development of malarial parasites within their mosquito vectors and the effects of temperature and rainfall on seasonal and altitudinal changes in mosquito populations. As a result, this system may be very sensitive to recently documented increases in mean temperature in the Hawaiian Islands. The Alakaʻi plateau, 1,200 to 1,500 m in elevation, is the highest area on Kauaʻi and falls within a zone where malarial transmission is dependent on increases in vector populations during the warmest months of the year. In the mid-1990s, prevalence of malaria in the Kawaikoi, Mohihi, and Halepaʻakai stream drainages was approximately 10% in the native forest bird community. We sampled birds in the same areas in 2007 and 2008 to test whether prevalence of infection has increased over the past decade - a response that might be expected if the mean temperatures have increased. Prevalence of malaria in Kauaʻi ʻElepaio and Kauaʻi ʻAmakihi has increased from 25% to 50% in ʻElepaio and from 7% to 32% in ʻAmakihi. While no direct cause and effect relationship can be established between these data and climate change, the increases are consistent with predicted altitudinal changes in disease transmission that would be expected in a warming climate.

4-7 Captive Propagation of the Critically Endangered ʻAlalā (*Corvus hawaiiensis*)

Blake Jones[2], Sara Bebus[2], Sharon Belcher[2], Marisa Boyd[2], Rebecca Espinoza[2], Tracey Goltz[2], Jennifer Holler[2], Emily Jordan[2], Rachel Kingsley[2], Kara Kneubuhler[2], Robby Kohley[2], Lisa Komarzcyk[2], Joshua Kramer[2], Amy Poopatanapong[2], Angela Sewell[2], Cyndi Kuehler[1], Alan Lieberman[1], Richard Switzer[2]
[1]San Diego Zoo Conservation Research, San Diego, CA, [2]Hawaiʻi Endangered Bird Conservation Program, Volcano, HI

The ʻAlalā or Hawaiian crow (*Corvus hawaiiensis*) is the only living species of corvid endemic to the Hawaiian Islands. Listed under the Endangered Species Act of 1973, the ʻAlalā's decline and extirpation from the wild is thought to be a result of a combination of human persecution, habitat loss, introduced predation, and exotic diseases. Since 2002 the ʻAlalā has become a species extant exclusively in captivity, under the management of the Hawaiʻi Endangered Bird Conservation Program (HEBCP). With facilities on the islands of Hawaiʻi and Maui, the HEBCP has been utilizing captive propagation with the ultimate goal of restoring the now absent wild population. Behavioral management, artificial incubation, and hand-rearing have been used since the inception of the HEBCP in 1993 to increase the productivity of the captive population. Genetics, ethology, embryology, and nutritional and veterinary science have been applied to enhance the management of the captive flock, which has grown from less than twenty individuals to sixty birds as of March 2009. Despite this increase, a decline in the hatchability of fertile eggs has occurred over the last sixteen years, probably as a result from inbreeding within the population. Further investigations into the possible link between embryonic development and genetics may benefit the productivity of the flock, which will aid in the ultimate goal of producing sizeable cohorts of young birds for release into the wild.

4-8 Parental Investment at the Nest by Wild Maui Parrotbill (*Pseudonestor xanthrophrys*): Implications for Captive Propagation and Recovery Efforts

Hanna Mounce[1], Dusti Becker[1], Tonya Rassmussen[1], Anna Rauch-Sasseen[1], Kirsty Swinnerton[3], David Leonard[2]
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Identified as extremely vulnerable to extinction, the Maui parrotbill (*Pseudonestor xanthrophrys*) is an endemic Hawaiian passerine with a small, isolated population. Future recovery efforts for this species will likely rely in part upon successful captive propagation. Knowledge of parental behavior in wild parrotbill may be used to help socialize juvenile parrotbill and to assess reproductive behavior of adult birds in captivity. A better understanding

of wild nest failures may also permit strategic collection of at risk chicks and eggs. Intensive observations during three parrotbill breeding seasons, January-June 2006-2008, were conducted at 17 different nests in the Hanawi Natural Area Reserve on east Maui, Hawai'i. Time spent on the nest by female parrotbill decreased with chick age. Females at failed nests spent significantly less time incubating than those that fledged a chick and the number of times per hour a chick received food was lowest at failed nests. There was no difference in male vocalization or provisioning rates at successful versus failed nests, but males often sang after feeding their mates and offspring. Weather severity was a significant factor explaining nestling mortalities during the first week. Collection of eggs and nestlings less than one week of age and during a pair's first nesting attempt early in the breeding season should have little impact on population growth of parrotbill.

4-9 Differences in Behavior and Recovery of Nēnē Flocks on Maui and Moloka'i

John Medeiros[1], Antone Ledesma[1], Sasha Smith[1], Crystal Prussick[2], Paula Hartzell[2]
[1]Hawai'i Division of Forestry and Wildlife, HI, [2]Pacific Cooperative Studies Unit, HI

We discuss the differences in behavior and recovery among nēnē (Hawaiian goose, *Branta sandvicensis*) flocks on the island of Moloka'i and Maui. Nēnēs have been released on these islands over the past decades to reintroduce nēnē into their historic range, following local expatriation. These releases have been largely successful; however, there are marked differences in the behavior among flocks with regard to continued site fidelity to release pens, with important repercussions on limitations in population recovery given the current management approach. Birds on Moloka'i, for example, exhibit nearly extreme site fidelity, while those on Maui have expanded geographically. We briefly present possible explanations for these differences, and focus on information needs and possible management strategies to better address these differences for recovery of the species.

4-10 Status and Conservation of Newell's Shearwaters on Kaua'i, Hawai'i: Reduction in Breeding Range and Developments Towards Protecting Colonies

Nick Holmes[1], Trevor Joyce[1], Jeff Troy[2], David Burney[3]
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The Newell's shearwater (*Puffinus auricularis newelli*), or A'o, is endemic to the Hawaiian Islands, is State and Federally listed as threatened in the USA, and listed as endangered on the IUCN red list. Between 75-90% of the population breeds on Kaua'i, where between 1993 and 2008, a population decline of 75% was reported, based on a concurrent decrease in ornithological radar targets recorded, and the numbers of fledglings collected as victims of artificial light attraction and collision with human-made structures. Providing practical long-term and comprehensive protection for this species at colony sites on Kaua'i has proven challenging, with efforts in the last decade hampered by basic knowledge such as the exact locations of colonies. Here we present a customized auditory survey methodology, and key results, from efforts to revisit historical colonies and identify new colonies, with an overall aim of identifying sites where long-term protection could be offered. We report an apparent breeding range contraction for the Newell's shearwater, including three colonies found to be inactive in 2006-2007 that were known to be active between 1980 and 1994, stressing the need for timely on-ground protection. We also report several previously unrecorded colonies in the more remote north-west of Kaua'i, and present a brief synopsis of initial efforts to provide protection at one of these colonies within the Upper Limahuli Preserve.

4-11 Ecology, Evolution, and Conservation Biology: Tales from a Feather as Told by the White Tern (*Gygis Alba*)

Norine Yeung
University of Hawai'i, Honolulu, HI

Feathers are used to examine ecological and evolutionary patterns in bird populations; a single feather can provide a source of stable isotopes and DNA for feeding ecology and genetic studies. Stable isotopes can inform a broad range of ecological studies by elucidating patterns in trophic food webs (e.g. feeding, migration and element cycling). Molecular markers are used to understand evolutionary processes by revealing dispersal patterns and population connectivity of a wide variety of species. These methods are useful for studies where they can supplement or replace more intrusive methods such as collection of regurgitates and blood samples,

banding, and collection of birds.Tissue samples from molted feathers, freshly dead and museum specimens were used to assess the ecological and genetic variation of the Pacific White Tern. Carbon (δ13C) and nitrogen (δ15N) isotope ratios were examined and findings show no difference within and among feather types. This suggests that any type of feather could be used as an indicator of the status of the individual and that diet is constant during individual feather growth. Additionally, carbon and nitrogen values were similar to those of adult and juvenile yellowfin tuna (Thunnus albacares) within the Hawaiian Archipelago indicating that White Terns feed on prey similar to that of both age classes of tuna. Mitochondrial DNA results suggest that there are no phylogeographically distinct species or subspecies within the Pacific. Furthermore, the recently established population of White Terns on O‘ahu shares haplotypes with all examined subspecies, suggesting multiple source populations across the Pacific.

Session: Terrestial Ecosystems

4-12 Modeling Hawaiian Plant Species Ranges Relative to Global Climate Change

Jonathan Price[1], Thomas Giambelluca[2], James Jacobi[3], Oliver Timm[4], Henry Diaz[5], Loyal Mehrhoff[3]
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We developed GIS models to produce potential range maps for over 1,000 native Hawaiian vascular plants based on current environmental conditions (specifically elevation, available moisture, and substrate age) for the documented locations of each species. Additionally, high-resolution climate change models have recently been developed for Hawai‘i based on IPCC change scenarios. These scenarios have been downsampled to a scale appropriate to address the sharp climatic gradients and adress both temperature and moisture patterns. The habitat parameters resulting from these models were then used to reproject the ranges of native plant species under future climate situations for the period 2070 - 2100. Using this information we can evaluate how the Hawaiian flora may respond to predicted climatic changes. Future conditions may affect plant species (particularly rare and endangered taxa) and plant community distribution relative to available habitat and current conservation reserves. We project that montane wet and many dry communities will be most acutely impacted.

4-13 Sensitivity of a Hawaiian Cloud Forest to Climate Change Over the Past ~3,500 Years

Shelley Crausbay, Sara Hotchkiss
University of Wisconsin at Madison, Madison, WI

Tropical montane cloud forests are considered sensitive to even minor climate changes because they are intimately connected with cloud formation. Our research describes vegetation dynamics and fire regimes in a Hawaiian cloud forest over thousands of years, set within the context of tropical Pacific paleoclimate records. We quantified pollen and charcoal particles preserved in sediment from Lake Wai‘ele‘ele, a small lake surrounded by cloud forest on northeast Haleakalā. We described vegetation dynamics with hierarchical clustering, a non-metric multidimensional scaling ordination, and the stratigraphic record of multivariate distance between successive pollen samples. To interpret the record in an ecological context, we used multivariate statistics to compare fossil pollen assemblages with a library of modern pollen assemblages, sampled across a study of modern vegetation gradients on Haleakalā. Pollen analysis documents notable changes in vegetation around Lake Wai‘ele‘ele through time. Although the site remained forested over the past ~3,500 years, community composition varied substantially. Most notably, ‘ōhi‘a (*Metrosideros polymorpha*) replaced kōlea (*Myrsine* spp.) as the dominant canopy pollen type only 2,400 years ago. *Astelia* spp., *Broussaisia arguta*, and *Melicope* spp. were more abundant 1,000 years ago and members of the Silversword alliance were more abundant 3,000 years ago. Additionally, fern abundance fluctuated dramatically throughout the record and was somewhat correlated with variation in El Niño/Southern Oscillation. Charcoal analysis demonstrates that fires were absent in this cloud forest. Overall, this paleorecord shows that cloud forest vegetation has been dynamic over the past ~3,500 years, perhaps in response to changes in aridity.

4-14 Climate Change Effects on the Wēkiu Bug, a Candidate Endangered Species Endemic to the Summit of Mauna Kea, Inferred from a Life Table Analysis

Jesse Eiben, Daniel Rubinoff
University of Hawai'i at Mānoa, Honolulu, HI

The alpine desert habitat on Mauna Kea represents one of the most extreme environments in the Hawaiian Islands. Characteristics include daily temperature fluctuations between 15ºF and 113ºF, winter snow pack, and virtually no plant life. With the threats associated with global climate change, it is obvious that this habitat will change and any specialized fauna associated with it must adapt or perish. The wēkiu bug (*Nysius wekiuicola*) is an insect predator/scavenger that tolerates low temperatures and feeds exclusively on wind deposited insects blown to the summit and immobilized by cold. This flightless bug is restricted to the cinder cones of Mauna Kea above 11,500 ft, and exhibits the most extreme morphological and behavioral adaptations in the genus *Nysius*. The wēkiu bug is a Candidate Endangered Species due to its decreasing numbers, limited range, specialized habitat requirements, isolated populations, and habitat destruction. We established the first lab colony of wēkiu bugs, and it was used to create a life table and temperature dependent growth curve. Under lab conditions (5-32ºC, 14:10 L: D) the wēkiu bug has low reproductive output compared to other *Nysius*. Developmental rate increases with temperature between 15ºC and 32ºC, wheras adult longevity shows the opposite trend. Although not surprising for insects, these findings contradict the assumption that wēkiu bugs require the low temperatures measured in its habitat. Warmer temperatures will not directly kill wēkiu bugs, but encroachment of lower elevation ecosystems and altered microhabitat effects could drastically change the resources available for the wēkiu bug on Mauna Kea.

4-15 What Factors Affect Haleakalā Silversword Reproduction?

Paul Krushelnycky
Department of Plant and Environmental Protection Sciences, University of Hawai'i at Mānoa, Honolulu, HI

The threatened Haleakalā silversword is a spectacular and integral component of the alpine ecosystem in Haleakalā National Park. Despite this plant's iconic status, relatively little is known about its reproductive ecology, information vital to its successful conservation. During the summer of 2007, I studied 32 flowering plants along the western rim of Haleakalā Crater, with the goal of quantifying several aspects of its pollination ecology. Half of the plants were located within a population of the invasive Argentine ant, allowing me to investigate the hypothesis that this ant may impact silversword reproduction through its effects on pollinators. While over a dozen insect species visited silversword flowers, *Hylaeus* bees were responsible for 85% of floral visits, confirming the importance of these endemic pollinators for the obligately outcrossing silversword. After accounting for several factors influencing visitation rates, I found that *Hylaeus* visitation to silversword flowers was significantly lower on plants located within the ant-invaded area. In contrast, seed set rates were not significantly different between plants located within invaded and uninvaded areas. Instead, there was a strong negative relationship between seed set rate and the distance to the nearest flowering individual. These patterns indicate that spatial isolation of silversword plants has an important effect on reproduction, which should be considered in outplanting restoration work. While the current degree of pollinator reduction associated with ant presence does not appear to reduce seed set, more widespread ant invasion, if it leads to more severe pollinator suppression, could result in impacts on silversword reproduction.

4-16 Identifying Reproductive Factors that May Limit Fruit Production in the Endangered Plant Hau Kuahiwi (*Hibiscadelphus giffardianus, Malvaceae*)

Melody Euaparadorn[1], Linda Pratt[2], Robert Peck[1]
[1]*USGS Hawai'i Cooperative Studies Unit, Pacific Aquaculture and Coastal Resources Center, Hawai'i National Park, HI,* [2]*U.S. Geological Survey, Pacific Island Ecosystems Research Center, Hawai'i National Park, HI*

Hau kuahiwi (*Hibiscadelphus giffardianus*) was reduced to a single individual at the time it was discovered in 1911. Propagation of seeds and cuttings from that tree resulted in a line of progeny that now exceeds over 200 individuals in Hawai'i Volcanoes National Park. For unknown reasons, fruit production from these trees is extremely low, with less than 2% of flowers producing fruit. To better understand limits to fruit production, we investigated several potential contributing factors: floral visitors and rates of floral visitation; pollen loads on insect visitors; receptivity of stigmas and viability of pollen; and pollen tube development and seed set in hand-pollinated flowers. Hawai'i 'Amakihi (*Hemignathus virens virens*) was the most abundant avian visitor (1.00±0.22 visits/flower/hr) followed by Japanese White-eye (*Zosterops japonicus*) (0.65±0.14). Insect visitors included fruit flies (*Scaptomyza palmae*) (0.96±0.28) and honeybees (*Apis mellifera*) (0.07±0.07). Sap beetles (*Prosopeus*

subaeneus) and Kamehameha butterflies (*Vanessa tameamea*) were rare visitors. Low levels of pollen (grains/insect) were found on fruit flies (0.11±0.08) and sap beetles (0.29±0.16); none were found on honey bees. Although receptivity of stigmas and viability of pollen was high (75.4% and 100%, respectively), pollination experiments found that pollen tubes were unable to penetrate stigmatic surfaces and fertilize ovules, even when flowers were out-crossed. Ineffective penetration of stigmatic surfaces and lack of subsequent pollen tube development between closely related individuals may represent self-incompatibility mechanisms that help avoid self-fertilization and promote outbreeding and genetic diversity.

4-17 Backyard Preservation: Insurance for *In-situ* Endangered Plant Recovery

Bruce P Koebele
Ka'ala Farm, Inc., Wai'anae, Hawai'i

With the loss of pollinators and seed-dispersers, the continuous introduction of alien pests and diseases, the unknown consequences of climate change, and the perpetual shortage of conservation personnel and resources, is it realistic to think that every in-situ recovery effort for the nearly 300 endangered plants in Hawai'i will be successful? No, it isn't. Why then, in the twelve years since it became legal in Hawai'i for the general public to possess endangered plants, have only 20% (i.e., one of every five) of these plants been commercially sold? Certainly, backyard preservation is not as desirable as in-situ preservation; nonetheless, it is preservation. Interviews with the owners of six commercial nurseries in Hawai'i that sell endangered plants revealed an overwhelming eagerness to increase their endangered species inventory, a nearly flawless ability to propagate endangered plants available to them, an impressive sales record (i.e., over 55,000 endangered plants have been sold to the public), and a frustration that the conservation community has provided them with so little source material. Reasons for this limited transfer, such as the rarity of source material, misconceptions about commercial nursery and public interests and abilities, and endangered plant tag issuance are explored and analyzed in this presentation.

Symposium: Environmental Education Efforts in Hawai'i

4-18 Outdoor Education at the Waihe'e Refuge

Denby Freeland-Cole
Maui Coastal Land Trust, Wailuku, HI

Maui Coastal Land Trust is a 501(c)(3) organization whose mission is to preserve and protect coastal lands in Maui Nui for the benefit of the natural environment and of current and future generations. Since our inception in 2001 we have protected almost 4,000 acres of coastal property on Maui and Moloka'i. In July of 2004, we purchased the 277 acre Waihe'e Coastal Dunes and Wetlands Refuge with the intention of conducting ecological restoration, protecting and preserving the numerous archaeological and cultural sites and providing a venue for educational programs. The Waihe'e Refuge conserves and protects coastal, spring-fed wetland, dune ecosystem, marine shoreline and riparian habitat for the recovery of native birds and native vegetation. Establishment of the Refuge eliminated the possibilities of development activities that could damage or destroy the rich archaeological and cultural resources that exist at the site. Permanent protection of the site provides the opportunity for careful planning and appropriate preservation and/or restoration. The Waihe'e Refuge offers an unparalleled opportunity for the children of Maui to connect with the historical and cultural roots of the island. Student groups visit the site to learn the natural and cultural history of the area. The developing programs at Waihe'e offer a variety of learning opportunities for students in kindergarten through high school. Students' time at Waihe'e may include such activities as becoming familiar with the native flora and fauna, studying Hawaiian culture, or assisting with ecological restoration.

4-19 Storytelling with Stuff

Thomas Cummings
Bishop Museum, Honolulu, HI

In his panel presentation, Tom Cummings will show-and-tell how Bishop Museum has, in its education programs, increasingly relied heavily on objects in the development of activities, using images, illustrations, specimens, replicas, costumes, scripts, music, and props. Also, when delivery is made on any of these activities the audiences – mainly students – are let to handle the variety of objects or "stuff". The other element Tom will share is that Bishop Museum creates a story-line in the development of its activities; i.e., writing a script that has the

elements of a standard story where – in a setting – characters, conflict, and resolution are present. The intent is that "Storytelling with Stuff" allows teaching concepts to be more fully understood while maintaining greater focus, and invites students to be part of the delivery, the teaching. Furthermore, these teaching concepts have both a Hawaiian cultural and science perspective.

4-20 The Hawai'i Nature Center Experience at Pouhala Marsh

Pauline Kawamata
Hawai'i Nature Center, Honolulu, HI

Beneath canopies of trees, in sunny marshes, and beside the rushing mountain streams, Hawai'i's children are discovering the wonders of our island home first-hand in the great outdoors at the Hawai'i Nature Center (HNC). As a private, non-profit organization, HNC's purpose is to foster awareness, appreciation and understanding of Hawai'i and encourage wise stewardship of the Islands in the future. This is accomplished through hands-on environmental education field experiences for school children, families and the public. Volunteer programs play a vital role in the success of environmental education. One example of a successful volunteer program is the wetland restoration effort at Pouhala Marsh. Pouhala Marsh, located in the West Loch of Pearl Harbor, is the last remaining natural wetland habitat on O'ahu's south coast and has been identified as a crucial resource for the protection and habitat for several Hawaiian plants and animal species. In a combined effort with other agencies, HNC began monthly service projects in December 2001. Since that time, over 1,700 volunteers have restored habitat areas for the endangered wetland birds and teaching sites for HNC's wetland education programs. The volunteer effort is combined with on-site wetland education presentations done by HNC and partner agencies prior to the start of each work day. Volunteers begin to understand and appreciate the importance of their hard work. Several other key elements are also incorporated with each work day in order to maintain a successful volunteer program and keep the volunteers happy, motivated and willing to come back for more!

4-21 Getting Their Feet Wet.....NOAA Explorations for Kids

Patty Miller
Hawaiian Islands Humpback Whale National Marine Sanctuary, Kihei, HI

The ocean is a "living classroom" just waiting for you and your students to explore. Students of today are going to be responsible for protecting our marine environment. Understanding the ocean from both a physical and biological point of view is vital to being able to protect it. Students need to understand how a healthy marine ecosystem functions, why they are important, what can impact them and what we can do to protect them. The study of the ocean and marine world needs to go beyond the classroom. Students and teachers need to get their feet wet and get involved in hands-on explorations and to investigate issues. Marine science can easily be integrated into everything you do in your classroom. This session will share a variety of resources that will help you integrate standards based marine science into your lesson. We will also share ways and sites to get students out into the water and participating in marine monitoring projects. The goal of marine education is to raise a population that become stewards of our ocean.

4-22 The University of Hawai'i at Mānoa Graduate K-12 Program: Integrating Research with Environmental Education Through Student-Scientist-Teacher Partnerships

Kanesa Duncan, Heather Spalding, Anuradha Gupta
University of Hawai'i at Mānoa, Honolulu, HI

The University of Hawai'i at Mānoa (UHM) Graduate Teaching Fellows in K-12 Education (GK-12) Program builds partnerships that incorporate research in the environmental fields of Ecology, Evolution, and Conservation Biology (EECB) into standards-based K-12 education. Partnerships between scientists, teachers and students, as well as schools and community organizations, enhance environmental education by integrating current research and cultural practices into science curriculum. Teachers and students experience cutting-edge scientific research first-hand, and the GK-12 fellows gain research assistance while improving their ability to communicate to students, teachers, and the broader community. Highly successful UHM GK-12 partnerships have evolved from a wide range of scientific questions, based in fellows' research, from population genetics to watershed ecology to invasion biology. These partnerships expose K-12 students to a variety of study organisms, including invasive ants, native seabirds, deep-sea algae and hammerhead sharks. In each partnership, the UHM GK-12 model maintains a balance between accuracy of data collection, communication of scientific processes, and educational goals. By the nature of the research in EECB fields, UHM GK-12 projects, are multidisciplinary, authentic,

grounded in local issues, aligned to school learner goals and relevant to both the public and the scientific community. Ultimately, successful partnerships highlight the importance of environmental education in developing a productive and capable citizenry. Students have opportunities to engage in authentic learning experiences and possibly train for future careers in environmental research, education and policy. Our presentation will highlight example GK-12 projects and provide suggestions for establishing and soliciting successful partnerships.

CONCURRENT SESSION 5: JULY 29, 3:20 – 5:20PM

Session: Marine and Coastal System

5-1 Conserving Biodiversity on Coastal Lands in Hawai'i

Stephanie Tom, Samuel Gon III, Jason Sumiye, Theresa Menard, Jody Kaulukukui
The Nature Conservancy, Honolulu, HI

Native biodiversity found on coastal lands in Hawai'i are threatened by rising sea levels due to climate change, as well as other critical threats. In 2008, The Nature Conservancy (TNC) completed a statewide assessment identifying conservation targets that represent coastal biodiversity, and mapping these targets across the main islands. The purpose of this biodiversity assessment is to understand the total distribution and viability of these biodiversity targets on coastal lands, as a first step toward anticipating change along coastlines due to development and climate. This evaluation process spotlighted a few key findings and strategies specific to biodiversity on coastal lands: Some targets, such as anchialine pools, are largely restricted to a single island, and require a combination of redundant protection there, as well as efforts to ensure representation across the archipelago. The geographic placement of important coastal areas ties into both terrestrial efforts and marine protection efforts, such that a more holistic approach, mirroring ahupua'a management, can be identified across the archipelago. By filling in the information gap of the statewide status of these biodiversity targets on coastal lands, the need for conservation actions is clearer and more urgent. We have identified a subset of the most viable examples of the coastal conservation targets, such that roughly 20% of the coast is identified as a high priority arena for action. TNC has identified this portfolio of sites necessary for seabirds, anchialine pools and coastal vegetation to persist into the future.

5-2 The Future of Coral Reefs: Local Actions Can Buy Time, But Not Prevent Decimation Unless Global Climate Change Is Simultaneously Addressed

Robert Richmond[1], Eric Wolanski[2]
[1]*Kewalo Marine Laboratory, Honolulu, HI,* [2]*James Cook University, Townsville, QLD, Australia*

Coral reefs are biologically diverse marine ecosystems of high ecological, economic and cultural value. While these ecosystems have experienced a variety of natural disturbances over geologic time, mounting anthropogenic influences are responsible for extensive coral reef losses over the past several decades, and the potential for recovery is bleak. Over the past century, there have been numerous studies demonstrating a continued loss of coral cover from reefs previously in the 60% - 80% range to levels in the 20% - 30% range. The anthropogenic disturbances of greatest concern in these losses include land-based sources of pollution (runoff, sedimentation, and eutrophication), over-fishing leading to phase shifts to fleshy algal domination, and mass bleaching events and ocean acidification tied to global climate change. Efforts at integrated watershed management can lead to increased coral recruitment rates following improvements in water and substratum quality. Likewise, protection of populations of herbivorous fishes and invertebrates can reduce the cover and associated sediment retention of invasive and indigenous fleshy algae. Such local measures are critical to the future of coral reefs however even successful programs will ultimately fail in protecting reefs if global climate change continues on its present trajectory. We suggest that aggressive efforts at controlling local stressors can buy several decades of time, and coupled with similarly aggressive efforts at controlling carbon emissions, can insure a legacy of viable reefs for future generations. Without both such efforts, our legacy will be reefs of low cover, low species and genetic diversity, and reduced value.

5-3 Deepwater Halimeda Meadows in Hawai'i: The 'Ōhi'a of the Ocean

Heather Spalding
University of Hawai'i at Mānoa, Honolulu, HI

The green alga (*Halimeda kanaloana)* forms expansive meadows over soft sediments, but little is known about its ecology in Hawai'i. We used technical diving, ROVs, and submersibles to describe spatial and temporal variation in distribution, abundance, demography, and growth of *H. kanaloana*. We found *H. kanaloana* meadows occurred to 90 m and covered a substantial area of the ocean floor, linking soft sediments to coral reefs. The meadows formed a unique habitat for cryptic organisms, and were used as a hunting ground for large, predatory fish and Hawksbill sea turtles. *Halimeda* were long-lived (> 27 months), but fluctuated greatly in segment number and height over time. Densities peaked at 20 m (342 ± 13 SE individuals per m^2), but varied seasonally and among locations. *Halimeda* growth was rapid (9.8% ± 1.4% SE new growth per plant per week) and generally decreased with increasing depth. Episodic abundances of other green algae (e.g., *Caulerpa filicoides*) and cyanobacteria (*Lyngbya majuscula*) were observed overgrowing *Halimeda*. Manipulative clearing experiments (mimicking observed anchor scars) showed *Halimeda* could quickly regrow from the intact holdfast, but was slow (> 20 months) to recolonize areas cleared of both holdfast and thallus. The perennial nature and rapid growth rates of *H. kanaloana* appear to contribute toward the broad success of this species and serves to inform management of deeper reefs. As an example, disturbance removing entire individuals over a large area, e.g. repeated cruise ship anchoring, would require years for recovery.

5-4 Restoration of a Coral Pool and Reef Ecosystem Invaded by Alien Red Mangrove

Ann Kobsa[1], Richard MacKenzie[2], Caitlin Kryss[2], Mitzi Messick[1]
[1]Malama O Puna, Pahoa, HI, [2]Institute of Pacific Islands Forestry, USDA Forest Service, Hilo, HI

The tidal pools and coastal land adjacent to the reef at Wai 'Opae Marine Life Conservation District, Puna, Hawai'i Island, have been invaded for several decades by the highly invasive red mangrove, *Rhizophora mangle*, and in the past decade mangroves have invaded the coral pools. The native coastal flora, including the endangered Hilo beach grass, *Ischaemum byrone*, has been almost eliminated from the areas of densest mangroves. We will report the results of removal of the mangroves at Wai 'Opae, primarily by treatment with the shoreline-approved, systemic herbicides Habitat and Aquamaster, using the drill-inject method on larger trees and foliar spraying smaller ones. This project includes an outreach and education component involving students and community members in manual cutting of the most makai mangrove keiki. We will present herbicide methodologies and results of mangrove removal, including effects on fish community structure in the tidal pools as determined using visual surveys and fyke nets. Monitoring is ongoing in open pools (lacking vegetation), and those surrounded by either native vegetation or mangroves. We will also discuss our plans for extirpation of mangroves on Hawai'i Island. Previously reported mangrove eradication efforts using manual removal or heavy machinery had much higher budgets. This project serves as a test-case for island-wide eradication of red mangrove, our next step, and for restoration efforts on the other islands. We hope to inspire others to initiate mangrove eradication campaigns.

5-5 Recruits in Unexpected Places: Coral Recruitment, Anthropogenic Iron Inputs, and Benthic Cyanobacterial Blooms on Midway Atoll

Wendy Cover, Donald Potts
University of California at Santa Cruz, Santa Cruz, CA

Coral recruitment is a biological process that fuels the resilience and replenishment of reef ecosystems, and is used as an indicator of reef health. Iron is a scarce or limiting nutrient on many atolls of the Pacific, and excess iron, often from shipwrecks or groundings, is believed to be a serious source of pollution leading to toxic cyanobacterial blooms. Benthic cyanobacteria contain numerous toxic compounds known to impact marine life adversely, and dense cyanobacterial blooms are known to decrease coral recruitment on some reefs. I investigated coral recruitment at sites with anthropogenic iron inputs and benthic cyanobacterial blooms on Midway Atoll (Northwest Hawaiian Islands) where intertidal and subtidal metal debris and dump sites provide concentrated sources of iron and other metals not normally present in carbonate reef systems. Benthic cyanobacterial blooms, primarily *Hormothamnion enteromorphoides*, occur seasonally at several Midway sites, covering over 50% of the substrate and growing over live corals. I tested the hypothesis that cyanobacterial blooms associated with metal debris on Midway also inhibit coral recruitment by measuring recruitment rates at two bloom sites, two nearby control sites, and two distant control sites, with 10 pairs of ceramic tiles deployed for 13 months at each site. Contrary to expectations, coral recruitment was significantly higher at both bloom sites

than at control sites, and I conclude that *Hormothamnion* does not impact coral recruitment negatively on Midway Atoll. This unexpected result has several possible explanations, with implications for management of metal debris on reefs.

5-6 A Survey of the Genetic Diversity of Free-Living *Symbiodinium*

Lisa M. Adams[1], Xavier Pohon[1], Ruth D. Gates[2], Misaki Takabayashi[1]
[1]University of Hawai'i at Hilo, HI, [2]Hawai'i Institute of Marine Biology, Kāne'ohe*, HI*

Free-living communities of the dinoflagellate *Symbiodinium* spp. may be the source of symbionts for many symbiotic reef invertebrate hosts, including corals. These free-living *Symbiodinium* could therefore potentially influence physiology of symbioses should they form symbiotic associations with hosts. We surveyed the genetic diversity of free-living *Symbiodinium* in the water column and sediments of coral reefs of Hawai'i, Florida Keys, and Okinawa Japan, using direct detection methods. Our DNA sequence analysis of the low-resolution chloroplast domain V-hypervariable locus using *Symbiodinium*-specific primers, found high levels of diversity with 38 different sequence types from clades A, B, C, D, F, and G; 24 of which are novel. Hawai'i was found to have particularly high diversity with representatives from all clades identified, whereas Florida samples revealed high diversity in clade B. Many sequence types were identified in both water column and sediments, indicating *Symbiodinium* likely utilize both habitats. The most ancestral types have been identified as both free-living and symbiotic in addition to being present in both water column and sediment and present in all three collection sites. This research shows that free-living *Symbiodinium* communities are diverse and may represent an opportunity for acclimation of hosts by incorporation of better adapted *Symbiodinium* types from the environment.

Symposium: Impacts of Sediments in Hawaiian Stream Ecosystems

5-7 Impacts of Sediments in Hawaiian Stream Ecosystems – Applying the Research to Regulatory Programs

Alexandre Remnek[1], Renee Kinchla[2], Linda Koch[1], David Penn[1]
[1]State of Hawai'i Department of Health, Honolulu, HI, [2]Research Corporation of the University of Hawai'i, Honolulu, HI

As early as the 1960s, the State of Hawai'i Department of Health (DOH) cooperated in research on sediments with the U.S. Geological Survey (USGS), the U.S. Department of Agriculture (Forest Service), the University of Hawai'i, and others. Analysis of streamflow and sediment data from Hawaiian streams generated "ecosystem-based" water quality standards adopted in the 1970s and still used today by regulatory programs across federal, state, and county jurisdictions. In the last decade, growing concern about achieving the water quality goals represented by these standards, abetted by intensified federal requirements to implement the standards through various state programs, led DOH and our customers to direct more resources towards documenting, understanding, and applying new information about sediment sources, transport, fate, and impacts. For example, we use sediment-related metrics addressing flow regime, bank stability, channel alteration, substrate composition and embeddedness, riparian conditions, and more to assess overall stream habitat quality and biotic integrity. We continue to conduct baseline and targeted monitoring of streamflow and suspended solids/sediment to acquire data for assessing water quality status, estimating sediment mass loading, and evaluating load reduction strategies. This involves several common methodological approaches with unique strengths, limitations, and uncertainties, including statistical comparison, rainfall-runoff analysis, and mechanistic watershed models such as LSPC (Load Simulation Program C++) and HSPF (Hydrologic Simulation Program Fortran). Our results suggest that applied research on the impacts of sediments in Hawaiian streams be directed towards more rigorous analysis of in-channel erosional processes, sediment transport dynamics, and their relationship with hydrologic and hydraulic modifications.

5-8 Influence of Feral Pigs (*Sus scrufa*) on Runoff, Sediment Transport, and Water Quality of the Mānoa Watershed.

Dashiell Dunkell, Greg Bruland, Carl Evensen
University of Hawai'i at Mānoa, Honolulu, HI

In Hawai'i, feral pigs (*Sus scrufa*) have been shown to disrupt soil layers, increase erosion, alter nutrient processes, and adversely affect native plants. However, their effect on runoff, sediment transport, and water quality is not well documented. Feral pigs may also harbor and transmit various infectious waterborne pathogens

dangerous to humans. We are investigating if feral pig exclusion influences total suspended solids (TSS) levels in runoff, the spatial and temporal variability in TSS in runoff and streams, and the correlations between TSS in runoff and other water quality and environmental factors such as slope, infiltration rate, vegetative characteristics. To accomplish these goals we are collecting throughfall and runoff samples from paired fenced/unfenced runoff plots and stream samples from multiple sites throughout the Mānoa watershed on O'ahu. Runoff plots have been in place since October 2007. Runoff samples have been collected after precipitation events monthly from June 2008 and will continue through May 2009. Evidence of feral pig disturbance has been documented inside runoff plots on multiple occasions. Initial results have revealed strong seasonal variability in throughfall, runoff volume, TSS in runoff, and enterococci levels. Data show lower levels of throughfall, TSS in runoff, and enterococci in summer rain events, and higher levels during fall and winter events. This study aims to help resource managers identify the effects of feral pigs and inform them of the effectiveness of fencing as a potential tool for increasing water quality and reducing pathogen transport.

5-9 Hydrology and Sediment Load from Two Contrasting Hawaiian Watersheds

Jonathan Stock[1], Gordon Tribble[2]
[1]USGS, Menlo Park, CA, [2]USGS, Honolulu, HI

In tropical watersheds, accelerating landscape changes are producing increasing amounts of fine sediment, potentially affecting the ecology of nearshore waters. To understand the factors that control the fine sediment load carried by streams to nearshore waters, we contrast two Hawaiian watersheds over the period Oct. 2004 - Sept. 2006. The perennial Hanalei River (Kaua'i) drains 48.4 km^2 with a median flow of 4.0 m^3/s. Its average annual suspended sediment load of 639 MT/km^2 is equivalent to a landscape lowering rate of 0.52 mm/y for a saprolite density of 1.2 g/cm^3. The intermittent Kawela Gulch (Moloka'i) drains 13.7 km^2 and flowed to the ocean ~30% of the time. Its average annual suspended sediment load of 322 MT/km^2 represents a landscape lowering rate of 0.26 mm/y for saprolite, half the lowering rate of Hanalei basin. At an experimental site within the Kawela watershed, feral-animal grazing has exposed volcanic rock and soil on steep slopes. Instruments here measure local runoff and erosion accompanying heavy rains that exceed the infiltration capacity of the soil. Variations in sediment concentrations during and between storms are consistent with depletion of a loose surface layer, seasonally weathered from harder underlying soils. Current average annual lowering rates range between 10-30 mm/y (May through Nov. 2008), about 100-fold greater than the rate measured for the overall watershed, and similarly greater than long-term rates of 0.13 mm/y determined from an ^{40}Ar-^{40}Ar date (1.45 Ma) on a capping basalt.

5-10 Performance of Vegetative Filters to Control Loadings of Sediment and Nutrients into Surface water Bodies in a Hawaiian Watershed

Micah Ryder, Ali Fares
University of Hawai'i at Mānoa, Honolulu, HI

Cover crops are important components in the control of non-point source pollution. They can minimize erosion by protecting the soil surface, slowing runoff velocities and increasing infiltration rates. Their effective use helps decrease sediment and nutrient loading into adjacent surface water bodies. This study was conducted to gage the effectiveness of three cover crops (sunn hemp, oats and sudex) as compared to fallow practice, at reducing surface runoff and sediment loading. The soil was an 'Ewa Silty clay soil with an 8-12% slope bordered by a gulch in Waialua, O'ahu, HI. Each treatment was replicated 3 times in a 10-m by 8-m plots. Runoff collectors were installed at each plot to sample surface runoff. Rainfall was measured at the site using a tipping bucket rain gage. Additional site data were taken, i.e., soil chemical and physical properties. Water samples were collected after each major rainfall event and analyzed for total suspended, total dissolved sediments, Nitrogen and Phosphorus. Results showed that cover crops substantially decreased soil erosion, sediment loading and improved surface water quality. Suspended solids were reduced by 63% for sunn hemp, 79% for oats and 54% for sudex as compared to fallow. Results for dissolved solids showed more variability especially between sampling dates. Dissolved solids concentration data showed some variability; however, the trend was that fallow had lower values than the cover crop treatments.

5-11 Applicability of the Hydrological Simulation Program-FORTRAN (HSPF) for Modeling Runoff and Sediment in Hawai‘i Watersheds

Mery Apple, Aly El-Kadi
University of Hawai‘i, Honolulu, HI

Quantifying the amount and effects of sediment in a body of water is difficult because of measurement limitations. Mathematical models are useful tools that may help describe complex physical processes such as sedimentation. Most existing watershed models have been developed for environments that may not be sufficiently similar to the small sizes and steep slopes, often with deep alluvial flumes, of Hawai‘i watersheds to be valid. This study is aimed at assessing the applicability of the watershed model "Hydrological Simulation Program-FORTRAN" (HSPF) for simulating, at various temporal resolutions, the hydrological and sedimentation processes occurring in Hawai‘i’s watersheds. Hawai‘i’s watersheds are characterized by diverse land uses, steep slopes, and spatially and temporally varied rainfalls. The study also included a sensitivity analysis to identify parameters that are most influential on the modeling results. The model’s performance was evaluated based on the relative percentages of error, regression analyses, and other selected statistical parameters. It is concluded that HSPF may be used under typical Hawai‘i conditions to simulate hydrology for a temporal resolution as fine as weekly. Furthermore, HSPF may be used to generally predict annual sediment values. Significant errors occurring in monthly, weekly, and daily sediment estimates generated by HSPF are most likely caused by the model’s inability to account for mass wasting and make it ineffective for use on such temporal scales. This study will help in addressing problems of Hawai‘i watersheds, developing remediation strategies, and enhancing procedures for determining TMDLs and other regulatory measurements for the State of Hawai‘i.

Symposium: Linking Ecology, Conservation & Health in Hawai‘i

5-12 Linking Coral Reef Integrity and Human Well-being in the Pacific Islands

John Pandolfi[2], Alan Friedlander[1], Jennifer Schultz[1], Jack Kittinger[1], Thomas Brewer[3], Rebecca Prescott[1], Josh Cinner[3], Marimar Berzunza[2], Chris Bird[1], Durrell Kapan[1], Robert Toonen[1], Bruce Wilcox[1]
[1]University of Hawai‘i at Mānoa, HI, [2]University of Queensland, Brisbane, Australia, [3]James Cook University, Townsville, Australia

Human perturbations to coral reefs have led to loss of biodiversity and ecosystem integrity. A principle challenge remains in understanding how declining coral reefs impact human health. We investigated the connections between coral reef condition and human well-being in 17 nations throughout the Pacific Islands, where coastal societies are dependent on marine ecosystems for goods, services and cultural values. A large number of socio-economic and demographic variables are highly associated with coral reef condition, with the major driver being per capita gross domestic product. We are currently assessing the relationship between human and coral reef health. Elucidating these linkages may lead to a better understanding of the regional dynamics and future trajectories of coupled social-ecological systems.

5-13 Shifts in Bacterial Communities in Healthy and *Montipora* White Syndrome-Affected Mucus

Ashley Smith[1], Greta Aeby[1], Teresa Lewis[2], Thierry Work[3]
[1]University of Hawai‘i at Mānoa, Honolulu, HI, [2]U.S. Fish and Wildlife Service, Dexter, NM, [3]U.S. Geological Servey, Honolulu, HI

Montipora white syndrome (MWS) is a coral disease found on reefs throughout Hawai‘i that presents with focal to multifocal tissue loss. Prior surveys found that reefs within Kāne‘ohe Bay had a higher prevalence of MWS than other areas in Hawai‘i. To understand what may be driving higher disease levels we examined several components of MWS within Kāne‘ohe Bay. We examined whether anthropogenic stress may be influencing disease prevalence by comparing the prevalence of MWS in different regions of Kāne‘ohe Bay, which have variable levels of exposure to terrestrial influences such as nutrients, sedimentation and pollutants. Field surveys showed that MWS prevalence was highest in south Kāne‘ohe Bay, the region most subject to terrestrial run-off. MWS results in progressive tissue loss with the average rate of mortality of 3.1% of the colony per month on tagged colonies. Microbial studies characterized bacterial communities in healthy vs. MWS affected coral allowing us to examine shifts in the bacterial profile under disease conditions and identify potential pathogens. Culture-dependant methods found mucus from MWS affected samples had 25 times more bacteria than mucus from healthy corals. Shifts in the bacterial community were also apparent with healthy mucus being dominated by *Alteromonas*, whereas *Vibrio*’s dominated in diseased samples. In diseased samples, not only did the dominant

bacterial species change, but also the relative abundance of other bacterial species associated with healthy mucus. Several bacterial species were identified as potential pathogens and are currently being tested in challenge experiments to investigate the etiology of MWS.

5-14 The Role of Biomedical and Veterinary Science in Elucidation of Disease in Marine Ecosystems

Thierry Work
U.S. Geological Survey, Honolulu, HI

A balanced approach that incorporates biomedical tools into disease investigations in marine ecosystems is critical. Such an approach involves the proper use of biomedical concepts and terminology to enhance clarity. Investigating disease should follow a logical series of steps including identification of disease, systematic morphologic descriptions of lesions at the gross and cellular level, and then experiments to understand disease pathogenesis and the complex interactions between host, pathogen, and the environment. This model for disease is widely accepted in the medical, veterinary and invertebrate pathology disciplines. Basic epidemiologic concepts to help investigators think systematically about the cause(s) of complex diseases are covered. A major goal of disease investigation is to amass data that will allow the establishment of standardized case definitions to distinguish particular diseases from each other. Concepts and facts amassed over the centuries by medical and veterinary pathologists are invaluable because of the robust comparisons that they enable. Arguments seeking to justify a focus on opportunistic versus primary pathogens detract from the main objectives of disease investigations: to characterize the normal microbiota and physiology of the healthy host; define the ecological interactions within the microbial community associated with the host; and investigate host immunity, host-agent interactions, pathology, pathogenesis, and factors that promote the pathogenicity of the causative agent(s) of disease.

5-15 Avian Malaria in Oʻahu's Forest Birds

Kira Krend
University of Hawai'i at Mānoa, Honolulu, HI

Anthropogenic forces in the form of habitat change, introduced species, and introduced disease have significantly altered the environment for Hawaiian forest birds. Avian parasites and disease, including avian malaria, are widely recognized as the most important factor preventing the recovery of native forest bird populations in low elevation habitats. With few native forest bird species left, avian malaria has been understudied on Oʻahu. This study investigated avian malaria at 6 sites on Oʻahu on over 15 species, including two native species, the apapane and Oʻahu ʻamakihi. A number of species were identified as reservoirs of malaria, including house finches, chestnut mannakins and apapane. Results indicated year-round transmission of malaria on Oʻahu. An association between malaria and avian pox was identified, suggesting dual transmission. Oʻahu ʻamakihi had only a 12% infection rate; the presence of large numbers of uninfected Oʻahu ʻamakihi in areas with high malaria prevalence in the multi-host community suggests they have evolved disease resistance. Interestingly, Big Island studies of a closely related congener, the Hawai'i ʻamakihi, revealed high prevalence of malaria in low elevation populations. These contrasting epidemiologies suggest that ʻamakihi have evolved two different solutions to the same disease induced selection pressures: resistance in Oʻahu ʻamakihi, versus tolerance in Hawai'i ʻamakihi. Oʻahu ʻamakihi can serve as a model system for understanding disease ecology and the evolution of resistance in Hawaiian honeycreepers. If disease resistance is confirmed, there are significant conservation implications for this species, including identifying resistant genes, as well as translocation of resistant individuals.

5-16 Heterogeneity in the Spatial Distribution of Humans and Mosquitoes: Dengue Risk on Oʻahu

Sophie O. Vanwambeke[1], Durrell D. Kapan[2]
[1]Department of Geography, Universite Catholique de Louvain, Louvain-la-Neuve, Belgium, [2]Center for Conservation and Research Training, Pacific Biosciences Research Center, University of Hawai'i at Mānoa, Honolulu, HI

Invasive vectors and pathogens are a major concern in Hawai'i, for both humans and wildlife. Dengue, a threat to 2.5 billion people globally, is in the Haiwaiian Islands an invasive pathogen transmitted by the invasive *Aedes albopictus*. In the Hawaiian Islands, dengue makes occasional, epidemic appearances, and few quantitative studies have investigated the absence of an endemic transmission cycle. In Hawai'i human activities are heterogeneously distributed in space and time; so are mosquito vectors. A major aspect of the spatial distribution of disease-transmission risk is the interface between human landscape uses and the environment, specifically the

location of vector habitats within the landscape, i.e. vector-host contact. To estimate the spatial distribution of humans and *Ae. albopictus* on O'ahu, we map standard data, such as census and surveillance data. To understand transmission risk, we integrate this rich empirical data with concepts from classical vector-borne disease models to estimate the density of vectors per host. Human density is mapped using two different approaches: mapping the population based on residence (as collected in the census), and including recreational areas, which potentially overlap more with the vector distribution. This transdisciplinary application allows us to better understand how spatial heterogeneity in human and mosquito distribution combine to shape the risk of dengue transmission in Hawai'i. Such spatially-explicit information has great potential for allocation of prevention and control resources should dengue reappear, a likely event considering Hawai'i's connections with endemic areas, but is also relevant to other invasive pathogen issues, such as avian malaria.

5-17 Hawaiian Mosquito Biodiversity: Barcoding with Cytochrome Oxydasel Gene Using High-throughput Screening

Panpim Thongsripong[1], Jon Winchester[2], Amy Henry[3], Durrell Kapan[5], Shannon Bennett[4], Bruce Wilcox[4]
[1]Department of Tropical Medicine and Medical Microbiology, John A. Burns School of Medicine, University of Hawai'i at Mānoa, Honolulu, HI, [2]Department of Zoology, University of Hawai'i at Mānoa, Honolulu, HI, [3]Department of Microbiology, University of Hawai'i at Mānoa, Honolulu, HI, [4]Asia-Pacific Institute of Tropical Medicine and Infectious Diseases, University of Hawai'i at Mānoa, Honolulu, HI, [5]Center for Conservation Research and Training, University of Hawai'i at Mānoa, Honolulu, HI

Accurate morphological identification of field-collected mosquito could be difficult for members of cryptic species complexes or even impossible when parts that would be used in species identification are destroyed. For such cases, DNA barcodes may provide important diagnostic information. Rochiln, I. et al (2007) developed a modified and improved DNA isolation protocol using proteinase K digestion and nucleic acid extraction to permit high-throughput screening of a large number of mosquito specimens for species identification using Polymerase Chain Reaction (PCR) to amplify high-copy nuclear ribosomal 28S DNA from mosquito legs. Here, we used the protocol to extract mitochondrial DNA cytochrome oxydase I (COI) genes which are widely used as DNA barcodes from one leg of each individual mosquito collected from different sites in the Hawaiian islands. We were able to extract mtDNA from mosquito legs and COI genes will be sequenced to confirm identification of Hawaiian mosquito species that will later be tested for infection by pathogens such as avian malaria and avian pox. This method could easily be applied in mosquito surveillance programs in other diversity hotspots that required the use of mtDNA in mosquito species identification. For example, we will be extending this study to characterize mosquito biodiversity in Thailand across disease transmission and emergence zones.

Session: Terrestrial Pests: Reseach, Management and Tools (Session 1)

5-18 A Biogeographical Comparison of Invasive Forest Weeds in Hawai'i

David Benitez[1], Tracy Johnson[2], Rebecca Ostertag[3]
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Plant invasions are economically and ecologically costly. Research suggests a species may differ physiologically and ecologically between invasive and native ranges and these differences may enhance invasiveness. We examined biogeographical growth and defense differences of three aggressive invaders in Hawaiian forests: the tree strawberry guava (*Psidium cattleianum*), the shrub Koster's curse (*Clidemia hirta*) and the herb cane tibouchina (*Tibouchina herbacea*). In quarantine in Volcano, Hawai'i, we tested the hypothesis that individuals from invasive Hawaiian populations are faster growing than individuals from native South American populations. We will test the hypothesis that invasive Hawaiian plants are less defended chemically and structurally. Seeds of focal taxa were collected in native ranges (Brazil and Venezuela) and introduced ranges (Hawai'i) and grown in a common garden for 120-180 days. Plant height, mass and relative growth rates were quantified for 30 paired populations. Key structural traits leaf toughness, leaf hair density and specific leaf area will be quantified and feeding trials with specialized insect pests will be conducted to compare plant defenses. Field observations and preliminary results support our first hypothesis; Hawaiian plants grew larger than South American individuals in the common garden and Hawaiian plants were observed larger and more abundant during field collections. Defensive data in support of our second hypothesis would suggest divergent resource allocation patterns implying these weeds are fundamentally different in Hawaiian forests. Understanding these differences can improve our theoretical knowledge of invasions and help develop more effective control strategies.

5-19 An Update on the Current Status of Biological Control Programs for the *Erythrina* Gall Wasp (*Quadrastichus erythrinae*)

Juliana Yalemar[1], Cynthia King[1], Leyla Kaufman[2], Walter Nagamine[1], Darcy Oishi[1]
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The *Erythrina* Gall Wasp (EGW), *Quadrastichus erythrinae* (Hymenoptera: Eulophidae) was discovered on O'ahu in April 2005, and within six months the species had spread across the Hawaiian Islands. EGW infestation has resulted in chronic defoliation and mortality of thousands of *Erythrina* trees, including *E. variegata, E. crista-galli*, and the endemic wiliwili tree, *E. sandwicensis*. Using classical biological control methods, researchers from the Hawai'i Department of Agriculture (HDOA) and the University of Hawai'i imported natural enemies of EGW from the purported native range in East Africa. Of the potential natural enemies screened, two wasps, *Eurytoma erythrinae (*Hymenoptera: Eurytomidae*)* and *Aprostocetus sp*. (Hymenoptera: Eulophidae), were selected to undergo the extensive risk assessment process. HDOA concluded testing for *E. erythrinae* in January 2007. After obtaining approval from USDA and the State of Hawai'i, field releases were initiated in November 2008. To date 3840 adult *E. erythrinae* have been released at field sites on Kaua'i, O'ahu, Moloka'i, Maui, and Hawai'i Island. *Eurytoma erythrinae* have been recovered from field release sites on all islands but it is too early to quantify establishment. It is unclear whether a single natural enemy will effectively suppress EGW populations. Therefore, the assessment of *Aprostocetus sp.* continues and is near completion. Field release permits will be sought in 2009. The objective of this presentation is to provide a current overview of *E. erythrinae* release and establishment, and a summary of *Aprostocetus sp.* host-range testing.

5-20 Recent Defoliations of Koa Forest on East Maui Caused by the Endemic Caterpillar, *Scotorythra paludicola*

William Haines, Daniel Rubinoff
University of Hawai'i, Honolulu, HI

For at least the last century, koa forests on the islands of Maui and Hawai'i have been defoliated by caterpillars of the endemic moth *Scotorythra paludicola*. These outbreaks are apparently natural phenomena, occurring relatively infrequently and causing low tree mortality. However, there have been two major outbreaks on East Maui in the past 6 years (2003-2004 and 2008-2009), defoliating about 16km^2 of koa forest in Kīpahulu Valley and Makawao Forest Reserve, and resource managers are concerned that defoliation in today's environment allows understory weeds to establish, and that more frequent outbreaks may cause higher tree stress or mortality. Triggers for outbreaks are unknown, as are the likely effects of climate change on their frequency. Here we report on monitoring of *S. paludicola* in Makawao Forest Reserve, and possible factors influencing populations. To examine abiotic factors, we analyzed the predictive effect of temperature and rainfall on outbreak occurrence during the past 100 years. We did not find a significant effect of either, although our analyses were limited by a small number of outbreaks reported in the literature, and there is some evidence that low rainfall might precede outbreaks. To monitor populations of caterpillars and parasitoids, we collected and reared over 1,000 caterpillars in recent years. All parasitoids reared from caterpillars were non-native, although native parasitoids have been documented from *S. paludicola* in the past. Long term, quantitative monitoring of moth populations, local climate, parasitism, and other factors will be necessary to get to the bottom of these outbreaks.

5-21 The Prevalence of *Angiostrongylus Cantonensis* in the Main Hawaiian Islands

Jaynee Kim, Kenneth Hayes, Norine Yeung, Robert Cowie
Center for Conservation Research and Training, Pacific Biosciences Research Center, Honolulu, HI

Recently, there has been an outbreak of eosinophilic meningitis on the island of Hawai'i, attributed to the nematode parasite, *Angiostrongylus cantonensis*. At present, the symptoms can be treated but there is no known cure. Therefore, it is imperative to gain more knowledge of this parasite's vectors and prevalence throughout the Hawaiian Islands, which will permit their detection, monitoring and possible eradication. The definitive hosts of *A. cantonensis* are rats and the intermediate hosts are snails and slugs. However, it can infect a wide range of accidental hosts, including humans. Specimens from snail and slug surveys previously undertaken throughout the main Hawaiian Islands were selected for screening for *A. cantonensis*, specifically five snail and slug species known from the literature to be intermediate hosts of *A. cantonensis*: *Achatina fulica*, *Bradybaena similaris*, *Laevicaulis alte*, *Parmarion martensi*, and *Veronicella cubensis*. Specimens were screened from O'ahu and Hawai'i Island. Following extraction of total DNA from these snails and slugs, *Angiostrongylus*-specific primers

were used to detect the presence of the parasite. Digestions of snails and slugs were also done to release nematode larvae and corroborate the genetic results. All species examined except for *B. similaris* tested positive for *A. cantonensis*. Future work will extend the study to all main islands and to additional snail and slug species to obtain a comprehensive picture of the distribution of *A. cantonensis*.

5-22 Effects of Eradication and Control of Two Species of Invasive Ants on Offshore Islets in the Hawaiian Archipelago

Sheldon Plentovich
University of Hawai'i, Honolulu, HI

Invasive species eradication and control are vital components of the conservation and management of many native ecosystems. Invasive ants, which are notoriously difficult to eradicate, have been largely overlooked despite the fact that many species have expanding ranges, can reach exceptionally high densities, and often cause catastrophic changes in ecosystems. We experimentally tested the effects of hydramethylnon on two species of invasive ants (*Pheidole megacephala* and *Solenopsis geminata*) on two pairs of offshore islets. In year one (i.e., 2002), *P. megacephala* was the most abundant arthropod on islets in pair 1 while *S. geminata* was the most abundant arthropod in pair 2. Following treatments with hydramethylnon, *P. megacephala* was not detected on the treated islet in pair 1 from 2003-2008. In pair 2, *S. geminata* numbers declined, but the species remained present on the treated islet from 2003-2005. During these periods ant densities remained high on untreated islets. Reduced densities resulted in increased weight and fledging success of wedge-tailed shearwater (*Puffinus pacificus*) chicks and increased leaf cover in the native plant 'ilima (*Sida fallax*) on pair 2. Substantial changes in the ant community were observed from 2003-2008 following the eradication of *P. megacephala*, including the appearance and spread of the yellow crazy ant (*Anoplolepis gracilipes*). This invasion coincided with declines in number of seabird chicks. We conclude that hydramethylnon can be used to effectively eradicate *P. megacephala*; however we recommend it be used cautiously, as part of an adaptive and integrated plan that includes continued monitoring and management.

Symposium: Experiential Environmental Education for Hawai'i's K-12 Students

5-23 NOAA Honua: Engaging Hawai'i's K-12 Students with NOAA Science!

Stephanie Bennett
NOAA Pacific Services Center, Honolulu, HI

Recognizing that an educated community is a key to understanding and sustaining the nation's ocean and coastal environments, the National Oceanic and Atmospheric Administration (NOAA) Pacific Services Center (PSC) supports an environmental literacy initiative called NOAA Honua (NOAA's World) for the Pacific region. Elements of this approach focus on educational opportunities for students and teachers, such as the Bay Watershed Education and Training (B-WET) Hawai'i Program and the Pacific Science Challenge. B-WET Hawai'i strives to create a population knowledgeable about the environment by supporting organizations that use the outdoors as the context for learning. By using the outdoor environment as a living laboratory, students readily grasp their connection to marine and aquatic ecosystems and immerse themselves in dynamic learning. B-WET Hawai'i funds projects that provide science-based outdoor experiences for K-12 students and professional development opportunities for teachers studying earth sciences, hazards, and climate change. In addition to B-WET Hawai'i, the Pacific Science Challenge is a new program that delivers NOAA science through a weeklong experience that utilizes the classroom and outdoor settings to teach how the scientific method is applied to solve a specific "challenge." NOAA's broad responsibilities extend from the surface of the sun to the bottom of the ocean, so it is fitting that this year's Pacific Science Challenge topic focuses on using technology to understand climate change within an ahupua'a (watershed). PSC, with partnerships and funding, has provided Hawai'i's communities with experiential environmental education programs to inspire and develop the next generation of scientists and natural resource managers.

5-24 Project Niu: STEM and Environmental Education through Project-Based Learning for K-12

Erin Nishimura, Evan Rapoport, Traci Downs, Hunter Downs
Archinoetics LLC, Honolulu, HI

Project Niu (www.projectniu.org) combines science, technology, and environmental education for K-12 students to engage in scientific examinations of the oceans by exploring the sources and widespread consequences of

marine debris. Through this project-based learning opportunity, students deploy custom-made, satellite-tracked sensors from local beaches then monitor these Niu devices on the Project Niu website as they float at sea. Because these Niu devices are drifters, carried by the ocean's currents and winds in a manner similar to common forms of marine debris (such as plastics, fishing nets, etc.), these high tech "message in a bottle" devices illustrate the earth's physical processes to students while also teaching them about the effect that humans have on the health of the oceans. These experiences with advanced technologies for remotely monitoring the ocean expose students to science, technology, engineering, & math (STEM) but also promote a personal connection with the environment and pose challenging questions about the ecological impact of their own actions and those of society. Project Niu was created by Archinoetics (www.archinoetics.com), a Hawai'i-based high-tech research and development company, through funding from the NOAA Bay Watershed Education and Training (B-WET) program.

5-25 Linking Watershed Health to Human Action: Inspiring Hawai'i's Next Generation of Watershed Stewards – The RELATE Project at the University of Hawai'i at Hilo

Cynthia Phillips, Chelsie Settlemier
University of Hawai'i at Hilo, HI

The River Environments Landuse and Ahupua'a Technologies (RELATE) Project at the University of Hawai'i at Hilo is a National Oceanic and Atmospheric Administration (NOAA) Bay-Watershed Education Training (B-WET) Grant. The aim of this project is to provide participating high school science teachers with an introduction to the RELATE Project and to provide participating high school students with meaningful outdoor experiences by relating human action on land to possible contamination of the Wailuku, Wailoa, or Ka'ahakini watersheds. The Project period covers the academic year 2008-09. During the project period, project goals were accomplished through in-field hands-on training with data collection methods and equipment, in-class visits by professional scientists, complimentary in-class curricula, in-field data collection, data analysis, and development and implementation of mitigation plans to improve the health of the watersheds. Participating students developed and implemented individual or group research projects. Dissemination of project outcomes were presented in varied formats. While some students chose to create posters, others chose to produce PowerPoint presentations or research papers. Students from one participating school chose to relate their project outcomes and mitigation plan through involvement in the 2009 Ocean Day community outreach event. Through the provision of meaningful outdoor experiences, students and teachers participating in the RELATE Project have shown increased awareness of stream health and ways in which human action impacts stream and watershed health. Additionally, participants increased the awareness of their local community on these issues through participation in community events.

5-26 Training Teachers to Use Underwater Robotics to Excite 6th Graders about Science, the Scientific Inquiry Process, and Monitoring Windward O'ahu's Coastal Waters

Herb Lee, Jr[1], Doug Knight[1]
[1]Pacific American Foundation, Kailua, HI, [2]NOAA, B-WET Program, Honolulu, HI, [3]Hawai'i Department of Education, Windward Elementary Schools

The Aholehole Project conducts teacher training for 5th and 6th grade teachers to lead their students in building underwater robots as a platform conducting experiments. So far 500 Windward elementary students have shared the excitement of building the small "Sea Perch" robots, originally designed by the Massachusetts Insititute of Technology. With help from undergrads from the University of Hawai'i at Mānoa, College of Engineering, the teachers led their students into Windward streams, fishponds, wetlands, and ocean waters to test their robots as underwater platforms for conducting experiments. Students used the ROVs to test water quality and collect photographs of underwater life using digital underwater cameras. Getting kids excited about science, using hands-on activities outside the classroom walls, and into the natural environment, was the objective for bringing relevance to the student's science experience. The teachers developed lesson plans to introduce the concepts of the scientific inquiry process, enabling students to see in concrete terms how science can serve conservation efforts by quantifying and assessing environmental impacts on our coastal waters, as well as demonstrating how technology can serve environmental stewardship. Teachers also organized their students to conduct service learning projects related to improving the overall water quality of Windward O'ahu. In an upcoming 2009 NOAA B-WET grant, the project will expand to serve teachers of O'ahu's Wai'anae Coast schools and expand to include 7th graders. For more about the project, see: http://thepaf.org/aholehole/

5-27 Hawai‘i Institute of Marine Biology: Window to the Northwestern Hawaiian Islands through Place-Based Learning and Marine Sciences

Carlie Wiener
University of Hawai‘i, Hawai‘i Institute of Marine Biology, Kāne‘ohe, HI

This presentation will highlight the accomplishments of a successful outreach and education program based out of the Hawai‘i Institute of Marine Biology (HIMB), specifically with the Northwestern Hawaiian Islands Coral Reef Research Partnership. The Papahānaumokuākea Marine National Monument (Northwestern Hawaiian Islands (NWHI)) serves as an excellent forum for marine education as it is one of the world's largest fully protected marine areas. Home to one of the last predator dominated ecosystems in the world; the Monument is both rich in cultural heritage and abundant in endemic species. The NWHI helps to inspire local students to explore marine sciences and to work with surrounding community members to increase awareness of Hawai‘i's unique marine ecosystem. HIMB is distinctive in that its faculty has been conducting ecosystem based research in the Monument for several years. Unique and biologically important science is used to promote an understanding of complex ecological systems and topics such as biodiversity and climate change to communities within the Hawaiian Islands. Using place-based and experiential education, HIMB's program has successfully amalgamated marine science concepts with hands-on activities, teacher development, and classes using interdisciplinary approaches that combine science with the arts and other subjects. Specific projects such as HIMB future marine scientists program, NWHI science tools student activities and HIMB NWHI science and research exploration continuing education course curriculum will be showcased and on display. These programs have worked to generate participatory activities and develop a sense of place in the community, strengthening relationships between schools, neighborhoods, and society.

CONCURRENT SESSION 6: JULY 30, 10AM – 12PM

Symposium: Climate Change and Hawaiian Birds

6-1 Climate Variability and Change in Hawai‘i

Thomas Giambelluca[1], Henry Diaz[2], Oliver Timm[1]
[1]University of Hawai‘i at Mānoa, Honolulu, HI, [2]NOAA-CIRES, Boulder, CO

Recent analysis has shown that Hawai‘i's climate is already feeling the effects of global warming. Sea surface and air temperature have risen significantly, especially in the past 30 years. Air temperature increases have been greatest for daily minima (nighttime) and for high elevations. Fluctuations in air temperature have been closely coupled with the Pacific Decadal Oscillation (PDO) over many decades. However, beginning around 50 years ago, the effects of global warming are apparently causing temperature to depart from the pattern dictated by the PDO cycle. Precipitation, while exhibiting high interannual and interdecadal variability associated with El Nino-Southern Oscillation (ENSO) and PDO, has generally trended downward over the past 100 years. The recent 30 years have been especially dry. Trends in the persistence of the trade-wind inversion are consistent with the downward trend in precipitation and suggest that the drying trend may be associated with poleward movement of mid-latitude storm tracks. Statistical downscaling of global climate model simulations for a middle-of-the-road emissions scenario (A1B) suggest that wet-season precipitation will decrease by 5-10%, while an increase of 5% is the most likely outcome for the dry season.

6-2 Paleoecological Perspective on the Sensitivity of Forest Bird Habitat to Climate Change

Sara Hotchkiss, Shelley Crausbay
University of Wisconsin, Madison, WI

Because the upper limit of cloud forest coincides with the trade wind inversion, predictions of future vegetation response to changes in the position, frequency, or intensity of the trade wind inversion are important for management of habitat for forest bird species. A gradient in moisture and vegetation composition along the upper limit of cloud forest from Hanawi to Waikamoi on Haleakalā suggests that neither climate nor vegetation will change uniformly along the upper cloud forest. Differences in vegetation and climate along the ecotone complicate predictions of future vegetation change across the range of many forest bird species. While past climate changes are not directly analogous to present changes, trends in factors that are likely to change in coming decades, such as temperature, drought frequency, El Nino-Southern Oscillation and trade wind strength, can be found in the past. With paleoecological methods it is possible to observe the response of cloud forest

vegetation to these past climate changes. Pollen records can be analyzed to emphasize changes in particular food plants or communities of importance to bird species, and comparison of sites that differ in relationship to the major features of climate can suggest likely vegetation trajectories under climate change scenarios. Paleoecological records from several islands show that cloud forest vegetation has responded to past climate changes with changes in species composition and suggest likely trajectories for future changes.

6-3 Climate Change and Avian Disease in Hawai'i: Is the Future Now?

Dennis A. LaPointe[1], Carter T. Atkinson[1], Michael D. Samuel[2]
[1]U.S. Geological Survey, Pacific Island Ecosystems Research Center, Hawai'i National Park, HI, [2]U.S. Geological Survey, Wisconsin Cooperative Wildlife Research Unit, Madison, WI

It is generally accepted that introduced mosquito-borne avian disease played a role in the extinction of many Hawaiian forest bird species and remains a main factor limiting the range and abundance of endemic forest species today. On the high islands of the Hawaiian archipelago, there is an inverse relationship between the occurrence of endemic forest birds and the prevalence of avian disease such that the most diverse and abundant populations are restricted to forests above 1700 m in elevation. A series of simple and complex models demonstrate that transmission of avian disease is likely limited at high elevations by the effect of low mean temperatures on the development of *Plasmodium* and the impact of climate on mosquito abundance and seasonality through its influence on larval mosquito development, larval mosquito predation, and the availability of larval mosquito habitat. For the last two decades, world health experts have been predicting an increase in the occurrence and geographical spread of vector-borne human disease due to global warming trends. Likewise, local climate change could have a profound effect on the distribution and severity of mosquito-borne avian disease in the Hawaiian Islands. The current local warming trend, when combined with more frequent and higher trade wind inversions, could eliminated the protective climate of high elevation refugia. Even subtle differences, such as warming, nighttime temperatures, could increase mosquito activity and enhance transmission. Recent data from Kaua'i and Mauna Kea suggests that climatic change may already be influencing transmission of avian malaria in high elevation forests.

6-4 Prospects for Hawaiian Forest Bird Conservation in a Changing Climate

Jeff Burgett[1], David Leonard[2]
[1]U.S. Fish and Wildlife Service, Honolulu, HI, [2]Division of Forestry and Wildlife, Honolulu, HI

Accelerating climate change will present large, and in some cases possibly insurmountable, challenges to the in situ persistence and recovery of Hawai'i's native birds. While concern has focused on the next several decades, we know that temperatures will remain elevated for millennia even after they plateau (>100 years from now) following a phase-out of fossil fuels, and sea levels will continue to rise long after that. What conservation strategies for Hawai'i's passerines are viable in the face of this long-term, global process? We outline the potential benefits and costs of four approaches: minimization of non-climate stressors, assisted range extension, assisted colonization, and indefinite captive propagation. Aggressive control of non-native predators and ungulates could increase survival rates and population sizes of multiple species within discrete areas, but may not expand ranges nor create climate refugia. Afforestation of potential upslope, disease-free range is feasible for some islands, but is constrained by soil and moisture regimes. Establishment of species on islands or volcanoes outside their historic range could be used to avoid extinction, but at risks to resident species from competition and potential hybridization. Long-term maintenance of captive populations would prevent immediate extinction of the most climate-vulnerable species, but the numbers required to maintain evolutionary viability are likely to be unsustainable.

6-5 Waterworld: The Future for Seabirds of Hawai'i and the Tropical Pacific

Elizabeth Flint, Holly Freifeld
U.S. Fish and Wildlife Service, Honolulu, HI

Recent projections of sea level rise associated with global climate change indicate a likely rise of 1-2 meters caused by thermal expansion alone, and more than 25 meters if there is substantial melting of land ice. Professional disincentives ("scientific reticence"; J.E. Hansen, 2007) to report worst-case scenarios (WCS), lead to widespread understatement of the full potential for sea level rise. Policy-makers seeking guidance about the likely effects of climate change thus are inadvertently misinformed about the scale of this threat. Many seabird species in Hawai'i and on other Central Pacific islands are largely restricted to remote, coralline islands that

provide no corridors to suitable habitat at higher elevation. The loss of these islands will be critical for these seabirds. Globally significant populations of at least 17 tropical seabird species are at risk. More than half of the nesting habitat for more than 95% of the world's Black-footed Albatross (*Phoebastria nigripes*) and Laysan Albatross (P. *immutabilis*) will be lost under the thermal-expansion-only scenario, and the six largest colonies of albatross in the N. Pacific will be lost altogether under the WCS. Proactive management for the WCS is warranted; within decades, rescue of human populations from catastrophes associated with climate change will preclude efforts on behalf of other species. We summarize likely loss of nesting habitat in the tropical Pacific under 2-meter and WCS projections of sea level rise. We propose a set of interventions including translocation to high islands within and beyond the species' historical ranges and restoration of breeding islands.

Session: Terrestrial Pests: Reseach, Management and Tools (Session 2)

6-6 Climate Matching and Range Expansion in Weeds Introduced Across Elevation Gradients in Hawai'i

Gabi Jakobs, Curtis Daehler
University of Hawai'i at Mānoa, Honolulu, HI

Climate matching between the site of origin and site of introduction is one approach to predicting the likely range of an introduced species, but invasive species may also expand their ranges into novel environments through adaptation. To investigate the role of evolutionary adaptation in determining invasive species ranges, we studied six European plant species that have invaded along steep environmental gradients of Hawaiian volcanoes and have been introduced repeatedly more than one hundred years ago. Field surveys suggested the occurrence of different ecotypes adapted to differing temperatures. Seeds were collected across elevation gradients from both volcanoes and grown in a greenhouse at cold and warm temperatures over two generations. Populations of some species, especially *Hypochaeris radicata*, *Plantago lanceolata*, *Rumex acetosella* and *Holcus lanatus*, had a clear home site advantage in germination and growth, indicating a genetic basis for the observed ecotypes, rather than phenotypic plasticity. This pattern was more pronounced in outbreeding than in inbreeding species, suggesting that the genetic diversity and recombination is a key factor that has promoted ecotypic differentiation. These results demonstrate the potential for rapid genetic differentiation during invasion across environmental gradients, resulting in patterns of ecotypic differentiation, similar to those often reported for native species. Multiple introductions and high initial genetic diversity in species may therefore be an essential factor promoting or limiting in the spread of recently introduced species, and efforts should be directed to preventing secondary introductions.

6-7 Remote Sensing and Invasive Weed Management

Stephen Ambagis[1], Trae Menard[2], Jeff Schlueter[2]
[1]*Resource Mapping Hawai'i, HI,* [2]*The Nature Conservancy, Kaua'i Program*

The Nature Conservancy (TNC) and Resource Mapping Hawai'i (RMH) developed an approach to map and monitor invasive weed species at the landscape level. Recent improvements to RMH's data acquisition system make it possible to collect image data optimized for visual interpretation at an unprecedented scale of 1.5 cm/pixel horizontal resolution. RMH in cooperation with the University of Hawai'i Hilo and native Hawaiian students with Kipuka use this data to detect visually Australian Tree Fern (ATF) and other weeds across approximately 40,000 acres of native forest watershed on Kaua'i. Initial results indicate the 1.5 cm/pixel image data significantly improves the ability to detect ATF compared to the previously available 15cm/pixel data. TNC is currently using the RMH data to guide ATF control operations in their Wainiha Preserve. Working in partnership with Dr. James Leary (UH / CTAHR) and Interisland Helicopter Company, TNC developed a helicopter-based aerial herbicide application system designed to deliver the smallest effective volume of herbicide to ATF individuals scattered across large areas. ATF coordinates generated from the RMH image data are compiled in the TNC GIS and provided to Interisland Helicopter Company to guide aerial control operations. Weed control coordinates acquired with an on-board GPS during these operations are overlaid on the RMH images to measure weed control progress. Analysis of future datasets and improvements in the technology will enable TNC to monitor the effectiveness of the treatment methods and the rate of weed re-establishment, thus informing their long-range ATF control strategy.

6-8 The History and Future of Biocontrol in Hawai‘i under Changing Conditions

Page Else
Big Island Invasive Species Committee, Hilo, HI

This presentation reviews literature on the history of biocontrol in Hawai‘i, changes in regulatory oversight, methods for biocontrol agent testing, and the potential impact of climate change on biocontrol introductions. Few people are aware that as many as 708 biocontrol agents have been released in Hawai‘i up to the year 1999 but only 286 became established. Of these, 14% also attacked non-target species. The negative impacts of biocontrol introductions have mainly been due to the lack of host specificity studies and pre-release risk analyses, and weak import regulations. The Board of Agriculture for Hawai‘i began reviewing applications in 1944. After increased review regulations in 1975, the host specificity of the 51 released biocontrol agents has been 100%. This presentation includes the proposed biocontrol release for strawberry guava as an example, with a discussion of outreach methods needed for varying social attitudes. Society must understand the choices, the risks, and how risks can be minimized. Challenges that will be faced in the future with changing climatic conditions include the difficulty of predicting host-specificiity under changing climates and vegetation responses. It is likely that invasive species will be favored under climatic disturbance, making biocontrol tools even more important for managers. However, Hawai‘i currently has only three quarantine facilities and limited funding for natural resource management. Finding appropriate host-specific agents can be very difficult and time-consuming, so managers cannot rely on biocontrol as the ultimate solution for invasive issues.

6-9 Hawai‘i Department of Transportation’s Statewide Noxious/Invasive Plant Project (SNIPP)

Christopher Dacus[1], Shahin Ansari[1], Ryan Taira[1]
[1]Hawai‘i Department of Transportation, Kapolei, HI, [2]SWCA Environmental Consultants, Honolulu, HI, [3]SWCA Environmental Consultants, Honolulu, HI

The purpose of the Hawai‘i Department of Transportation’s (HDOT) State Noxious/Invasive Plant Program (SNIPP) is to develop a program to address HDOT’s important role in avoiding the introduction and spread of invasive plant species along Hawai‘i’s State roads. Three years of funding have been allotted, with pilot elements of the program being developed on O‘ahu prior to application to neighboring islands. HDOT has already been proactive on invasive species through: (1) updating Section 665 (Invasive Plant Species Management) of the construction specifications for North-South Road on O‘ahu’s ‘Ewa Plain to include protocols for prevention, identification and reporting of invasive plants; (2) removal of invasive plants along sections of H-3 Freeway, followed by revegetation with native koa; and (3) dedication of State Planning and Research (SPR) funds towards development of a hydroseed mix to plant highway rights-of-way with native species. The SNIPP program will go beyond these initial activities to develop: a 10-year strategic plan detailing HDOT's invasive species’ policies, goals, and performance measures; incorporating best practices for the control of invasive species into near and mid-term construction projects; an Integrated Roadside Vegetation Manual addressing partnerships with stakeholders; education and training materials for highway construction inspectors, maintenance contractors and consultants; and prioritizing, mapping, eradication and control of selected invasive plants.
Through SNIPP, HDOT will better integrate itself with other groups focused on invasive species management and control, enabling efficient use of limited resources.

6-10 A Potential Rationale for Hawai‘i to Request Special State and Federal Prevention Efforts to Assist Long-term Biodiversity Conservation

Lloyd Loope[1], Patrick Conant[1]
[1]USGS-PIERC, Makawao, HI, [2]Hawai‘i Department of Agriculture, Hilo, HI

A current priority of Hawai‘i’s Coordinating Group on Alien Pest Species (CGAPS) is to “gain special recognition and dispensation from federal laws that do not take into account Hawai‘i’s separate geography and environmental vulnerabilities.” The concern is that international trade agreements and some federal programs often pre-empt state laws/regulations and interfere with protection of Hawai‘i from damaging invasive pests, often despite the State of Hawai‘i’s formal objections. The general result of federal pre-emption is to reduce Hawai‘i’s ability to enact effective prevention policies. The CGAPS Steering Committee is striving to develop a consensus regarding what “environmental values” most urgently need protection from potential pathways for pests for which regulation is feasible. An effective approach may involve embracing the priority of protecting Hawai‘i’s dominant native plant species, such as ‘ōhi‘a (*Metrosideros polymorpha*), koa (*Acacia koa*), māmane (*Sophora chrysophylla*), ‘a‘ali'i (*Dodonea viscosa*), naio (*Myoporum sandwicense*), wiliwili (*Erythrina sandwicensis*), and hapu'u (*Cibotium spp.*).

Protection of coffee, pineapple and sugarcane through special regulations has been largely successful for over 100+ years while major forest trees (including high value koa) have never received protection through special regulation by Hawai‘i Department of Agriculture Plant Quarantine Rules. If any of our dominant species should suffer serious decline due to a newly established invasive species, entire native Hawaiian ecological communities could be permanently damaged or even eventually lost. If protected, these species will likely be among the most important for restoration efforts to stabilize conservation lands and watersheds in the face of global warming.

CONCURRENT SESSION 7: JULY 30, 1 – 3PM

Symposium: Integrating Science and Culture: A New Paradigm for Large Scale Ecological Restoration and Conservation in Hawai‘i

7-1 The Hawai‘i Restoration and Conservation Initiative - An Overview

Christian Giardina[1], Chipper Wichman[2]
[1]*Institute of Pacific Islands Forestry, Hilo, HI,* [2]*National Tropical Botanical Gardens, Kaua‘i, HI*

Native ecosystems and the Hawaiian culture they sustain face a stark future. While many landscapes, riparian areas and coastlines across Hawai‘i have conservation status, and restoration and conservation activities by diverse entities proceed on numerous fronts, the potent forces of invasive and exotic plants, animals and pathogens are wreaking havoc on our native ecosystems. The Hawai‘i Restoration and Conservation Initiative seeks to: i) establish a new dialogue between traditional practitioners, land and water managers, scientists and Hawai‘i’s diverse communities; ii) implement new tools and strategies for conducting restoration and conservation at large spatial scales; and iii) support and mentor a new generation of stewards. To achieve these goals, this initiative requires a comprehensive planning, development and demonstration process that will provide Hawai‘i with a blueprint for: embracing a new culturally-based land stewardship paradigm; undertaking emergency actions to prevent imminent extinctions and new invasive introductions; establishing a comprehensive statewide assessment; enhancing cultural opportunities; developing new tools; implementing new restoration and conservation strategies; and expanding educational, recreational and economic development opportunities. Although both the scale and scope of this integration are unprecedented in Hawai‘i, large-scale efforts are the norm for tackling major ecological problems in other regions. Numerous successes at smaller scales across Hawai‘i, a new generation of tools based on modern science that permits understanding and managing Hawaiian ecosystems at an unprecedented level of detail and the strength of already established partnerships provide the necessary pieces for achieving large-scale restoration and conservation in Hawai‘i while also stimulating a new sustainability economy.

7-2 Anchoring the Restoration and Conservation Initiative in a Native Hawaiian Perspective

Kekuhi Kanahele
Edith Kanaka‘ole Foundation, Hilo, HI

I ola‘oe, I ola mākou nei - "My life is dependant on yours; your life is dependant on mine". This fundamental belief permeates Hawaiian social-ecological relationships, which are sustained by the recognition that all life and the physical environment are sacred and this sacredness sustains life. These linkages hold many critical insights into biological conservation, restoration and sustainable development, and to initiate and sustain a large scale restoration and conservation effort, we must embrace a culturally-based land stewardship paradigm that draws from and integrates traditional approaches to land management and modern tools for viewing and understanding Hawaiian landscapes. Education and outreach need to be the central pillar of such an initiative and will include working with communities to understand relationships with their land base; training communities in cultural stewardship of land and ocean resources; curriculum development for all levels of education; and creating new partnerships for achieving cultural stewardship of these natural resources.

7-3 The Importance of Rare Plant Conservation in Large Scale Ecological Restoration

Chipper Wichman[1], Christopher Dunn[2], Loyal Mehrhoff[3], Susan Cordell[4]
[1]*National Tropical Botanical Garden, Kalāheo, HI,* [2]*Lyon Arboretum, University of Hawai‘i,* [3]*Pacific Island Ecosystems Research Center, U.S. Geological Survey,* [4]*Institute of Pacific Islands Forestry, USDA Forest Service*

As large-scale ecological restoration initiatives in Hawai‘i gain momentum, protecting botanical biodiversity must be aggressively undertaken. With 274 plant species currently listed as endangered, Hawai‘i has the most

endangered flora in the US and time is running out. Historically, inadequate funding has constrained successful conservation of these rare species. This must be reversed if a large-scale restoration effort is to be successful. The current Plant Extinction Prevention Program's (PEP) state-wide network of field biologists will be a central component of an effective strategy to prevent extinction however it will require increased staffing and resources to meet our future challenges. The expanded PEP Program will channel genetic material into a stronger, better-funded network of Federal, State, and private seed storage and propagation facilities. The limitations of the current network are exemplified by the state's primary tissue culture lab for rare Hawaiian species. Located at the Lyon Arboretum, this very successful lab is in an aging wooden structure that hardly befits its critical role as a statewide in vitro mico-propagation facility. Better understanding of rare-plant genetics will be another critical element needed to produce viable populations which are representative of the levels of genetic diversity found in natural populations. A robust network of researchers will be needed to address this vital component of the strategy. Finally, new reintroduction, sanitation, and seed-storage protocols, as well as landowner incentives, will be required to promote the successful establishment of large numbers of rare plants in the large-scale ecosystem restoration projects that Hawai'i the Restoration Conservation Initiative (HRCI) will generate.

7-4 Large Scale Restoration as an Adaptive Strategy to Climate Change

Boone Kauffman[1], Loyal Mehrhoff[1]
[1]Institute of Pacific Islands Forestry, Hilo, HI, [2]Pacific Island Ecosystems Research Center, Honolulu HI

Climate change represents an unprecedented crisis threatening the native biota of Hawai'i. Changes in climatic variables such as temperature, rainfall patterns, drought, and sea level rise will create unknown threshold and nonlinear responses of ecosystems and the species that compose them. Climate changes will likely alter fire patterns; increase spread of diseases, alters nutrient cycling and diminishes reproductive success. Native species with narrow ecological tolerances are most threatened while invasive species adapted to a wide range of conditions will likely thrive. The dynamics of native ecosystems and how they will respond to climate change must be understood in order to implement adaptive strategies to that will allow the persistence of the native Hawai'i biota. Intact native forests are most resistant to subtle changes in climate. In contrast, land use/land cover change often exacerbates the impacts of global climate change. For example, a loss of overstory canopy not only degrades wildlife habitats but also increases in-stand temperature, decreases relative humidity, increases water stress, and increases in the occurrences of wildfire. The greatest and perhaps last opportunity to restore native forested watersheds and the ecosystem services they provide is now. Future changes in climate will certainly increase difficulties in restoring degraded landscapes. Large scale restoration of Hawai'i forested watersheds (especially at higher elevations) will create habitats to threatened native fauna, while providing other ecosystem services such as C sequestration and positive effects on water quantity and quality.

7-5 Hawaiian Plant Initiative - Retooling the Green Industry

Chris Dacus, Boyd Ready
Landscape Industry Council of Hawai'i, Honolulu, HI

Most of the human built environment in Hawai'i is in the lowlands stretching from the ocean to the base of the mountains, including residential communities, vacation resorts, and other places where people live and work. The vegetation in this area is almost completely nonnative. Some of these nonnative plants are invasive and the built environment serves as the vector to invade the remaining natural, native-dominated habitats of Hawai'i. The Landscape Industry Council of Hawai'i, which encompasses the related green industry associations in the State of Hawai'i, has developed a plan to retool the Green Industry over 20 years to reduce the industry's use of invasive plants and dramatically increase the use of native Hawaiian plants. The goal of this retooling is for the built environment to serve as the vector for the spread of native Hawaiian Plants. The strategy includes developing better supply and selection of native Hawaiian plants, fostering greater professional and personal environmental responsibility, and nurturing future green stewards.

7-6 Statewide Assessments: Resource and Condition Mapping for Large Scale Restoration and Conservation

Sam Gon[1], Jon Price[1]
[1]The Nature Conservancy, Honolulu, HI, [2]The University of Hawai'i at Hilo, Hilo, HI

Understanding the distribution and condition of Hawai'i's natural resources is critical to knowing whether these resources are being effectively conserved. In the context of a large-scale restoration and conservation initiative,

detailed information is required to evaluate the effectiveness of implemented prescriptions, to plan for future actions, to efficiently allocate funds, and to justify the expenditure of public funds. The Restoration and Conservation Initiative will develop a multi-tiered approach to assessing resources including a statewide assessment that builds on the Effective Conservation program as well as agency-wide efforts or organize available spatial information about our natural resources. This approach will include statewide (broadest scale, coarsest resolution), ahupua'a / watershed scale (medium scale, 1,000s of acres, medium resolution) and project scale (finest scale, 10s to 100s of acres, high resolution). The approach will identify resources of concern including biological, economic, cultural and social health factors. The assessment will also determine limiting factors such as invasive plants and animals, fire, or land-use. Resulting maps and information will help identify data gaps, which will be filled with new spatial layers using on-the-ground and remote sensing based approaches. The result will be a statewide conservation view of Hawai'i's ecosystems, the successes and the potential target areas where partners can pool resources for efficient action, and an information base for developing a statewide restoration and conservation blueprint.

Symposium: Coastal Watershed Management: Issues and Potential Solutions

7-7 Coastal Watershed Management: An Overview

Ali Fares
University of Hawai'i at Mānoa, Honolulu, HI

Coastal watersheds have unique features, including proximity to the ocean, weather and rainfall patterns, subsurface features, and land covers. Hence, there is a need for a better understanding of various physical, chemical, biological processes, and social, economical and legal issues involved. The objectives of this presentation are: i) to give an overview of the hydrological, management, socio-economical, and legal aspects of coastal watersheds with emphasis on Hawai'i's conditions; ii) to present an overview of different hydrological models for small coastal watersheds on tropical islands. The impact of stream chemical, biological, and sediment pollutants on the quality of receiving waters, such as estuaries, bays, and near-shore waters is covered. The economic values of watershed conservation, and the management and regulation of water resources in a coastal watershed are also discussed. In addition, there is a brief mathematical description of hydrological cycle components including rainfall, evapotranspiration, infiltration, and surface and subsurface flow. There is an overview of a few case studies using different hydrological watershed models. Addressing various components and issues of coastal watershed modeling will help resource managers, researchers, consultant groups and government agencies to adopt sustainable watershed management practices.

7-8 Nutrient Bioavailability of Soils and Sediments in an Australian Estuary Influenced by Agriculture: Linking Land to Sea

Katherine Chaston[1], Phil Moody[2], William Dennison[3]
[1]*IM Sytems Group, NOAA Office of Ocean and Coastal Resource Management, Honolulu, HI,* [2]*Natural Resource Sciences, Queensland State Department of Natural Resources and Mines, Brisbane, QLD, Australia,* [3]*University of Maryland Center for Environmental Science, Cambridge, MD*

Land-based pollutants are among the leading threats to coral reef ecosystems in Hawai'i and globally. The potential impact of increased nutrient and sediment loads to inshore reefs of the Great Barrier Reef and an increase in algal blooms in several Australian estuaries, bays and coastal lakes, has necessitated research on the downstream effects of land use on Australian waters. Nutrient bioavailability of runoff from agricultural soils was investigated in the Maroochy River watershed, Australia, a coastal watershed influenced by agriculture. Suspended sediments, river and estuarine sediments and deposited sediment in the near-shore coastal ocean were collected and analyzed for nutrient bioavailability using chemical analyses and phytoplankton bioassays. Suspended sediments in the Maroochy River, which consisted of silt and clay-sized particles, had elevated Fe-oxide-extractable P and total P concentrations comparable to fertilized soil. Similarly, the deposited sediment sampled offshore of the river mouth had elevated total P, Fe-oxide-extractable P and total N concentrations that were much greater than the underlying marine sediment. The deposited offshore sediment contained mainly clay-size particles and appeared to be terrigenous in origin due to its similar composition to estuarine suspended sediments and terrestrial soils. This study demonstrated that nutrient-rich clay-sized particles of terrigenous origin are being transported and deposited offshore during erosion events. It highlights the need for multifaceted watershed management that encompasses a) erosion control measures that reduce suspended sediment loads of nutrient-rich clay- and silt-sized fractions to coastal waters, and b) nutrient reduction strategies.

7-9 Restoration and Protection Plan for the Nāwiliwili Watershed, Kaua‘i, Hawai‘i
Aly El-Kadi, Monica Mira, James Moncur, Roger Fujioka
University of Hawai‘i, Honolulu, HI

This study dealt with developing a restoration and protection plan for the Nawiliwili Watershed, Kaua‘i, Hawai‘i, USA. The proposed plan covers the nine elements required by the U.S. Environmental Protection Agency for watershed based plans that are developed or implemented with Section 319 funds to address requirements of Section 303(d) of the federal Clean Water Act for listed waters. The elements include identification of the causes that will need to be controlled to achieve contaminant load reductions; an estimate of the load reductions expected for the management measures described in the plan; a description of the nonpoint-source (NPS) management measures that will need to be implemented to achieve the load reductions; an estimate of the amounts of needed technical and financial assistance, associated costs, and resources; an information and education component for the public; a schedule for implementing NPS management measures identified in the plan; a description of interim measurable milestones for determining whether NPS management measures are being implemented; a set of criteria that can be used to determine whether loading reductions are being achieved; and a monitoring component to evaluate the effectiveness of the implementation efforts over time. Limitations of approaches adopted, especially due to data limitations, are stressed where appropriate.

7-10 Impact of Best Management Practices in a Coastal Watershed
Kelly Morgan
University of Florida, Immokalee, FL

The Kissimmee River, Lake Okeechobee, and Everglades are part of a vast wetland system that historically extended over 200 miles from the Kissimmee chain of lakes, near Orlando, ending in the mangrove estuaries of Florida Bay, south of Miami. This nutrient-poor wetland system supported a diverse and large community of species across huge seasonal and inter-annual variation in rainfall. The combination of a subtropical climate and supply of potentially arable land, proved to make South Florida a desirable place to farm and live. With agricultural and urban development of the landscape, several areas of Lake Okeechobee and the Everglades have experienced increased nutrient loading, particularly phosphorus, resulting in shifts in the algae and plant communities found within lakes, marshes, and near-shore marine environments. Reducing this "phosphorus enrichment" is the primary goal of Lake Okeechobee and Everglades restoration efforts brought about by the Everglades Forever Act (EFA). Site-specific best management practices to reduce the quantity and improve the quality of runoff leaving agricultural lands have improved water quality of associated wetlands. Another method used to reduce phosphorus for complying with the EFA includes the development of man-made wetlands, called stormwater treatment areas (STAs). These restoration actions should reverse environmental impacts of increased P loading while maintaining the original goals of supporting agricultural production and urban development. BMPs and storm water treatment measures similar to those used in Florida would have similar affects on impacted wetlands in Hawai‘i.

7-11 The Waiāhole Ditch: A Case Study of the Management and Regulation of Water Resources in Hawai‘i
Lawrence Miike
Hawai‘i Commission on Water Resource Management, Honolulu, HI

The Waiāhole Ditch Contested Case was the first opportunity the Hawai‘i Commission on Water Resource Management and the Hawai‘i Supreme Court had to rule on and review the 1987 State Water Code’s approach to the complex interrelationships between preservation versus use of the state’s freshwater resources. Historically, Hawai‘i’s streams were the linch-pin around which land was apportioned and managed. Streams were essential for the diversion of large amounts of water to grow the staple food, wet-land taro, and were an important source for the traditional and customary gathering of fish, crustaceans, and mollusks for food and cultural purposes. This uniquely Hawaiian historical balancing between preservation and use found its modern counterpart in the Commission’s and Court’s struggles to quantify the Water Code’s definition of “reasonable and beneficial” offstream uses, as well as how to establish priorities between stream preservation/restoration and offstream uses. The Waiāhole Ditch Contested Case not only revealed the intellectual challenges the Commission and Court had to and continues to face in performing this balancing act, but also provides a “behind-the-scenes” glimpse into how legal rulings are made that provide guidance for future decisionmaking.

Symposium: Monitoring and Evaluating Impact of Incidental Take to Protect Species

7-12 Monitoring Under Incidental Take Permits for Listed Species

Bill Standley
U.S. Fish and Wildlife Service, Honolulu, HI

Permits authorizing the incidental take of threatened and endangered species on state or private lands can be issued by State and Federal regulatory agencies under two types of agreements, Safe Harbor Agreements (SHA) and Habitat Conservation Plans (HCP). In order to issue such permits, the U.S. Fish and Wildlife Service must first determine whether the actions will appreciably reduce the likelihood of survival of the species covered under the agreement. Similarly, the Hawai‘i Department of Land and Natural Resources can only issue a state take license when the permitted actions, along with the mitigation proposed, are expected to provide a "net conservation benefit." Verifying that the assumptions made to make such determinations are correct requires monitoring of both the scope and intensity of the impacts that actually occur and of the effectiveness of the mitigation implemented. The accuracy of such monitoring is particularly critical for HCPs where the mitigation implemented is based on the take observed each year. The ability to detect the take that occurs depends on both the efficiency of the searchers and the persistence of the carcasses over time. Quantifying the benefits of the mitigation actions requires an estimate of the number of individuals of each covered species that will benefit from the mitigation, as well as the effectiveness of those actions. The methodology to monitor such impacts and the mitigation to offset them are not well developed, and the following presentations will discuss some approaches currently being applied in Hawai‘i, along with specific research needs.

7-13 Fatality Monitoring Associated with Wind Energy Development in Hawai‘i and Throughout the United States

Alicia Oller
Tetra Tech EC, Inc., Portland, OR

Wind energy provides a clean, renewable energy source that is in high demand in Hawai‘i and throughout the United States (U.S.) as a response to concerns about global climate change. As wind power has become more common, the need to address potential environmental impacts has increased. Birds and bats have been identified as a group potentially at risk because of collisions with wind turbines and associated structures. Fatality monitoring studies are central to understanding what species are directly impacted by commercial wind energy facilities. When designing and implementing fatality monitoring, it is essential to consider the objectives of the study, target species, geographic location, vegetative conditions, topography and other site conditions in order to develop appropriate methods for field surveys and data analysis. Also, as wind energy development becomes more prevalent, impacts to threatened and endangered species may occur. Only a few publicly available studies have been designed to document potential incidental take of a listed species including two wind energy associated facilities in Hawai‘i authorized by state and federal Habitat Conservation Plans. The correct methods and take calculations are important to understanding the ultimate impact to the viability of a threatened or endangered species population.

7-14 Down to Earth: Light Attraction Minimization and Monitoring Strategies for the Kaua‘i Seabird Habitat Conservation Plan

Andrea Erichsen, Adam Griesemer
Division of Forestry and Wildlife, Līhu‘e, HI

Planning of the Kaua‘i Seabird Habitat Conservation Plan (KSHCP) is underway to provide a comprehensive, long-term solution regarding island-wide incidental take of ‘a‘o (Newell’s shearwater, *Puffinus newelli*), ‘ua‘u (Hawaiian petrel*, Pterodroma sandwichensis*), and ‘akē‘akē (Band-rumped storm petrel, *Oceanodroma castro*) due to attraction to lights and collisions with overhead utilities. KSHCP Planning illustrates a lively interplay between scientific information and practical actions to quickly decrease human impacts on wildlife. Points for discussion will include: an overview of the “take” problem, estimating impacts using best available data, assessing the efficacy of avoidance and minimization practices, ranking the value and feasibility of compensatory mitigation, and implementing scientifically-based monitoring of incidental take on a large spatial scale.

7-15 Planning Recovery for Endangered and Threatened Plants in North Kona

Edith Nonner[1], Hans Sin[2], J Scott Fretz[3], Paula Hartzell[1]
[1]Pacific Cooperative Studies Unit, Honolulu, HI, [2]Hawai'i Division of Forestry and Wildlife, Hilo, HI, [3]Hawai'i Division of Forestry and Wildlife, Honolulu, HI

One of the major Hawaiian natural resource management issues that has generated debate is the protection of native ecosystems versus public hunting. Hawai'i is unique in that none of the game species hunted are native. Hunting remains a popular and cherished activity for many of Hawai'i's residents. However, Hawai'i has the highest number of endangered and threatened plant species (377) in the U.S., and management for higher populations of game mammals may potentially have serious negative effect on protected plant species. In response, the Hawai'i Division of Forestry and Wildlife has carried out plant surveys (2003-2007) and developed a game mammal management plan within the Pu'u Anahulu Game Management Area and the Pu'u Wa'a Wa'a Cooperative Game Management Area in North Kona, Hawai'i. A Habitat Conservation Plan is currently being developed to avoid and minimize impacts, as well as to contribute to the recovery of protected plant species. In collaboration with partners, the Plan is being developed to deal with potential impacts of game mammal management on listed species and critical habitat of *Kokia drynarioides*. Avoidance and minimization efforts will focus on protection of remaining high plant density areas, as well as on staff and hunter education. Mitigation strategies contributing to recovery of these species include outplantings and propagation, habitat restoration, as well as consideration of more creative approaches to protected plant species recovery.

7-16 Contributing to Species Recovery and Net Conservation Benefit on Maui: A Kaheawa Perspective

Gregory Spencer
First Wind, Environmental Affairs Division, Kihei, HI

Since 2006, Kaheawa Wind Power (KWP) has been implementing a Habitat Conservation Plan (HCP) that includes substantial mitigation directed at the endangered Nēnē (*Branta sandvicensis*), Hawaiian Petrel (*Pterodroma sandwichensis*), Hawaiian Hoary Bat (*Lasiurus cinereus semotus*), and threatened Newell's Shearwater (*Puffinus auricularis newelli*) on the island of Maui. The HCP contains provisions that support a range of avoidance, minimization, monitoring, and mitigation initiatives designed to (a) enhance understanding of the interaction between covered species and the wind project, (b) measure direct and/or cumulative impacts or effects, (c) guide species-specific mitigation that will offset these impacts, and (d) provide a net ecological benefit in alignment with species recovery goals. Mitigation for each species is designed to be commensurate with estimated and observed impacts but must also demonstrate a net conservation benefit for the species. Maintaining a net benefit requires that mitigation actions must represent the best available scientific information and address pressing threats and/or principle factors limiting species recovery. Conservation initiatives aimed at providing a net benefit on behalf of HCP-covered species on Maui include improving annual survival and productivity of these species in the wild by controlling predators, improving available habitat, captive propagation, population reintroduction and translocation, and collaboration on research and monitoring that will inform critical management decisions. The development of specific mitigation strategies that complement and enhance ongoing recovery initiatives for these species on Maui will be discussed, along with examples of inherent challenges, biological success criteria, and the importance of collaboration and adaptive management.

7-17 Opportunities for Students and Researchers: Protected Species Research and Information Needs

Paula Hartzell[2], J Scott Fretz[1]
[1]Hawai'i Division of Forestry and Wildlife, Honolulu, HI [2]Pacific Cooperative Studies Unit, Honolulu, HI

Opportunities for students and principal investigators is presented in an overview of specific research and information needs for recovery of endangered and threatened seabirds, waterbirds, bats, nēnē, and plants, among other species, from the perspective of providing net benefit from incidental take of these species. High priority research needs include, for example, reassessment of nēnē population status and recovery needs by island; how behavior differs between colonies, and how this affects their population success; determining return rate of released and non-released Newell's shearwaters; investigating movement and use of wetlands by waterbirds, particularly on O'ahu; determining the effect of feral cats and cat colonies on Kona (Big Island) waterbirds; life history of ōpe'ape'a (bats); exploring bat avoidance and recovery options; developing species specific propagation techniques for protected plants; and developing a trained wildlife technician workforce within the Hawaiian Islands.

Session: Terrestrial Pests: Reseach, Management and Tools (Session 3)

7-18 The Effects of Rodents on Reproduction in Rare and Endangered Plants of Hawai'i Volcanoes National Park

Joshua VanDeMark[1], Linda Pratt[2], Lloyde Loope[3]
[1]Hawai'i Cooperative Studies Unit, University of Hawai'i at Hilo/PACRC, Hilo, HI, [2]U.S. Geological Survey, Pacific Island Ecosystems Research Center, Hawai'i Volcanoes National Park, HI, [3]U.S. Geological Survey, Pacific Island Ecosystems Research Center, Makawao, Maui, HI

Rodents, especially rats (*Rattus* spp.), are well-documented predators of many native Hawaiian plants. The basic biology of many rare Hawaiian plant species is poorly understood, and the role that rodents have in affecting their reproduction is largely unknown. We investigated factors that may limit the reproductive success of 13 species of rare and endangered plants in Hawai'i Volcanoes National Park, including impacts by rodents. Each species was monitored on a monthly or bi-monthly schedule and signs of rodent activity were recorded. Evidence of seed predation by rodents was documented through examining the soil seed bank, conducting seed offering trials, and observing fruit both prior to and after dispersal. More than half of the target species displayed signs of damage caused by rodents including predation of reproductive structures, bark stripping, and seed predation. Damage to seed capsules, before dispersal, was as high as 66% in *Sesbania tomentosa*, and 50% in *Melicope hawaiiensis*. In the soil seed bank, 99% of *M. hawaiiensis* showed signs of rodent predation. Seed offering trials showed high rates of predation for *Sicyos macrophyllus* (47%) and *Hibiscadelphus giffardianus* (100%). More than 50% of dispersed fruit from *Sicyos alba* had evidence of rodent predation. It is important to understand the extent to which rodents limit reproductive success of individual rare and endangered plant species in order to guide management strategies for preserving the diversity of Hawai'i's flora.

7-19 Eradicating Rats from Islands Using Anticoagulant Rodenticides – Brodifacoum or Diphacinone?

Penny Fisher[1], Eric Spurr[1], John Parkes[2]
[1]Landcare Research, Pest Control Technologies team, Lincoln, NZ, [2]Landcare Research, Invasive Species International team, Lincoln, NZ

Use of toxic baits is one option available to managers seeking to eradicate invasive rodents from offshore islands. Many successful rat eradications from islands around New Zealand have used broad-scale (aerial) application of pellet baits containing the anticoagulant rodenticide brodifacoum. Relative to other anticoagulants, such as diphacinone, brodifacoum has high acute toxicity to mammals and birds and prolonged residual persistence in mammalian liver imparting more pronounced secondary hazard to predatory and scavenging wildlife species. Diphacinone has lower single-feed toxicity, especially to birds, and more rapid elimination from mammalian liver indicating an overall lower secondary hazard to non-target wildlife than brodifacoum. In Hawai'i, diphacinone is currently being used in small island eradication attempts, which include post-application monitoring of both rodent kill (efficacy) and environmental residues of diphacinone. There is, however, less information available on the environmental and non-target impacts of diphacinone relative to brodifacoum. This presentation will summarise the findings of recently completed laboratory studies of brodifacoum and diphacinone residues and their effects in mammals, birds and invertebrates. The relevance of the findings to planning of future island eradications will be highlighted, particularly where managers need to balance potential costs and acceptability of a one-off application of toxin to an island against the conservation benefits of permanently removing rodents from it.

7-20 Impacts of Tamaligi (*Falcataria moluccana*) Invasion and Subsequent Control in Forests across Tutuila Island, American Samoa

Flint Hughes[1], Tavita Togia[2], Amanda Uowolo[1], Peter Craig[2]
[1]Institute of Pacific Islands Forestry, USDA Forest Service, Hilo, HI, [2]National Park Service of American Samoa, National Park Service, Pago Pago, American Samoa

Science-based assessments of the impacts of invasion as well as subsequent management actions taken to deal with such invasions are critical components to successful invasive species control programs. Here we present results of collaborative research between the National Park of American Samoa (NPSA) and the Institute of Pacific Islands Forestry (IPIF) of the USDA Forest Service to determine the impact of invasion by the fast-growing, nitrogen-fixing tree *Falcataria moluccana* (a.k.a. albizia in Hawai'i and *tamaligi* in Samoa) on native Samoan forests. We also evaluated the response of these forest ecosystems to the control of tamaligi. Results indicate that, even though tamaligi tree biomass accounted for 70% of total biomass in invaded stands, most of

the dominant Samoan trees found in intact native forest stands were also present in both the tamaligi-invaded and tamaligi-controlled stands; this suggests that once large tamaligi trees are killed, the disturbance-adapted native tree community readily recaptures the site. Rapid recovery of native trees following tamaligi control also aids in reducing forest floor light levels and constrains tamaligi seedling recruitment. Tamaligi invasion substantially increases soil nitrogen (N), but control of tamaligi returns available soil nitrogen levels to those seen in intact native forests. Overall, results indicate that tamaligi invasion has a profound effect on the structure and function of native Samoan forests, and that effective management actions have helped to return previously invaded forests to there native state.

7-21 Integrating Conservation, Management, and Science in a Traditional Cultural Context: Tamaligi (*Falcataria moluccana*) Control in Forests across Tutuila Island, American Samoa

Tavita Togia[1], Peter Craig[1], Flint Hughes[2], Amanda Uowolo[2]
[1]National Park of American Samoa, National Park Service, Pago Pago, American Samoa, [2]Institute of Pacific Islands Forestry, USDA Forest Service, Hilo, HI

The successful management of invasive species - whether in Hawai‘i or other Pacific Islands - depends on our ability to properly consider and effectively engage the broader social, cultural, and ecological forces under which a given invasion occurs. In American Samoa, the invasive tree *Falcataria moluccana* (a.k.a.Tamaligi in Samoa and Albizia in Hawai‘i) constitutes a key threat to the native forests of the National Park of American Samoa (NPSA). This fast-growing, but shade-intolerant tree species readily establishes itself from wind-blown seed in gaps of native Samoan forest. The NPSA invasive species management program has developed successful partnerships with the Samoan villages that lease lands to the park by working with the traditional chief (matai) councils and utilizing local villagers to restore these forests. The involvement of the traditional matai councils has created widespread grassroots support for our conservation goals and management actions to kill established tamaligi trees and allow natural regeneration of the forest. To date over 4,700 mature invasive tamaligi trees have been killed, reclaiming 1,500 acres of forest. A collaborative research program was established between NPSA and the Institute of Pacific Islands Forestry of the USDA Forest Service to determine the success and impact of the removal of tamaligi trees by NPSA. The collaborations of NPSA with the matai councils, other government agencies, and non-profit organizations has resulted in native forest restoration, research, and outreach which has fostered increased recognition and pride in the natural and cultural resources of American Samoa.

7-22 Improvements and Changes in Ungulate Management in Hawai‘i based on The Nature Conservancy’s Forest Recovery Project

Evelyn Wight, Jason Sumiye, Theresa Menard
The Nature Conservancy of Hawai‘i, Honolulu, HI

Over approximately two years, The Nature Conservancy of Hawai‘i (TNCH) worked with multiple partner organizations to test and evaluate ungulate control programs and research methods in its preserves. Prohunt and Landcare Research were hired to provide professional animal control and data analysis, respectively; Telemetry Solutions provided GPS animal tracking collars; and TNCH contracted a market study to assess the business feasibility of a local company providing these services. Shortcomings of the project included incomplete datasets from collared animal experiments and an inability to establish a viable local animal control industry. However, data that were collected revealed information about ungulate behavior and valuable lessons learned, based on TNCH analysis. Positive outcomes have included the addition of specially-trained dogs to TNCH’s ungulate control teams and standardized use of GIS and GPS tools. In this presentation we will briefly present TNCH’s analysis of final data results from collaring research and specific conservation results in 17,000 acres of TNCH preserves.

CONCURRENT SESSION 8: JULY 30, 3:20 – 5:20PM

Symposium: Harmful Algal Blooms in Hawai‘i

8-1 Algae on Coral Reefs, an Overview

Celia Smith
University of Hawai‘i, Honolulu, HI

Harmful algal blooms on coral reefs often referred to as ‘phase shifts’ have been associated with elevated nutrients and/or lowered herbivory pressures on reefs. These blooms are serious threats to coral dominated

ecosystems, yet not all algal blooms are the same. Some algal blooms are persistent, some blooms are episodic, some blooms are populated by palatable algae, and some blooms are populated by non-palatable algae. The management of reefs to mitigate macroalgal phase shifts will be much improved by moving past generalities and towards understanding species responses in detail to driving forces. Knowledge of the biologies of bloom algae and their herbivores is ultimately essential to implementing solutions that are effective. In this symposium, we hope to stimulate this realization by presenting several case studies which show contrasting features in the bloom species, and end with management insights for our future challenges.

8-2 Impacts of Excess Nutrients on Maui's Marine Environment

Meghan Dailer, Celia Smith
University of Hawai'i, Honolulu, HI

Nuisance algal blooms of the invasive *Hypnea musciformis* and the native *Ulva fasciata* are problematic in shallow coastal waters around urbanized regions of Maui. Sources of land based nutrients in nearshore marine environments on Maui include but are not limited to: fertilizer runoff from large scale agricultural areas, leaking septic tanks and cesspools, and sewage effluent from underground injection wells. Sewage effluent on Maui contains elevated levels of many nutrients including those that are important for algal growth and photosynthetic needs. Growth rates from laboratory sewage effluent addition experiments in this study are similar to those observed in bloom situations for both *H. musciformis* and *U. fasciata* and these growth rates significantly increased with increasing levels of sewage effluent. However, no significant difference in growth rate was found between treatments for the invasive *Acanthophora spicifera* and the native *Dictyota acutiloba*. This confirms that *H. musciformis* and *U. fasciata* similarly respond to excess nutrients more positively and faster than *A. spicifera* and *D. acutiloba*. This explains why excessive agal biomass formations on Maui are dominated by *H. musciformis* and *U. fasciata.* Nutrient uptake rates of *H. musciformis* and *U. fasciata* illustrated their ability to utilize substantial levels of macro and micro nutrients in 24 hours. Therefore, ambient water column testing in bloom areas should incorporate adjustments for algal nutrient uptake. Lastly, *H. musciformis* and *U. fasciata* significantly increased tissue δ15N values reflecting increasing additions of sewage effluent, confirming their potential uses as biological indicators of sewage effluent in the field.

8-3 Some Initial Impacts of the *Leptolyngbya* Bloom at Hōnaunau

Linda Preskitt
Division of Aquatic Resources, Kamuela, HI

In May 2008, University of Hawai'i at Hilo researchers reported an unusual cyanobacteria bloom in Honaunau Bay, west Hawai'i Island, which is known for its healthy coral reef system. In an area previously documented as high coral cover (>40%) and low cyanobacteria cover (<5%), *Leptolyngbya crosbyana* was most abundant at 40% cover. Division of Aquatic Resources mapping in August, 2008, resulted in two areas with heavy *L. crosbyana* coverage: the north and south sides of a deep sandy area, from 8m to 22m depth. Total area of the two sites was 12,120m^2, with an estimated *L. crosbyana* biomass of 5,207 kg. Monitoring in January, 2009, also discovered large areas of bleached and/or diseased *Porites rus* adjacent to the bloom. This bloom is especially baffling as there are no previous reports identifying *L. crosbyana* as a nuisance species. Underlying factors of the bloom are being investigated: in the fall of 2007 rainfall was approximately 300% of normal; the neighboring village is mainly on cesspool or septic systems; and land use in the neighboring watershed is primarily agricultural. The cyanobacteria bloom at Honaunau Bay is of serious concern as such blooms may result in detrimental impacts to the reef by (1) death of the reef building corals, (2) adverse affects of toxic secondary metabolites on humans and other marine life, (3) increase in bacterial biomass and decomposition, (4) localized input of additional nitrogen through nitrogen fixation that may drive other blooms or changes in the ecosystem.

8-4 Removing Invasive Alien Algae on Moloka'i: A Community-Based Approach

Cecile Walsh[1]
[1]Division of Aquatic Resources, Hilo, HI, [2]The Hawaiian Learning Center, Moloka'i, Hawai'i, [3]Ka Honua Momona Int., Moloka'i, Hawai'i, [4]National Fish and Wildlife Foundation, Washingtion D.C

The Division of Aquatic Resources, Aquatic Invasive Species Team has received external funds to remove invasive alien algae species from selected reef flats and culturally significant fishponds along southern Moloka'i. Currently there are four invasive algal species of interest; *Gracilaria salicornia* being the primary species targeted for removal efforts. The goal is to prevent the further spread of this alien species by education, outreach, and

community participation. Addressing local concern, the AIS team conducted distributional surveys confirming this alien species has spread from its original sites of introduction. Without intervention this alien species will continue to spread smothering coral reef habitats directly leading to mortality and decreased species diversity along the entirety of southern Moloka'i. The AIS team will conduct a year long project consisting of mechanical algae removal, community clean-up events, educational workshops, and outreach activities. Community participation will empower the community to help protect its rich and diverse marine habitat along southern Moloka'i. A bio-secure protocol for the processing and recycling of the alien algae is being developed; ensuring that there will be no reintroductions and that the algae biomass is utilized in a beneficial manner. This process will also include the distribution of processed algae to local farmers to be used as mulch on their crops. Monitoring algae re-growth will measure the success of the algae removal to minimize further coral reef degradation. This project will serve as a model for community-based invasive species control across Hawai'i.

8-5 Dealing with Aquatic Alien Invasive Species: A Multidimensional Solution

Robert Nishimoto, Linda Preskitt
Hawai'i Division of Aquatic Resources, Hilo, Hawai'i

Alien invasive algal species are a significant threat and harm to our coral reefs with severe negative consequences for Hawai'i. Cleanup costs are a burden to the state's budget and should be used as a last resort. Monitoring (mapping), early detection (ballast water) and control (super sucker) are effective deterrents being used. Recent advances in the study of harmful algal blooms and community awareness and concerns have expanded our options to battle this scourge to our coral reefs. The recent establishment of an Herbivore Management Area on Maui by the Department of Land and Natural Resources seeks to control alien nuisance algae by enhancing natural herbivory. The application of differing salinity regime was successfully used by the Kukio Resort staff to control an invasive algae species in their artificial lagoon. The recent development of Eyes of the Reef (EOR) program by the Division of Aquatic Resources (DAR) will engage regular reef users in the reporting of conditions on reefs they visit regularly. This first-tier statewide early detection network has been designed to provide reliable reports of changing reef conditions (presence of alien algae, coral bleaching and disease, crown-of-thorns, etc). DAR will follow-up with a response team to confirm sighting, recommend management action, with follow-up monitoring, if necessary. Early detection by engaging the public in a collaborative and coordinated effort is an effective means to manage these insidious threats to our coral reefs.

Symposium: Reproductive Biology of Hawai'i's Endganderged Flora: The Role of Research in Conservation

8-6 Reproductive Biology of Rare Hawaiian Plants: What Do We Know and How Can We Learn More?

Donald Drake, Clifford Morden
Botany Department, University of Hawai'i, Honolulu, HI

The native angiosperm flora of Hawai'i is renowned for its endemism (89%) and for threats to its conservation. Of the approximately 1,158 named angiosperm taxa, 269 (23%) are federally endangered, and similar numbers are either being evaluated for listing or are presumed extinct. Many taxa are extremely rare, with at least 150 being represented by natural populations of fewer than 50 individuals. We have surveyed the literature for published data on the reproductive biology of endangered Hawaiian plants, including aspects of breeding system, pollination biology, seed dispersal, seed predation, seed germination and dormancy, reproductive phenology, and population genetics. For all but a very few species, little data have been published beyond what a plant's floral traits allow us to infer about its mating system. More research is clearly needed. We briefly discuss some of the opportunities and constraints that affect the ability of researchers to collect publishable data on rare Hawaiian plants. Our goal is to spark interesting discussions between research scientists and conservation managers, leading to more efficient use of our complementary skills, and ultimately to improve the effectiveness with which data are collected and applied to the conservation of rare plants.

8-7 Seed Dormancy and Germination of Hawaiian Montane Species: Meeting Common Goals of Basic Science and Conservation

Carol C. Baskin, Jerry M. Baskin
University of Kentucky, Lexington, KY

One of our lifetime research objectives is to understand the world biogeography of seed dormancy/germination; thus, we need information for species from throughout the world. Conservationists attempting to restore or rehabilitate plant populations also need information on how to germinate seeds, and fulfillment of these common goals is illustrated by studies on species in the montane zone of Hawai'i. The tropical montane zone was not included in the world biogeography of seed dormancy diagram in "Seeds..." due to lack of information. As a result of collaboration with many people in Hawai'i, we now have germination data for 188 species from the Hawaiian montane zone. A dormancy profile, showing proportion of species with nondormant seeds (11.2%) and the five classes of dormancy [morphological (MD, 3.7%), morphophysiological (MPD, 20.7%), physiological (PD, 52.1%), physical (PY, 11.2%) and combinational (PY+PD, 1.1%)] has been constructed. Significant discoveries include MD and MPD in the lobelioids, epicotyl dormancy in *Psychotria mariniana*, and deep PD in *Leptecophylla tameiameiae*. In some species, PD-break occurs over a range of temperatures, but in others it requires a relatively low or high temperature. Breaking PD or MPD may take many months; dormancy break/germination of seeds of the same species may differ between islands; and drying seeds may increase dormancy (PY, *Sapindus*) or break it (PD, *Solanum*). This collaborative effort is an example of how basic research conducted at a university relates directly to conservation objectives.

8-8 Seed Longevity Research and Seed Banking of Hawaiian Plants

Alvin Yoshinaga
University of Hawai'i at Mānoa, Honolulu, HI

Until recently, little work was done on developing seed banks for native Hawaiian plants because of the widespread belief that seeds of Hawaiian plants were inherently difficult to store. In 1995, the USDA National Seed Storage Laboratory (now NCGRP), the University of Hawai'i Center for Conservation Research and Training (CCRT), and the Lyon Arboretum started a research program that demonstrated that seeds of most Hawaiian plants could be stored. They identified effective storage methods that are now increasingly used in Hawaiian plant conservation. Standard seed longevity research methods for agricultural seeds assume that an infinite number of expendable seeds are available for research. For rare plants for which few seeds are available, methods need to be modified. Using large numbers of seeds for research improves the quantity and quality of information from the research but decreases the number of seeds available for immediate conservation use. In academic research, experimental design and statistical analysis center on hypothesis testing. In seed longevity research on rare plants, a model based on resource allocation among risky investments may be more appropriate. Despite these constraints, research on longevity of Hawaiian seeds has given important support to NCGRP's studies on improving understanding of longevity of seeds in general. This case differs from others in this symposium in that both NCGRP and CCRT's research is applied research for specific uses rather than basic academic research. Nonetheless, their research has enjoyed both support from working conservationists and fruitful collaborations with basic academic seed science researchers.

8-9 Reproductive Biology and Population Genetics of Hawaiian Ferns

Tom Ranker
University of Hawai'i at Mānoa, Honolulu, HI

Native Hawaiian fern species comprise about 17% of the native vascular plant flora and they dominate some ecosystems. Although fern species do not generally suffer any unusual threats relative to those experienced by other plants, they are subject to the same stresses and threats that are leading to the demise of many plant taxa. Various colleagues and I have conducted population genetic studies of 15 Hawaiian fern species in the genera *Adenophorus*, *Asplenium*, *Dicranopteris*, *Sphenomeris*, and *Sadleria*. From those surveys we inferred levels and patterns of genetic diversity at three geographic scales: within populations, within islands, and across islands. Although there was some variation across species, we generally found that individual local populations and/or island-populations exhibited genetic endemism in the form of unique alleles. This genetic uniqueness suggests that conspecific populations on different islands should be managed as distinct conservation-management units. In addition, we inferred that most species reproduced sexually and that most individual sporophytes were produced via outcrossing. In the face of shrinking population sizes, such historically

outcrossing taxa are likely to suffer from inbreeding depression due to the increased expression of deleterious alleles normally masked from expression in heterozygotes. Estimates of minimum-viable-population size for the rare species *Adenophorus periens* suggested that the largest, remnant population of this species may no longer have enough individuals to maintain current levels of genetic diversity over time. These genetic studies are providing insight into 1) evolutionary patterns and processes and 2) the potential impact of alternative conservation management strategies.

8-10 Fruitful Partnerships in Plant Reproductive Ecology for Conservation Management – An Australian Perspective

Caroline Gross
The University of New England, Armidale, NSW, Australia

Australia, the largest island in Oceania, has a rich flora (c. 20,000 species) and a diversity of landscapes. Many ecological communities are endangered and 25% of the flora is threatened with extinction. There are many parallels with Hawaiian ecosystems in terms of high endemism and key threatening processes. In Australia, concerns with recovering threatened species have prompted partnerships between researchers and conservation agencies. *Bertya ingramii* (Euphorbiaceae), for example, is known from <200 plants across three cliff populations in an upland reserve. Field studies revealed that the species is in an extinction vortex due to herbivory, seed predation, asynchronous flowering and an absence of recruitment. Genetic assays showed that covert hybridisation with a congener may best explain poor levels of recruitment in one population. In another example, fertile populations were discovered in a declared sterile-species (*Grevillea rhizomatosa*, Proteaceae), but more importantly, extraordinary variation in breeding systems was detected over a small area (7km x 8km). Genetic tools and field studies of sexuality revealed that reproductively isolated populations have unexpectedly high levels of gene diversity - a likely consequence of somatic mutations. These studies have assisted management with a re-determination of conservation status and fire management planning. The researchers gained valuable insights into the ecology of rarity, a platform for the training of six research students, five publications and media coverage shared with conservation agencies. Fast tracking of permit applications, facilitated access to reserved populations and field assistance were the most valuable types of support provided by the collaborating conservation agencies.

Symposium: Marine Debris Priorites and Actions in Hawai‘i

8-11 Addressing Marine Debris in Hawai‘i: A Dynamic Statewide Action Plan

Carey Morishige[1, 2], Kris McElwee[1, 2]
[1]*NOAA Marine Debris Program, Honolulu, HI,* [2]*I.M. Systems Group, Inc., Rockville, MD*

The National Oceanic and Atmospheric Administration Marine Debris Program (MDP) has been a partner in efforts to combat marine debris in Hawai‘i since 2005. Across the Hawaiian Archipelago, a number of efforts are taking place to address the impacts of marine debris. In order to prioritize Hawai‘i marine debris issues, coordinate between projects, and create a strategic plan of action, the MDP supported statewide planning workshops that began in Honolulu, June 2007. From the initial workshop, partnerships were created and a commitment made to develop a Hawai‘i Marine Debris Action Plan (HI-MDAP), the first statewide action plan in the nation to comprehensively address the issue of marine debris. The HI-MDAP includes greater coordination among partners, identification of potential avenues for funding, and increased communication. The development and implementation of the HI-MDAP is being supported by the MDP with assistance from the US Environmental Protection Agency, Region 9. HI-MDAP partners identified five focus areas for the plan: 1) Research and Assessment, 2) Outreach, 3) Land-based Debris Prevention, 4) Beach Cleanup, and 5) In-water Removal and Prevention. Information on past and ongoing marine debris activities was gathered and new actions brainstormed and discussed in detail. Feasible priority actions are currently being identified. In fall 2009, MDP and EPA will host a final meeting to introduce the new HI-MDAP to key decision makers, managers, and potential supporters. This presentation will highlight the work has that taken place on this plan to date, priority actions for Hawai‘i, and the next steps for implementation.

8-12 Urban Stream and Storm Water Controls as a Key to Preventing Marine Debris
Randall Wakumoto
City and County Department of Environmental Services, Kapolei, HI

The City and County of Honolulu's Storm Water Management Program falls under the Federal EPA's Clean Water Act. The city is required to implement a program that meets the goals of the National Pollutant Discharge Elimination System (NPDES). The goal of the NPDES program is to reduce pollutants from the City's streams and storm drains to the maximum extent practicable. The permit is broken up into various components targeting specific issues that affect storm water runoff. For example, when addressing the problems associated with marine debris, the City has undertaken a comprehensive storm drain inspection and maintenance program to identify and prioritize their field operations to effectively mitigate the problems associated with trapped materials in the City's existing storm drain system. Another example is through an ongoing pilot street sweeping study that will be used to determine the effectiveness in capturing sediments and debris in certain areas. Other programs or projects such as storm drain retrofits; drainage/water quality improvements; enforcement related to illegal discharges; and public outreach programs like Adopt-A-Stream and Adopt-A-Block, in most cases directly affect the amount of marine debris that would otherwise be transported down into our streams and near shore waters. The intent of this presentation will be to summarize these findings and highlight some of the positive benefits of these programs and activities in addressing the City's fight against non point source pollution in a highly urbanized environment.

8-13 At-Sea Detection of Derelict Fishing Gear: An Interdisciplinary Strategy to Address Marine Debris
Kris McElwee[1, 2], Carey Morishige[1, 2]
[1]*NOAA Marine Debris Program, Honolulu, HI,* [2]*I.M. Systems Group, Inc., Rockville, MD*

Derelict Fishing Gear (DFG) is a threat to marine ecosystems, posing entanglement hazards for marine life and smothering the living substrate upon which it settles. Across the Pacific, DFG is recognized as a major environmental threat to coastal and nearshore areas. A regional "hotspot" for DFG is the Hawaiian Archipelago, particularly the Northwestern Hawaiian Islands. In response to the threats posed by DFG in coral reef environments and the enormous cleanup costs of removal from the reefs, researchers have explored methods of detecting and eventually removing DFG in the open ocean. A December 2008 workshop brought technical experts in physical and biological oceanography, remote sensing, and unmanned aircraft systems together with individuals with practical expertise in fishing, economics, and marine debris. The specific goals of the workshop included 1) seeking solutions to locating DFG for removal, and 2) consideration of a census of DFG to assess the scale of the problem and determine the fraction of DFG that enters sensitive shallow-water environments. Participants developed a strategy that included steps in each of the following areas: characterizing DFG in the water column, characterizing the operational environment, developing models to predict the location and movement of DFG, and developing remote-sensing capacity to detect DFG. This presentation will review the background of the problem and the strategy that was proposed to improve our ability to measure, detect, and determine methods of addressing DFG, with the ultimate goal of preventing it from affecting our living marine resources.

8-14 Lessons from Our ʻŌpala: Marine Debris in the Classroom
Kimberley Weersing, Barbara Mayer, Barbara Bruno
University of Hawaiʻi, Center for Microbial Oceanography: Research and Education, Honolulu, HI

Marine debris is an emergent, globally significant issue with severe ecological and economic impacts. To facilitate classroom instruction about this important topic, the Center for Microbial Oceanography: Research and Education (C-MORE) has developed a Marine Debris Science Kit, which provides lesson plans and materials in a portable, self-contained format. This three-lesson unit introduces 8th to 12th grade students to the sources, distribution, and consequences of plastics and other marine trash through hands-on activities, a computer modeling exercise, and multimedia presentations. In Lesson 1, students rotate through interactive stations that illustrate four biological impacts of marine debris: entanglement, ingestion, transport of invasive species, and concentration and delivery of toxic compounds. In Lesson 2, students identify the source of an actual item of marine debris using OSCURS, an online ocean surface current model developed by NOAA researchers. Students also learn how ocean physics drive the distribution of marine debris. Finally, in Lesson 3, students analyze the history of plastic production and consumption, and brainstorm solutions to the marine debris problem. The take-home message is that there are hidden costs to the convenience, efficiency, and versatility of plastics and that these costs are being

paid for by society and the environment. The complete program requires three 45-minute class periods, but many of the activities are discrete and can be easily rearranged to fit various curricular objectives and time constraints. This and other Science Kits are aligned with HCPS science standards and are available for teachers to borrow free of charge from C-MORE (http://cmore.soest.hawaii.edu/education.htm).

POSTER PRESENTATION ABSTRACTS BY PRESENTING AUTHOR

POSTER ABSTRACTS BY CATEGORY

Climate Change

P-1 The Hawai‘i Permanent Plot Network: Research Infrastructure for Studying the Effects of Climate Change and Forest Dynamics

Faith Inman-Narahari[1], Rebecca Ostertag[1], Christian Giardina[2], Susan Cordell[2], Lawren Sack[3]
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The Hawai‘i Permanent Plot Network (HIPPNET) provides forest plots and data for studying long-term climate and species changes in native Hawaiian forest. HIPPNET has completed the first census in two 4ha intact, native-dominated plots on Hawai‘i Island, one in montane wet forest at Laupāhoehoe and the other in lowland dry forest at Palamanui. All native woody species ≥1 cm diameter have been mapped, measured, and identified. In each site we have >15,000 individually tagged stems of 15-25 species. HIPPNET has also installed climate stations at each site to provide continuous environmental data including temperature, rainfall, light, and relative humidity. These climate data, coupled with repeated census data, will allow us to correlate changes in tree species, mortality, and growth rates with climate variables. HIPPNET maps of spatial distribution layered onto high-resolution LiDAR data will allow us to track changes in species distributions along micro-topographic gradients, and make it possible to model future climate-driven range shifts for native species in both wet and dry forest systems. These predicted range shifts can have important consequences for our local watershed hydrology and preservation of species diversity. In addition, we provide this infrastructure to be available to other researchers that wish to work in these plots in which all the vegetation has been mapped and identified. Thus research in HIPPNET plots will be essential for making informed policy solutions to best shape our cultural, economic, and ecological future.

P-2 An Adaptation Scheme for Climate Change Effects on the Biodiversity within the East Maui Watershed

Alison Cohan[1]
[1]University of Denver, Denver, CO, [2]The Nature Conservancy, Maui, HI

Few concrete adaptation strategies have been discussed for East Maui’s native ecosystems despite the knowledge that climate change will likely reduce ecosystem health and increase non-native species invasion. The East Maui watershed provides the largest single source of harvested surface water in the state and contains numerous endemic and endangered species. This project explores the potential impacts of climate change on the biodiversity of the East Maui watershed and analyzes practical adaptation options to maximize ecosystem resiliency. An online survey was distributed to environmental professionals to identify the greatest climate change-related threats and the best adaptation strategies for the East Maui watershed. Adaptation strategies considered included protecting key ecosystem features, reducing anthropogenic stressors, representation, replication, restoration, refugia, and relocation. Survey respondents rated loss of biodiversity, invasive species, and habitat loss as the largest climate-change related threats and impacts. Reducing anthropogenic stressors and protecting key ecosystem features were rated as the top adaptation strategies. Respondents also showed strong support for biocontrol as a tool for climate change adaptation. Survey results are explored in light of potential limitations to strategy implementation and success. Results indicate that "no regrets" adaptation opportunities (those that reduce vulnerability and whose non-climate change-related benefits exceed the costs of implementation), specifically controlling invasive species and utilizing biocontrol, may ultimately prove the best course of action for proactively adapting to climate change effects in the East Maui watershed.

P-3 GIS Modeling & Remote Sensing for Sustainability & Climate Change

Ian Hanou, Brian Collins
AMEC Earth & Environmental, Lakewood, CO — Abstract Withdrawn

Education and Outreach

P-4 Promising Outcomes: Ka Hana ʻImi Naʻauao – A Science Careers Curriculum Project
Scott Bowditch, Lisa Galloway, Kelly Roberts, Noelani Puniwai
University of Hawaiʻi at Mānoa, Center on Disability Studies, Honolulu, HI

This study - a 2006-08 U.S. Department of Education project conducted in Hawaiʻi secondary schools - explores the effectiveness of culturally responsive science curricula aimed at increasing the number of ethnic minorities, especially Native Hawaiians, in science-related careers. Surveys were administered to 203 students at four high schools to measure their: 1) perceptions of science; and 2) science career interests. Students' perceptions of their academic efficacy, frequency of behaviors conducive to learning, and behaviors valued by the Hawaiian community also were tested. Quantitative results indicate culture is a valuable resource for educators because teaching students through - rather than just about - Hawaiian culture can: a) increase students' sense of efficacy in science; b) strengthen students' interest in and respect for Hawaiian traditions, history, language and natural resources; c) improve student outcomes, including frequency of positive, culturally appropriate behavior; and d) improve teacher competency in addressing diverse students' needs. The science career interest survey consists of 12 statements corresponding to three target attitudes regarding careers in the scientific field: family support of science studies; perceived interest in/opinion of science careers; and perceived dreams of science careers. Data gathered in the final year of the study will be presented and viewers are welcome to sign up for their own free copy of the final curriculum at www.cds.hawaii.edu/kahana.

P-5 4,627 Pounds and Counting
Chana Dudoit[1], Barbara Natale[2], Anuradha Gupta[2]
[1]Oregon State University, Corvallis, OR, [2]University of Hawaiʻi, Honolulu, HI

The ahupuaʻa of Kalihi has a population size of approximately 110,000 residents, comprising the most culturally and socioeconomically diverse community in the state. The majority of housing units consist of multi-family dwellings and the State's most numerous public housing complexes. As new buildings get wedged into every available open space, rainfall infiltration decreases and polluted runoff increases. These complex demographics present substantial challenges for effective community-based water quality improvements within the Kalihi Ahupuaʻa. Kalihi Stream, an impaired water body under the Clean Water Act, Section 303(d), is littered with debris from residential, commercial and industrial areas. Undesirable non-native species have adversely impacted the Kalihi Stream ecosystem. The general lack of awareness and appreciation for Kalihi Stream as a unique and beautiful resource perpetuates the problem. Utilizing public outreach, education and participation activities, the project purpose is to quantifiably and positively change project participant behavior within the Kalihi Ahupuaʻa, and to prevent and reduce pollutant loads, thereby improving water quality and the biological integrity of Kalihi Stream. Since July of 2006 participation in KAUPA's community workdays has increased from 6 volunteers to over 80 at a single event. Community members have stenciled 131 storm drains, removed a total of 4,607 pounds of litter from Kalihi Stream, removed 64 non-native catfish, and started a Polynesian community garden in which community members have planted over 300 edible and medicinal Polynesian plants. KAUPA's current volunteer base is 2,000 strong, contributing 8,769 hours to Malama ʻĀina activities!

P-6 Combining Volunteer Opportunities with Eco-Tourist Activities: An Innovative and Exportable Model for Promoting Voluntourism
Brooke Porter
Pacific Whale Foundation, Maui, HI

Volunteer-based vacations are becoming widespread in the tourism market and the term "voluntourism" is a now widely accepted as part of the travel vernacular. Considerable research has been dedicated to investigating the motives behind participation in voluntourism, although the difference in professed interest and actual participation has yet to be explored. Pacific Whale Foundation acts as host and hub for Volunteering on Vacation, a voluntourism program that offers volunteer opportunities through multiple partner agencies. Entering its third year, the Volunteering on Vacation program model was originally designed in response to limitations of existing volunteer opportunities on Maui. Common limiting factors amongst host volunteer agencies included limited operating hours, small staff and/or accessibility. Utilizing its ecotour operations, including staff and resources, Pacific Whale Foundation was able to address these previous limiters of volunteer programs with a simple co-

marketing approach. Pacific Whale Foundation continues to market the Volunteering on Vacation program parallel to and as a follow up activity to its highly sought-after marine ecotours. Participation from 2007 to 2008 increased nearly five fold, suggesting the efficacy of this strategic model. It is proposed that co-marketing a volunteer opportunity alongside or as a follow-up activity to an existing tour activity is a valuable and exportable model resulting in increased voluntourism participation. A survey of past participants is currently being undertaken to further investigate the Volunteering on Vacation model.

P-7 Kokua ʻĀina Youth Initiative at the National Tropical Botanical Garden: Cultivating a Green Collar Workforce

Lea Taddonio, Janet Mayfield, Nicole Shores
National Tropical Botanical Garden, Kalāheo, HI

The Kokua ʻĀina Youth Initiative (KAYI) is a new experiential educational program launched Fall 2008 at the National Tropical Botanical Garden's headquarters on Kauaʻi. KAYI admits local high school students ages 14-19 with the aim to spread awareness and appreciation of tropical plants, particularly Hawaiian native plants, while providing hands-on experience in horticulture, botany, conservation, cultural studies and social entrepreneurship. KAYI participants are currently assisting to develop a nursery where they are responsible for selecting and propagating plants and developing creative ways to share their efforts with the Kauaʻi community/visitors. Students are also paid a work stipend and receive life skills training in money management, resume writing, effective communication and interview preparation to better prepare them for securing successful employment opportunities in the future.

P-8 PRISM at UH Hilo: Communicating Science through Culture, Connections & Conservation

Jon Eldon, Colby Kearns-McNaughton, Donald Price, Elizabeth Stacy, Jan Zulich
University of Hawaiʻi at Hilo, Hilo, HI

PRISM Fellows at UH Hilo are broadening science literacy in Hawaiʻi by developing culture-infused, place-based science curricula, forging connections between K-8 students and local scientists, and promoting environmental awareness and action. Over three years, 28 PRISM Fellows have partnered with over 50 elementary and middle school teachers to develop 19 standards-based curricula in marine and terrestrial environments. PRISM curricula incorporate math, art, language arts, and technology and have been implemented in over 60 classrooms, reaching over 1,400 students. PRISM Fellows bridge modern scientific and local cultural knowledge by infusing science lessons with native values, beliefs, and practices, including the important Hawaiian value, "Malama i ka ʻAina," or "Caring for the Land." Fellows further enrich these lessons by recruiting scientists from Hawaiʻi's federal, state, and nongovernmental agencies into the PRISM ʻohana (family). These scientists, many of whom are an affiliate faculty of UH Hilo's TCBES M.S. Program, are broadening hands-on opportunities for students in the conservation and restoration of native species and habitats. Through such collaborations, PRISM is developing a community of practice in science education and empowering students to make a difference in their communities. Fellows further develop their communication skills and promote scientific literacy through outreach to non-partner teachers, integration of PRISM curricula into teacher workshops, coordination of Science Nights at PRISM schools, and participation in community events. Fellows also communicate science to a broad audience through the development of PRISM website, newspaper and newsletter articles, a PRISM brochure, individual project posters, and local TV and radio segments.

P-9 Community-based "Beach Watcher" Monitoring Program Explores Human Impact on Waikīkī's Coastal Resources

Anne Rosinski[1]
[1]*Reef Watch Waikīkī, Honolulu, HI,* [2]*University of Hawaiʻi Sea Grant, Honolulu, HI*

As the economic engine of Hawaiʻi's visitor industry, home to 20,000 residents, and host to four million tourists per year, it is clear that Waikīkī is a place of concentrated human activity. Heavy human use can create an array of threats to the coastal environment. Despite this knowledge, there is currently no effort to quantify the impact of human use in the area or to explore how Waikīkī's coastal and marine resources are being impacted. In March 2009, Reef Watch Waikīkī launched its Beach Watch program, which trains community volunteers to conduct human use surveys along the Waikīkī coastline. Volunteers collect data on the types of human activities and environmental threats present in the water and on the beach within ten survey sites that collectively span the

length of the Waikīkī coastline. Information documented on the data sheet include number of surfers in the water, number of fishing boats, and volume of trash observed at a given site. Equipped with knowledge gained from Reef Watch Waikīkī's volunteer training, Beach Watchers also interact with beach-goers providing information about the program and the coastal environment. Over time, the data collected will help to quantify how human behavior is affecting Waikīkī and then guide Reef Watch Waikīkī's future efforts to improve the health and vitality of Waikiki's beaches and reefs through marine education programs and community stewardship projects.

P-10 Pacific Science Camp - A NOAA Initiative for Middle School Student Scientists

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— Abstract Withdrawn

P-11 What invasive species do you wish were never introduced to Hawai'i? Can this help us prevent future problems?

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Over 20,000 species of plants and animals have been introduced into Hawai'i by man. Fortunately, less than one percent of these have had serious impacts on Hawai'i's native ecosystems and our quality of life. However, the consequences of this relatively small number of invaders have been significant. What would our native ecosystems be like today if certain invasive species had never been brought here? Consider if *Miconia* had never been introduced, or Coqui frogs, avian malaria, smallpox, rats, ants, or ungulates? We believe that one way to appreciate the value of prevention is to think about the consequences of those problem species that have already had major impacts on our ecosystems, and then visualize what it would be like today if those plants or animals had never become established here at all. With this in mind, we are soliciting nominations for the top 30 species of plants and animals that you wish had never been introduced into Hawai'i and why. This poster will be used to gather these data from participants of the 2009 Hawai'i Conservation Conference. These initial results will be summarized and presented at the 2010 Conference. We will then expand the survey and solicit the same type of information from the public. We hope that this effort will help all of us gain a better understanding of the true merits of prevention of future problem invasive species by projecting compelling scenarios of a Hawai'i spared of some of our most problematic alien organisms.

P-12 Conservation of the Joseph F. Rock Herbarium Wood Collection

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Conservation of the Joseph F. Rock Herbarium wood collection (HAW) is important for making these dried specimens, which were collected in Hawai'i and were previously an orphaned archive of primary data, publicly available. Development of an interactive educational web portal (http://www.herbarium.hawaii.edu/collections/wood) for native and commercial woods of Hawai'i provides a new resource to students, faculty, and citizen scientists. Literature, archived herbarium specimens, scanning electron microscopy (SEM) photographs, specimen label data, and anatomical glass slides were recorded with an Epson GT-15000 scanner and stored in a MySQL database to unify research on native Hawaiian woods and introduced timber species. Herbarium voucher specimens of 16 species, SEM images of 68 species (ca. 1,200 images), and wood blocks of 48 species were inventoried and digitally archived. Expanding the genetic, taxonomic, and environmental data collections, as well as the physical and mechanical properties of these woody species is vital to examine the complex and synergistic terrestrial variables of global climate change in the Hawaiian Islands. Primary research on seasonal cellular growth rates of woody species in the State of Hawai'i is limited. As a result, we found numerous native species and one invasive species that may be useful for high resolution climate change research.

Management Tools

P-13 Tired of Data Shopping? NRInfo has Your Park Natural Resources Needs Covered!

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The Natural Resources Information Portal (NRInfo) is an online junction where data, maps, images, species accounts, and documents about natural resources in national park units can be accessed, appended, and shared. This portal was created by the IRMA project (Integration of Resources Management Applications) to simplify the sharing of information in the National Park Service (NPS). NRInfo currently contains information from the NPS data systems NPS Data Store, NPSpecies, Natural Resources Bibliography (NatureBib), and NPS Focus to name a few, making data searches more convenient and efficient. For example, a researcher investigating how climate affects shorelines and intertidal species in the Pacific island park units could log on to the portal and search for documents regarding climate change and species (NatureBib); look for data and GIS layers regarding changing shorelines (NPS Data Store); then get a species list for each park concerned (NPSpecies). Databases for geology and soils, air and climate, water, landscapes, and human use will be added to the portal in the future. Presently, the portal is accessible through NPS computers for personnel and contractors, but the portal will be made available to the general public in 2010.

P-14 Development of a Successful Predator Exclusionary Fence at Hawai'i Volcanoes National Park

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The survival of many of Hawai'i's endangered species depends on protection from introduced mammalian predators. High costs required to conduct traditional control in perpetuity often render it impractical on a broad scale. In 2003, Hawai'i Volcanoes National Park constructed a 5 hectare exclosure to protect Nēnē (*Branta sandvicensis*) from feral pigs, cats and mongooses and to test the feasibility of the design in Hawai'i's challenging environment. The fence, adapted from the Arid Recovery Project in Roxby Downs, South Australia, was designed to exclude cats, foxes and rabbits. The basic components are a 6' high fence covered with 1" hex mesh, a skirt to prevent digging underneath, and a floppy arc at the top to prevent climbing over. The total cost for construction was $45/meter; however, due to a significant increase in the price of steel, we estimate the current cost for materials and labor at approximately $67/meter. The fence has been monitored for ingress as well as durability. Six years later, no ingress by cats, mongooses or pigs has been documented, while detections of these animals have continued outside the exclosure. Recent trials further suggest the fence effectively excludes mongooses. The overall condition of the fence is very good, particularly considering its proximity to corrosive volcanic emissions. Due to the success of this trial, HAVO is considering the fence design for larger scale protection of Nēnē and other species in the park. This effective conservation tool offers an alternative method of protection where predatory mammals threaten native species.

P-15 Water Assessment Tool for Evaluating Risk (WATER)

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The Water Assessment Tool for Evaluating Risk (WATER) is a pollution risk assessment tool developed for use in the field by Natural Resources Conservation Service (NRCS) employees and others developing conservation and nutrient management farm plans. The tool was developed in Microsoft Access®. WATER is a product of several previous tools developed by the University of Hawai'i-College of Tropical Agriculture and Human Resources (UH-CTAHR) and NRCS from 2003 to present. The tool contains five main components: 1) A pre-screening water risk assessment based on soil, geographic and climate data, which provides a simple assessment for the potential of polluted leaching and runoff leaving a field; 2) A more rigorous transport component based on runoff estimates (curve numbers) found in NRCS Technical Release 55 (TR55): Urban Hydrology for Small Watersheds, the Revised Universal Soil Loss Equation (RUSLE), and local conditions. This transport component transfers input data into the following two components; 3) A phosphorus (P) risk component based on soil phosphorus amounts (ppm) and transport potential; 4) a nitrogen (N) risk component that balances soil nitrogen with plant uptake and

leaching and runoff potential; and 5) A fertilizer input component that balance nutrients with recommended nutrient quantities. All components, except the transport component, provide a report summary of results with relative risks. WATER is a management tool that aims to improve conservation planning decisions with regards to pollution risks from farming, which will help conservationists and farmers reduce pollutants leaving farm operations.

P-16 Fuel Break Project at Pōhakuloa Training Area

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Of the 2,400 native Hawaiian plant species remaining in the state, almost half are endangered and most occur nowhere else in the world. At Pōhakuloa Training Area (PTA), there are 19 endangered and threatened species, 15 of which are plants. Wildfires pose a high threat to the native habitats of these species, especially where the invasive fountain grass (*Pennisetum setaceum*) is abundant. The fuel break project was developed under the auspices of the Installation Fire and Safety Office, USAG-HI. The project has been implemented by the Army's Natural Resources Program to help reduce the effects of wildfire on these sensitive habitats. Establishing the most cost effective and efficient strategy for this fuel break project is important. Wildfires are unpredictable and therefore difficult to plan for. The data collected from a monitoring system, consisting of 16 plots set up in March 2009, will be used for future management planning. Monitoring will consist of a replicated system of measurements of height and density of fountain grass re-growth. Measurement points of one meter intervals are spaced along three transects in plots measuring two meters wide by ten meters long. The data will aid in determining the effects of chemical means of fuels reduction, re-spray intervals, effective use of funds, and personnel hours. In addition, eight plots will be used to monitor ungulate effects on the fuel break. Monitoring of the 24 plots will take place over a period of 1-3 years and results will be incorporated into the standard operating procedures.

P-17 Cattle Grazing as a Tool for Reducing Guinea Grass Fuel Loads on a Military Training Base in Hawai‘i

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Invasive guinea grass (*Panicum maximum*) can carry high intensity, fast moving fires. Dense stands of fire-prone guinea grass are a major fire hazard on military lands of Marine Corps Training Area Bellow (MCTAB) and consequently to the neighboring residential community on O‘ahu, Hawai‘i. Traditionally in Hawai‘i mechanical removal and prescribed fire have been used to reduce guinea grass fuel loads. However, since MCTAB shares its borders with urban landscapes; smoke, air quality restrictions and liability associated with prescribed burns are major concerns. The aim of this study was to investigate alternative control methods for reducing guinea grass fuel loads on MCTAB. Twelve 50 m^2 plots were established to which the following four guinea grass removal treatments were applied in replicates of three: mechanical, herbicide, cattle grazing and control. Guinea grass biomass was sampled and weighed before, immediately following application of treatments, and five months post treatment application. Results indicate that surface fuel loads on MCTAB average 6 tons/acre. Mechanical treatment was the most effective in reducing guinea grass fuels immediately following treatment application. However, five months post treatment application grazing plots appeared to have the least guinea grass fuel loads as well as reduced fuel continuity suggesting the long-term effectiveness of grazing in lowering fire hazard on MCTAB. A cost analysis for a ten-year period also revealed grazing to be the most cost effective treatment. Adopting a long-term grazing program is likely to reduce the fire hazard on MCTAB and maximize training capacity of the Marines.

P-18 Monitoring Weather Patterns and Trends for Pacific Island National Parks

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The Pacific Island Network (PACN) is one of 32 regional National Park Service Inventory and Monitoring networks. The PACN includes 11 parks: eight in Hawai‘i, and one each on Saipan, Guam, and in American Samoa. To evaluate the health of the parks' ecosystems, PACN scientists have chosen 15 'vital signs' for long-

term monitoring; one of these vital signs is weather/climate. Pilot implementation of the weather monitoring protocol started this year. Data from existing monitoring stations, such as stations of the National Weather Service, the U.S. Geological Survey and Remote Automated Weather Stations, are analyzed for the PACN parks and islands. Annual reports summarize conditions for climatic elements such as temperature, precipitation, and wind in the last year. If historical data are available recent data are compared to long-term means, and trends are identified. In addition, the extent and duration of extreme events (droughts or extreme rainfall) are tracked. Presented are results of data analysis for one station as an example of this new monitoring effort in the national parks of the Pacific. Weather data analysis and reporting will provide support to park managers and researchers for understanding ecosystem development and change. Data from long-term stations may help us evaluate the effect of global climate change on local weather patterns.

Invasive Species

P-19 The History of Game Species Introductions in Hawai‘i

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Since the first Europeans arrived in Hawai‘i, 21 species of mammals and birds have been successfully introduced for hunting. We have little understanding about the historical and cultural underpinnings that led to the introduction of game species. Our aim was to investigate the interrelationship between the intentional introduction of game species and shifting political and cultural perspectives over time. Historical records of game species introductions and inter-island translocations were compared with historical events since European contact (1778). Changes in public opinion toward game corresponded with major historical periods that can be demarcated by six major political events: (1) game were presented to royalty in exchange for safe harbor or goods; (2) after the Mahele (1848), colonists yearned for birds and mammals, welcoming all game; (3) following Annexation (1899) game bird importation and hunting became a source of Territorial revenue while eradication programs targeted ungulates as major threats to plantation watersheds; (4) post-World War II (1945), hunting became a tourist draw, triggering importation of birds and mammals and effecting a shift in ungulate management from ‘eradication’ to ‘harvest;’ (5) after Statehood (1959) introductions ceased and ranchers began to oppose game mammals as competitive grazers; and (6) since the Native Hawaiian Legislative Package (1978) an impetus to conserve native ecosystems is reflected by ungulate eradication efforts and the absence of intentional introductions or translocations of game. Landscapes provide a record of cultural values. Thus, historical analysis must include cultural factors so as to utilize past lessons to bring about future change.

P-20 Invasive Species Early Detection Efforts in Hawai‘i 1997-2009

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The early detection of new infestations of invasive plants and animals before they become established is considered a critical step to preventing costly long-term invasive species management problems. Coordinated statewide efforts for early detection began on the island of Maui in 1997, the island of Moloka‘i in 2005, and in 2006 for the islands of O‘ahu, Lāna‘i, Hawai‘i, and Kaua‘i. Midway Atoll in the Northwest Hawaiian Island chain was surveyed in 1999 and 2008. These island-wide surveys for high-risk invaders were predominantly focused on roadsides and “hotspots” (arboreta and nurseries). Many of the species on the detection lists were deemed high risk via the Hawai‘i Weed Risk Assessment (HWRA) process. In addition to the systematic surveys, citizens on the islands of Maui, O‘ahu, and Kaua‘i were trained to look for target species in their communities. General distribution data was ascertained for 94 of 126 target species on Maui, 48 of 115 target species on Lāna‘i, 45 of 126 target species on Moloka‘i, 37 of 90 target species on Kaua‘i, 76 of 140 species on the island of O‘ahu, and for 194 species on Midway Atoll. Survey teams are currently searching for 134 target species on the island of Hawai‘i. This poster summarizes these efforts and highlights some of the successful interceptions of new incipient invaders.

P-21 Successful Maui Invasive Species Committee (MISC) Efforts Controlling Fountain Grass, *Pennisetum setaceum*, in Maui County

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Maui Invasive Species Committee, Makawao, HI

A member of the Hawai'i Noxious Weed List, fountain grass (*Pennisetum setaceum*) was discovered invading the dryland habitats of Lana'i in the early 1900's and Maui in the 1960's. Native to northern Africa, this fire adapted and drought tolerant species threatens native dryland ecosystems by increasing fuel loads, thereby affecting the intensity and frequency of wildland fires, and outcompeting native plant species for resources. Distribution of the long-lived seeds is achieved primarily through wind dispersal, though seeds are spread by water, vehicles, animals, and humans as well. Constant challenges for eradication of this species include continued introduction and/or detection of new remote populations, a seed bank viability of a minimum of six years, difficulty and expense of early aerial detection, and a lack of general public awareness. Organized, repeated efforts by MISC personnel beginning in 2005 through present day have proven to be successful in controlling and greatly reducing the number of individuals within distinct populations. Total number of plants detected and treated, either by manually pulling or applying chemical, per control visit has consistently and significantly decreased from year to year with nearly 6,000 plants found and treated in 2005 to fewer than 700 in 2008. Further analysis of data sets and environmental factors may contribute to achieving the goal of eventual containment and potential eradication of fountain grass in Maui County.

P-22 A Coqui-free Certification Program on the Island of Maui

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The coqui frog (*Eleutherodactylus coqui*), native to Puerto Rico, is an invasive alien species in Hawai'i. There is widespread agreement that coqui pose significant environmental, economic, and quality-of-life threats to Hawai'i. Continued inter- and intra-island movement of frogs through the nursery trade seriously undermines ongoing efforts to control the spread of this pest. To address vectoring through the nursery trade, the Maui Invasive Species Committee developed and implemented a voluntary coqui-free certification program. The program encourages specific practices designed to prevent the spread of coqui frogs. Of 76 plant industry businesses contacted on Maui, 34 expressed interest in participating, four of those after the program launch. Twenty-nine businesses are now certified coqui-free. Business size did not appear to influence willingness to participate. However, 24 businesses of 38 that responded to a self-classification question identified themselves as small-volume businesses during pre-program interviews. Pre- and post-program consumer surveys (N = 303) were also collected to gauge interest in the program and measure program influence on purchasing behavior. Scores for pre- and post-program consumer surveys suggest no significant change in consumer behavior as a result of the program. However, respondents' strong feelings that coqui frogs are an issue in Hawai'i (68%), that the issue is important to them (56%), and that they would seek out a coqui-free certification program if available (79%), indicate that with appropriate outreach the program may be very successful at influencing consumer behavior.

P-23 A Review and Update of the Multi-Agency Program to Support the Conservation Uses of Rodenticides in Hawai'i

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Introduced rats, mice, and mongooses have contributed to the decline and extinction of much of Hawai'i's unique biota. Since the early 1990's, the Toxicant Working Group has coordinated the research, registration and use of rodenticides to control these introduced predators in native ecosystems in Hawai'i. Until 2008, the rodenticide product, active ingredient, and application method were limited to Ramik® Mini Bars (0.005% diphacinone) applied in tamper-resistant bait stations. In 2008 the first rodenticide label permitting all application methods (hand and aerial broadcast, bait stations, burrow and tree-crown baiting) was approved for use in Hawai'i. Hawai'i now has the same application methods that are used in New Zealand. We have also been innovative by being the first in the world to use aerial broadcast of diphacinone (less toxic to non-target species and less persistent than

brodifacoum) to eradicate rats from two offshore islands (Mokapu and Lehua). Although these are significant milestones, before we can routinely treat large areas of the main Hawaiian Islands we must engage in extensive public dialogue and outreach to ensure that nearby communities and other interested parties have accurate information with which to evaluate the risks and benefits. To provide a formal framework for this process, and to comply with environmental review laws, state and federal agencies are working on a NEPA document. We have contracted a community outreach firm to provide us with professional expertise during this phase.

P-24 Rat Eradication on Lehua Island via Aerial Broadcast of Diphacinone--50

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Invasive rats (*Rattus exulans*) may threaten many rare and endangered native species including numerous coastal plants, invertebrates and nesting seabirds on Lehua Island. The eradication of rats would allow natural recovery and active restoration of native species negatively impacted by rats. Rodenticide pellets containing the active ingredient diphacinone at 0.005% were broadcast by helicopter in January 2009. This is a newly available conservation tool in the U.S., and Mokapu Island (February 2008) was the first in the world where aerial rodenticide application using this safer active ingredient was used to eradicate rats. Island eradications in other parts of the world have usually used rodenticides which are far more persistent and bioaccumulative, thus imparting a much higher risk to nontarget species and the environment. Operational aspects as well as mitigation and monitoring of nontarget and environmental effects will be discussed. This project demonstrates that the aerial application of diphacinone rodenticide is an effective tool for conservation. These results will be useful in planning future rat eradication and control projects in the Pacific.

P-25 Relative Abundance, Reproductive Cycle and Home Range of Rodents in Ka‘ena Point Natural Area Reserve

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Ka‘ena Point Natural Area Reserve, hosts one of the largest seabird colonies in the main Hawaiian Islands, and contains several species of endangered plants. Due to the negative impacts of invasive mammals on these native species, construction of a predator-proof fence is planned for late 2009 and all invasive mammals will subsequently be removed. Rodent monitoring began in 2008 to document species present, their relative abundance, reproductive cycle and home range. Combinations of live and snap traps were used for one week per climatic season (February, April, July and November). Thirty-one rat traps were placed at 50m intervals and 40 mouse traps were placed at 10m intervals throughout all vegetation communities. Sex and reproductive status of all specimens were determined. Several rats and mice were outfitted with spools of thread glued to their backs, and then released. Home range size was calculated by following trails of thread. Only two rodent species were documented; *Mus musculus* and *Rattus rattus*, with mice trapping indices (# rodents/trap-night) exceeding rats by 2:1. Based on trapping, relative abundances for both species peaked in April, and were stable throughout other seasons. The distribution of both species appeared to shift within the reserve throughout the year, suggesting that they may take advantage of seasonally available food items. This baseline data will be crucial for demonstrating and measuring the effectiveness of predator-proof fencing and will provide basic target species data to determine the appropriate eradication timing and methodology parameters, such as bait station or broadcast baiting density.

P-26 Assessing Biofuel Crop Invasiveness for Hawai‘i: A Comprehensive Case Study

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Biofuels continue to be touted as a renewable solution to declining energy supplies that could simultaneously reduce greenhouse gas emissions, but biofuel species often have attributes that may make them invasive. Weed risk assessment systems predict which plants may become problems by investigating their biology and history of invasiveness elsewhere. These protocols were used to provide an empirical comparison of invasion risk for 40

proposed biofuels versus a random sample of 40 non-biofuels in Hawai‘i. Twenty-eight of forty (70%) biofuel plants had a high risk of invasiveness versus ten of forty (25%) non-biofuels, and were two to four times more likely to naturalize or be invasive in Hawai‘i or elsewhere. Because of climatic and ecological similarities, predictions of biofuel crop invasiveness in Hawai‘i are applicable to other island and subtropical ecosystems worldwide. We demonstrate the utility of an accessible and scientifically proven risk assessment protocol that allows users to predict if introduced species will become invasive in their region of interest. Propagule pressure created by extensive plantings can exacerbate invasions, a scenario expected with large-scale biofuel cultivation. Proactive measures, such as risk assessments, should be employed to predict invasion risks, which could be mitigated via implementation of appropriate planting policies and adoption of the “polluter-pays” principle. High risk species could be designated as noxious weeds which require permission to plant. Proponents of high risk species could be required to pay a bond to fund control of escaping crops or to do the control at their own expense.

P-27 “Hawai‘i’s Invasive Plant Species”: An Interactive Tool for Identification, Management and Public Outreach

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Invasive alien species of plants and animals within the Hawaiian Islands have a deleterious effect on human health and well-being, agriculture, commerce, and the environment. More than 1,300 non-native vascular plant species have been documented for the Hawaiian Islands, with more naturalized species documented every year. The rapid identification of invasive plant species in the field, and the participation of the general public in recognizing and reporting of invasive non-natives, is critical to the eradication of non-native species. Bishop Museum’s Hawai‘i Biological Survey (HBS) has developed a web-based multi-access, multimedia key of more than 200 species currently listed as noxious by the State of Hawai‘i, of greatest invasive potential as determined by the O‘ahu Early Detection Team, and/or having a high Weed Assessment Risk value. The identification tool will be placed on the world-wide-web in conjunction with the online interactive forum Ask a Bishop Museum Scientist (hbs.bishopmuseum.org/askascientist) in which dialogue between HBS staff and field workers, land managers, scientists, and the general public may assist in the identification of new non-native species and known invasive plant species outbreaks. Hawai‘i’s Invasive Plant Species was developed using Lucid3 software, can be readily updated, and has the potential for incorporating all species currently recognized as invasive in the Hawaiian Islands and those species with the potential to become serious pests in the future. The interactive key includes a comprehensive resource of photographic images and illustrations and information relating to the identification, eradication, and distribution of each species.

P-28 Effect of Pre and Post Emergence Herbicide Application Timing on Hydroseeded *Fimbristylis cymosa*

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Fimbristylis cymosa is native Hawaiian coastal sedge that has potential use as a groundcover for roadside re-vegetation, riparian restoration and landscaping. Large-scale planting of this species can be successfully done by hydroseeding, but little is known about selective weed control after sowing. In order to maximize weed control while minimizing injury to seedlings, proper timing of pre and post emergence herbicide application is essential. In 2008, field studies were conducted to evaluate application timing of oxadiazon (2.24 kg a.i./ha), oryzalin (2.24 kg a.i./ha) and a mix of aminopyralid (0.10 kg a.i./ha) and fluazifop-p-butyl (0.28 kg a.i./ha) on plant counts of newly hydroseeded *F. cymosa*. The pre emergence herbicides oxadiazon and oryzalin were applied at 7 and 14 days after hydroseeding (DAH), while a post emergence herbicide mix of aminopyralid and fluazifop-p-butyl were applied with or without oxadiazon at 28, 42 and 56 DAH. Final plant counts collected at 92 DAH reveal that pre emergence herbicide application from 7 to 42 DAH severely reduced the number of *F. cymosa* seedlings. Plant mortality caused by herbicide injury was high when oxadiazon was applied with aminopyralid and fluazifop-p-butyl. Plots treated with aminopyralid and fluazifop-p-butyl did not show a significant reduction in plant counts. Results from this study indicate that the post emergence herbicides, aminopyralid and fluazifop-p-butyl can be applied as early as 28 DAH to selectively control many broadleaf and grassy weeds on hydroseeded *F. cymosa*.

P-29 Current Molecular Characterization and Disease Management Results for *Puccinia psidii*, the ʻŌhiʻa Rust

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The ʻŌhiʻa Rust caused by *Puccinia psidii* remains a serious threat to the native ʻŌhiʻa forests in Hawaiʻi. Samples of infected Myrtaceae from new areas continue to be submitted to our laboratory for confirmation and storage. The rust has also been found on new hosts. In the fall of 2008, it was discovered severely infecting Allspice plants on the island of Oʻahu. Molecular analysis of the rust samples started in 2008 was expanded by running the samples through PCR reactions with three new florescent labeled primers, bringing the total number of primers run to six. Single spore cultures of rust from Rose Apple, Brush Cherry, Nīoi (*Eugenia reinwardtiana*) and Allspice were multiplied on Rose Apple plants to increase urediniospores for bulk spore storage. The DNA extracted from these samples represents pure culture lines from their respective hosts. Molecular analysis of the samples continues and at present, results bolster the observation that the rust infecting the various Myrtaceae hosts in Hawaiʻi is a single strain. Fungicide trials initiated in 2008 continue, and compounds are being tested that are commercially available to nursery growers and the general public. A fungicide with Tebuconazole as the active ingredient is a promising candidate. Results of the disease survey, molecular analysis, and fungicide trials will aid state officials in generating import restrictions and protocols for shipping Myrtaceae hosts into Hawaiʻi.

P-30 Control of *Acacia koa* Wilt

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Acacia koa is a Hawaiian endemic tree, which is both economically and ecologically important for Hawaiʻi. However, *A. koa* has suffered from a severe wilt disease caused by *Fusarium oxysporm* that was first isolated in the island of Hawaiʻi in 1980. The overall objective of this project is establishing new koa plantings. To achieve this goal, the specific objectives are to develop a rapid molecular method to confirm the presence of pathogenic *F. oxysporum* and to identify genetic markers in koa associated with improved koa wilt tolerance. In 2008, the collection of *F. oxysporum* cultures was begun from six mature diseased koa trees in the College of Tropical Agriculture and Human Resources, Hamakua Research Station on the Island of Hawaiʻi. Over 147 cultures were collected including 78 *Fusarium*, of which 30 were *F. oxysporum*. These *Fusarium* cultures were isolated from diseased branches, bark, trunk and roots. Pathogenicity tests have begun and 11 isolates out of 16 were pathogenic. The pathogenicity test will be continued and the isolates and future collections will be used for genetic analysis to develop molecular methods to identify pathogenic isolates. The koa tissue is polyphenol and polysaccharide rich therefore the DNA extraction protocol needed improvement. A new modified method was established by increasing the PVP amount from 2 % to 3 % and reducing the tissue: extraction buffer ratio from 3:10 to 1:30. Selected koa families that differed most in tolerance to koa wilt based on earlier studies will be used to identify genetic markers.

P-31 Potential for Biocontrol of *Tibouchina herbacea* and Other Melastomes Using *Syphraea uberabensis*

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Syphraea uberabensis (Coleoptera: Chrysomelidae) is a South American flea beetle whose adults and larvae feed externally on *Tibouchina* foliage and soft stems, causing enough damage to kill small plants. Under quarantine evaluation as a potential biocontrol agent for *Tibouchina herbacea* (Melastomataceae), *Syphraea* has been tested on a variety of native and non-native species within the order Myrtales to identify its expected host range in Hawaiʻi. Recent multi-choice behavioral tests with adult beetles supported results in no-choice tests indicating a host range restricted to several melastomes, all of which are invasive weeds in Hawaiʻi. *Syphraea* appeared unlikely to impact the weeds *Tibouchina urvilleana*, *Miconia calvescens* and *Clidemia hirta*, but showed significant preferences for feeding and egg laying on other *Tibouchina spp*., *Pterolepis glomerata*, *Melastoma candidum* and a few other melastomes. We consider the potential for using this biocontrol agent in management of these various melastomes.

P-32 Impacts of Strawberry Guava and its Biocontrol
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Strawberry guava (*Psidium cattleianum*) has long been recognized as a major threat to Hawaiian forests, but the severity of its impacts has not been widely publicized until recently. We now have an accumulation of detailed evidence that demonstrates compellingly the need for more effective ways of managing one of the state's worst invasive species. The biocontrol agent *Tectococcus ovatus* has been identified as the best potential tool for slowing the spread of strawberry guava across hundreds of thousands of acres of native forest. Monitoring rainforest plots at an invasion front on Hawai'i Island; we have established baseline data for measurement of the future impacts of biocontrol on strawberry guava. We discuss the progress toward use of this new tool and plans for its application statewide.

P-33 Host Choice by *Cryptorhynchus melastomae*, a Stem Boring Weevil for Biocontrol of *Miconia*
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Cryptorhynchus melastomae is a stem boring weevil known to feed on *Miconia calvescens* and a few related melastomes in its native Costa Rica. The adult weevils feed externally on *M. calvescens* foliage and stems, and the larvae feed and pupate within stems. To evaluate the suitability and potential impacts using the weevil for biocontrol in Hawai'i, we studied its host choice behavior in the laboratory. Plant species within the Order Myrtales were evaluated in multi-choice testing if they showed the slightest vulnerability to *C. melastomae* in no-choice tests. Feeding and egg-laying preferences of the adult weevils indicate that its host range may extend to several weedy melastomes in Hawai'i; no melastomes are indigenous to Hawai'i. We discuss the implication of multi-melastome host use by this biocontrol agent for long term management of *M. calvescens*.

P-34 Smothered in Sphagnum: Managing Moss at Ka'ala
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The high level of expertise required for bryophyte identification has meant that invasive mosses have been given little attention in Hawai'i. *Sphagnum palustre*, a bog moss, was purposely introduced to the Ka'ala Natural Area Reserve (NAR) on O'ahu in the 1960's from the Big Island, where it is indigenous. Though *Sphagnum*, on O'ahu, cannot produce spores, an eightfold increase in the size of the core infestation has been observed over the last 12 years. Through vegetative reproduction, *Sphagnum* now occupies an area estimated at 1.25 ha. St. Gabriel's Moss Killer (SGMK) is an organic mossicide composed of clove oil and vinegar. It shows promise as a safe, less labor-intensive means of controlling *Sphagnum* than manual removal. To compare the efficacy of manual removal against that achieved using both a low and high dose of SGMK, we established 40, one m^2 plots within the *Sphagnum* infestation (10 replicates per treatment plus a control). Impacts to non-target species were measured using stem counts of plants under one meter. Though differences were not significant, reductions in four common native species were, on average, higher in the manual removal and high dose treatments compared to either the control or low dose groups. At six months all three treatments (high and low dose SGMK and manual removal) were equally successful in killing *Sphagnum* and, on average, regeneration was < 5%. These data suggest that low doses of SGMK can effectively control *Sphagnum* while having little or no impact on non-target species.

P-35 Comparing Seed Mass, Germination Success, and Seedling Growth Rates in *Psidium cattleianum* Populations from Hawai'i and Brazil
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Introduced to Hawai'i in 1825, the tree strawberry guava (*Psidium cattleianum*) has become one of the state's worst invasive weeds. Despite tremendous impacts, little is known about the plant's invasive ecology. Evidence suggests intraspecific differences exist among invasive species, and these differences may contribute to invasiveness. Such differences have been observed with strawberry guava; in Brazil, its native habitat, plants are less frequent, more variable, and seldom form dense thickets, unlike in Hawai'i. To evaluate intraspecific

differences in seed germination and early seedling growth – both important indicators of invasiveness - we quantified mass, germination rate and early seedling growth for seeds from 30 Brazilian and Hawaiian populations. Twenty seeds per population were weighed to calculate averages, and 100 seeds of each were sown to quantify germination rates. The height and mass of five seedlings of each sample will be quantified 60 days post sowing. Initial findings suggest seed masses are comparable, but Brazilian populations hold greater variability. We expect to qualify the relative contribution of seed mass and early growth rates to seedling competitive abilities. Our findings will represent the most geographically diverse characterization of strawberry guava seed traits, contributing to the understanding of invasive seed/seedling ecology. These findings could enhance theoretical knowledge of plant invasions, leading to more accurate weed risk assessments. Practically, an understanding of varietal differences among an invader is important for prioritization of control efforts, and to locate ancestral populations. This research complements previous and ongoing work to develop effective strategies to control this pest.

P-36 Effects of Light Availability on Biomass and Reproductive Organ Production of the Invasive Rangeland Shrub *Ulex europaeus L.* on Mauna Kea, Hawai‘i

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Ulex europaeus (gorse) are thorny shrubs found in degraded pasturelands, an extreme fire hazard, and noxious weeds in Hawai‘i. They form monotypic stands infesting thousands of acres and alter native ecosystems, produce highly acidic soils, and suppress native plant germination, such as at Mauna Kea, Hawai‘i. However, gorse is light demanding so the addition of forest canopy over gorse stands may be an effective bio-control. I seek to determine the percentage light availability provided by forests and plantations that produce significant decreases in gorse biomass accumulation and reproductive organ production. I surveyed forests and plantations on the eastern slopes of Mauna Kea to determine light availability under different species’ canopies, then tested whether artificial shading (shade cloth structures) that mimics these forests would limit gorse growth and reproduction. I created and applied five light treatments to gorse individuals/cohorts: ambient light (control), 73%, 80%, 90%, and 98% shade and measured basal area, height and volume of 80 plants for 12 months. Following the final measurement all plants were harvested to determine dry mass. I used allometric modeling (16 individuals of differing size) to estimate initial biomass and actual dry weight of harvested plants for final biomass to compute Relative Growth Rates. Results show that the 73% shade treatment decreased biomass accumulation to 1/3 that of the control and that this trend continued up to 98% where gorse individuals/cohorts died and biomass was reduced to just 1/10 that of the control. These initial results suggest that planting native forests and/or plantations with contiguous canopies in gorse stands will reduce biomass accumulation.

P-37 Fuel Loading and Fire Parameters in Nonnative Grasslands on Military and Surrounding Lands on Oah‘u, Hawai‘i

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Recurring wildland fires in landscapes dominated by the invasive guinea grass (*Urochloa maxima*) pose a significant threat to surrounding native ecosystems, landowners, and military preparedness. To more effectively manage Hawai‘i’s natural resources while maximizing military training opportunities, the invasive grass-wildfire cycle must be aggressively managed, and ultimately eliminated. Predicting and managing fire behavior is commonly done with fire models (e.g., BehavePlus), but their realistic use requires a better understanding of spatial and temporal changes in the parameters that most drive fires – fuels and climate. This initial study was conducted to quantify the spatial and temporal variability in fuel parameters. We hypothesized that fuel moisture, total aboveground fuel load, and live:dead biomass ratios would vary with land use history (grazing, fire history), topographical position, and overstory cover. To address this hypothesis, we quantified these variables across military lands and surrounding areas along the Wai‘anae Coast and North Shore areas of O‘ahu. Fuels in guinea grasslands exhibited a wide range of biomass, live:dead ratios, and fuel moistures. Low elevation sites with no tree overstory exhibited the lowest live and detrital fuel moistures at 28% and 9%, respectively. Schofield Barracks sites exhibited the highest live and detrital fuel moistures at >50% and >30%, respectively. Initial results will guide continued sampling efforts to quantify how fuel parameters vary both spatially and temporally. Relating these parameters to climatic data will substantially improve future predictions of the probability of ignition and potential fire behavior, which will be of widespread use to fire managers.

P-38 Invasive Grass Distribution Patterns Along Elevation Gradients in Hawai'i: C3 versus C4 Grasses
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The Hawaiian Islands have been strongly impacted by introduced grasses, which have displaced native vegetation. Most serious grass invaders use the C_4 photosynthetic pathway, while C_3 grasses have been less threatening. Considering altitude, rainfall, and temperature, previous work suggested that rainfall may be the most critical factor influencing C_4/C_3 grass distributions in tropical areas, but temperature may also be important. In Hawai'i Volcanoes National Park (HAVO), a 1968 survey across an elevation gradient found that a transition from C_4 to C_3 grasses occurs around 1,400m elevation, corresponding to a mean maximum temperature for the warmest month of 21°C. To determine whether patterns have changed in the last 40 years, we did vegetation surveys (roadside and natural habitats) along elevation gradients on the islands of Hawai'i and Maui in June 2008. At HAVO, we found the transition point for C_4 to C_3 grasses seems to have increased to 1550m (natural habitat) and 1750m (roadside). This shift in transition point for C_4/C_3 grasses may be influenced by changing disturbance regimes or climate. Contrary to previous grass studies in the tropics, we found that the relative percent cover of C_4 grasses is strongly correlated with mean annual temperature (r=0.927 to 0.698), but not precipitation. An upward shift in C_4 grass dominance has conservation implications, since many C_4 grasses strongly alter fire regimes and other ecosystem processes.

P-39 As The World Ferns...
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Originally introduced to Hawai'i as an ornamental plant, *Cyathea Cooperi*, also known as the Australian Tree Fern (ATF), have become one of Hawai'i's leading invasive plant species. The greatest concentration occurs on the island of Kaua'i. The Nature Conservancy is implementing an ambitious landscape level plan to detect and eradicate this species from these lands. Our main goal is to effectively utilize innovative methods as an efficient solution to large-scale invasive species eradication. A new and improved technological process in remote sensing and image interpretation has substantially influenced the identification and mapping process for eradication. This process involves a small aircraft equipped with extremely high resolution cameras that take pictures in both multispectral and natural color. Data collected from these images is aimed to provide more clarity for the researcher to identify the species of interest. This allows large quantities of information to be gathered with minimal direct impact on the environment in a short period of time. After the images are captured and processed, they are pieced together to form a multispectral mosaic that is used to visually analyze and identify all ATF in the area using various Geographical Information Systems software. Using this software and high resolution imagery, we are able to consistently identify definite and a possible ATF. This data is then used with mapping devices to accurately locate individual ATF in the field during the process of eradication.

P-40 Tamaligi (*Falcataria moluccana*) control in forests across Tutuila Island, American Samoa
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A key threat to the National Park of American Samoa (NPSA) is invasive trees that overtop the native rainforest. NPSA has developed a successful partnership with the Samoan villages that lease lands to the park by working with the traditional village chief councils and utilizing local villagers to restore these forests. This approach, combined with extensive outreach, has created widespread grassroots support for NPSA's conservation goals and management actions to remove invasive species. To date, over 4,700 mature invasive tamaligi trees (*Falcataria moluccana*) have been killed, reclaiming 1,500 acres of forest. A collaborative research program was established in 2007 between NPSA and the Institute of Pacific Islands Forestry (IPIF) of the USDA Forest Service to determine the success and impact of the removal of invasive tamaligi trees by NPSA. Our work demonstrates that most of the dominant native Samoan trees are present even in the heavily invaded forests and are ready to recover once the tamaligi is killed. Fast recovery of the native trees following tamaligi control keeps forest floor light levels low and severely limits tamaligi seedling recruitment. Tamaligi invasion increase soil nitrogen (N), but

with tamaligi control soil N levels return to those of intact forests. NPSA control efforts not only restore native Samoan forests, but the soils that support these forests as well.

P-41 Vegetation Response Following Feral Pig (*Sus scrofa*) Removal in Pu‘u Maka‘ala Natural Area Reserve, Hawai‘i

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Feral pigs alter terrestrial ecosystems in many places by trampling and browsing native vegetation and, presumably, facilitating nonnative plant invasions. In Hawai‘i, feral pig eradication is commonly recognized as the first step for native ecosystem management. Following pig removal, however, native vegetation recovery seems to vary depending on site characteristics, intensity and duration of pig impacts, and native and invasive plant propagules. The objective of this study was to quantify changes in native understory diversity and nonnative invasive plant distribution following pig removal in Pu‘u Maka‘ala Natural Area Reserve. We quantified native indicator species density and nonnative species abundance along five transects prior to and eight years following pig removal (2000 and 2008). Many native indicator species were more abundant following pig removal (e.g., *Clermontia spp*, *Cyrtandra spp*). Total ground vegetative cover doubled following pig removal, primarily due to native fern and herbaceous regrowth. Nonnative plant cover remained low (<5%) after pig removal. However, nonnative *Psidium cattleianum* frequency increased 3-fold from seedling colonization. This increase in *P. cattleianum* may be independent of pig removal and merely a result of close proximity to the advancing invasion front. Despite increases in nonnative plant frequencies following pig removal, low nonnative cover indicates that eradication of these plant species is still a viable option. Invasive plants are dispersed by many vectors and are often pre-adapted to take advantage of increased resource availability following ungulate disturbance. As a result, invasive plant species management is a critical component that should be incorporated into ungulate removal plans.

P-42 Preliminary Results from the First GPS Telemetry Study of Pigs on Moloka‘i

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In 2008, The Nature Conservancy in Hawai‘i used a private contractor (Prohunt Inc.) to assist with feral ungulate control and conduct telemetry monitoring. The purpose of the latter was to determine the home range sizes of pigs and goats, as well as to evaluate the effectiveness of fences and natural barriers on TNC preserves and partner lands on Maui, Moloka‘i and Kaua‘i. Herein, we present preliminary results from the first telemetry study of pigs on Moloka‘i using global positioning systems (GPS). Data was recovered from 11 pigs with GPS collars (Telemetry Solutions, Quantum 5000). Data was also collected on hunter effort by using GPS which logged the hunters' and dogs' daily hunting routes. The number of days pigs were tracked varied from 2 to 116 days. Home range size (minimum convex polygon) ranged from 2.3 to 109.4 hectares (5.7 to 270.3 acres). Home range size seemed to be influenced by the number of GPS points received, as well as gender, site, survival during the tracking period, and whether or not an animal was displaced. No displaced pigs crossed any fences or natural barriers. Two sows were examined to see if hunting had an effect on home range. Both had larger home ranges when no hunting was occurring and showed a constriction in home range during periods when hunting was nearby (i.e. on the same side of the valley or fence as she was). Interestingly, one sow seemed to repeatedly investigate hunting sites (where dogs had been).

P-43 Impacts of Feral Cattle on Forest Vegetation of Kohala Mountain, Hawai‘i Island

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Feral cattle have played a primary role in the historical decline of native Hawaiian mesic forests. The presence of feral cattle has been implicated in significant alterations to native forest structure and composition, but few studies have quantified these impacts. This information is critical to better understand and manage the mechanisms of degradation associated with feral cattle presence in remnant native forests. In collaboration with the Kohala Watershed Partnership, we conducted a study of the impacts of feral cattle on native ‘ōhi‘a (*Metrosideros*

polymorpha) forests on the windward slope of Kohala Mountain, Hawai'i Island. Specifically, we established permanent monitoring plots to compare an area that has historically had feral cattle with an adjacent, cattle-free control area to address the impacts of feral cattle on forest structure and composition. Results indicate that feral cattle significantly impact native mesic forests. In particular, ground cover composition in the presence of cattle shifted heavily towards nonnative graminoids, largely precluding the germination and establishment of native tree species. Most native tree regeneration in the area with feral cattle occurred on standing trees and downed coarse woody debris. Increases in nonnative understory plants were likely related to tree canopy cover, which was significantly lower in areas with feral cattle. In addition, cattle altered stand structure, skewing size class distribution towards smaller stems. The data from this study provide a greatly increased understanding of the ecological effects of feral cattle on remnant native forests, critical information for the sustainable management of Hawaiian native ecosystems.

P-44 Identifying Differential Allocation of Food among Queens within Nests of Argentine Ants (*Linepithema humile*) Using Fluorescent Dyes

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The invasive Argentine ant (*Linepithema humile*) is capable of reducing native biodiversity and disrupting ecosystem services, particularly in high-elevation habitats. Unfortunately, control measures have not been entirely effective. Toxic baits greatly reduce ant abundance, but some nests invariably survive, allowing populations to recover. The fact that most nests contain multiple queens may contribute to nest survival, as one or more queens may not be fed toxic bait by workers. Our research tracked the allocation of food within nests to identify whether food is partitioned among queens. In lab trials, we 1) tested the efficacy of two fluorescent dyes mixed in artificial diet to mark worker and queen ants, and 2) measured the extent to which individual queens were fed when queen number differed within nests. We found a 1% solution of FB28 to be the most effective dye, marking 98.3% of workers fed for 3 days. In nests differing in queen number (n=6 replicates per nest size), all queens in single-queen nests fluoresced at medium to high levels. In nests with 3 and 5 queens, 11.1% and 10.0% of queens, respectively, failed to fluoresce. Furthermore, 27.8% of queens in 3-queen nests and 23.3% of queens in 5-queen nests fluoresced weakly, suggesting they were provided with only small amounts of food. Our results support the hypothesis that food is differentially allocated within nests of Argentine ants. We also found that eggs and young larvae fluoresced, providing further opportunity to study food allocation in nests.

P-45 Searching for New Tools for Invasive Ant Control in Hawai'i

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Ants are among the most damaging of Hawai'i's invasive species. Efforts to control invasive ant populations typically use attractive baits formulated with insecticidal toxicants. These baits, however, have met with variable success, depending on the management situation and the ant species targeted. For example, at Haleakalā National Park, the Argentine ant has proved to be especially difficult to control with existing bait products. In 2007-08, I tested three new bait products in an effort to improve tools for managing, and ideally eradicating, this ant in the park. Gourmet Liquid Ant Bait, formulated with a borate active ingredient, performed well in field-based bait preference tests but failed to provide significant control in large scale experimental plots. 0.5 HP Ant Bait is granular bait that employs two different bait carriers as well as two different active ingredients - the metabolic inhibitor hydramethylnon and the insect growth regulator pyriproxyfen. Trials with this product sharply reduced numbers of ants in the plots, but multiple nests survived repeated bait applications. Finally, Advion Mole Cricket Bait (MCB), granular bait formulated with the new active ingredient indoxycarb, yielded promising results in laboratory colony trials but produced little or no control when broadcast in field plots. In all three cases, results at one scale failed to accurately predict outcomes at the largest scale (field plots), underscoring the difficulty of controlling invasive ants in complex natural settings. Future work may need to focus on developing specific bait carriers tailored for particular situations to improve results.

P-46 Non-target Species in Alien Yellowjacket Control Trials Provide Feedback on Impact of Wasp Predation on Hawaiian Arthropod Biodiversity

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— Abstract Withdrawn

P-47 Introduction, Spread and Impacts of Alien Snails and Slugs in Hawai'i

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The horticultural trade has been implicated as one of the most important vectors of snails and slugs globally, including in Hawai'i. During 2004-2006 we surveyed nurseries, botanical gardens and other similar facilities on the six largest main Hawaiian Islands to document the snail and slug species present. In 2006 we began and are continuing to document snail and slug species in non-nursery habitats to determine which species are established outside nurseries. In the nurseries we recorded 31 terrestrial species, of which all but two were alien and five had previously not been recorded in Hawai'i. There are now 38 established non-native terrestrial snail/slug species recorded in Hawai'i. While many have been established for a long time, the non-nursery surveys indicate that some of the newer introductions are spreading quickly and becoming established. In most cases it is not known if these aliens have actively replaced native species or occupied modified habitats from which native snails had already vanished. However, as they spread, especially to higher elevations still occupied by native snails, they may be impacting the native snail fauna, perhaps in some cases via competition for certain components of the litter. Predatory snails, introduced for biocontrol purposes have impacted native snail species via predation. Alien slugs, especially, impact forest regeneration by killing native plant seedlings, perhaps thereby modifying native snail habitats. Hawai'i has more established alien terrestrial snail and slug species than any other Pacific island or archipelago and the rate of introduction shows no sign of declining.

P-48 Using Detector Dogs to find *Euglandina rosea*

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Euglandina rosea, the predatory snail native to the Southeast United Staes and released in Hawai'i in 1955 to control the giant African snail (*Achatina fulica*), is regarded as one of the primary threats to the survival of native Hawaiian land and tree snails. Finding and controlling *Euglandina rosea* poses many problems for natural resource managers as the predatory snails are often difficult to locate and, without building a snail exclosure, impossible to keep out of native snail habitat. Detector dogs have been used on many conservation projects and have been trained to detect many different targets, such as: animal scat, plants, and animals. The Army Natural Resources Program contracted with Working Dogs for Conservation based in Montana to train two dogs to detect *Euglandina rosea*. Initial training took place in Montana during November/December 2008 and January/February 2009. The dogs and their trainers continued to train here in the Wai'anae Mountains of O'ahu between February 24 and March 19, 2009. This project was a trial to gauge the feasibility of using dogs here in Hawai'i to assist field workers with *Euglandina rosea* detection. The dogs proved that they have a lot of potential and perhaps could be a valuable asset working cooperatively with humans to increase the chances of finding more predatory snails in the field.

P-49 Invasive Veronicellid Slugs in the Main Hawaiian Islands

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The family Veronicellidae includes some of the most damaging and widespread slugs in Hawai'i. These invasive slugs are major domestic, agricultural, and environmental pests. The first record of a veronicellid in Hawai'i was in 1900. However, the different veronicellid species are difficult to distinguish and correctly identify. The focus of this study was to resolve this problem, which has led to considerable confusion as to the actual species present in Hawai'i. According to historical collection data (Bishop Museum) and literature reports, and more recent surveys, three species have been recorded: *Laevicaulis alte*, *Sarasinula plebeia*, and *Veronicella cubensis*. I have re-examined these collections using three approaches. External morphology can distinguish the black slug, *L. alte*

from the other two, but it was not possible to distinguish *S. plebeia* and *V. cubensis* reliably by external morphology. Adult specimens of these two species were therefore dissected and distinguished on the basis of key reproductive structures. Juveniles, however, could not be distinguished, so a DNA sequencing approach involving the 16S mitochondrial marker was used and proved reliable for distinguishing individuals with undeveloped reproductive structures. Using a combination of these three approaches, I am now able to confidently identify these veronicellid species. A number of specimens labeled as *S. plebeia* in the Bishop Museum were sequenced and shown to be *V. cubensis*. It is possible that the brown slug, *S. plebeia*, quite variable in color, may never have been in Hawai‘i or that it was but is no longer widespread.

P-50 2008 Field Season at Kure Atoll: Habitat Restoration and Seabird, Monk Seal, and Spinner Dolphin Monitoring

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Located at the northwest tip of the Hawaiian archipelago within the Papahānaumokuākea Marine National Monument, Kure Atoll provides nesting habitat for 17 seabird species and is one of the six breeding sites of monk seals in the Northwest Hawaiian Islands. Habitat restoration efforts during the 2008 field season included chemical and manual removalal of 32 acres of the invasive species, *Verbesina enceloides*, outplanting of 6 acres of native shrubs and groundcover, and removal of 7,325 pounds of marine debris from marine intertidal and subtidal coral reefs. *Verbesina encelioides* was chemically treated with Round-up and mechanically removed by paid staff and volunteers. Differences between spraying and hand-pulling weeds were tested in a continuation of a 2007 trial to determine (1) Long term kill rate of spraying vs. hand-pulling and (2) Long-term kill rate of native plants. Rare plant range was increased by transplanting, propagating, and outplanting 100 *Eragrostis paupera* and 50 *Lepturus repens*. Seabird monitoring included banding 1,947 Black footed Albatrosses, 369 Laysan Albatrosses, 50 Christmas Shearwaters, 46 Brown Boobys, and all 13 Masked Booby fledglings. Staff assisted in the tagging and monitoring of 15 weaned monk seal pups. One necropsy was conducted on a dead monk seal born at the pier. Ten spinner dolphin surveys were conducted with a minimum of 700 photographs taken during each survey. During the 2008 season, various groups were hosted on island including National Geographic's Wild Places, US Coast Guard, as well as two Hawaiian cultural practitioners and a group of marine archaeologists.

P-51 Are Introduced Barn Owls (*Tyto alba*) a Significant Predator of Procellariform Seabirds in Hawai‘i?

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Introduced Barn Owls (*Tyto alba*) in Hawai‘i are known to prey upon Newell's shearwaters (*Puffinus auricularis newelli*). However, the significance of this predation in the decline of these threatened seabirds is unclear. Understanding these interactions has important implications for guiding management priorities at shearwater colonies. From 2006-2007, we opportunistically collected 41 Barn Owls from Bird Air Strike Hazard (BASH) reduction programs near two active Wedge-tailed shearwater (*Puffinus pacificus*) colonies, and control sites without seabirds nearby, on Kaua‘i. We considered Wedge-tailed Shearwaters a reasonable proxy for Newell's shearwaters given their similar size and breeding behavior. We also collected cats from seabird management projects on Lana‘i and Maui to provide diet comparison to a known seabird predator. We analyzed owl proventriculus contents, and compared the Carbon and Nitrogen stable isotope ratios in muscle biopsies obtained to known terrestrial (rodent, amphibian, large invertebrates) and potential marine (shearwater) reference samples. Proventriculus contents revealed no traces of seabirds from Kaua‘i Barn Owls. Stable isotope results also suggested a primarily terrestrial diet for the Owls sampled, however a clear marine signature was present in a small number of individuals, including one from Lehua Islet. Of importance, owls collected near airports were primarily sub-adults (95%), suggesting a sample biased towards more inexperienced birds that appear less likely to take shearwaters. Here we present preliminary results, including discussion of owl hunting behavior, periods of highest risk for endangered seabirds in Hawai‘i, and the application of a novel lab technique for monitoring predators.

Freshwater/Brackish Systems

P-52 Atlas of Hawaiian Stream Animals

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The Atlas of Hawaiian Stream Animals was produced through a collaborative effort by the Hawai‘i Division of Aquatic Resources and Bishop Museum to aid in the determination of critical habitat statewide as part of a major effort to organize, catalog, report, and disseminate information on the status of Hawaiian streams and their aquatic resources. The information in the Atlas includes all data from historic and present State stream surveys as well as information from over 200 reports and publications from experts statewide. The Atlas combines species observation information from a relational database (MS Access) with spatial information from a geographic information system (ArcGIS) to provide tabular, graphical, and map-based results for more than 30 of the most commonly observed native and introduced animals. The description for each animal species includes habitat characteristics like habitat type (riffle, run, pool, etc.), depth, and substrate, as well as instream distributional characteristics like elevation, maximum downstream barrier height, and distance inland. The Atlas’s design provides easy updating of the species information to allow new survey data to be rapidly incorporated in future web and printed versions. The Atlas provides insight into important factors affecting habitat and distribution of aquatic animals and improves decision-making for habitat and instream flow issues among the different watersheds.

P-53 Characterizing the Habitat Structure and Unique Fauna in Anchialine Pools on the Island of Hawai‘i

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Anchialine pools are rare and localized brackish-water systems fed by a mixture of groundwater and seawater. They do not have a direct surface connection to the ocean, but do fluctuate with the tide. Occurring in restricted places worldwide, these coastal ecosystems are found on four Hawaiian Islands with the majority on Hawai‘i Island. These systems support a unique anthropod and mollusc fauna, including candidates for listing as threatened or endangered species. We have conducted baseline surveys of pools in four coastal national parks on the Island of Hawai'i, and are developing a classification scheme based on pool structural origin, size, age, water chemistry, substrate, and vegetation type. A range of pool types occur in the national parks, from culturally modified to undisturbed pools, collapsed lava tubes, fissures, and caves. Species identified during pool reconnaissance surveys include the common crustaceans *Metabetaeus lohena* (candidate) and *Halocaridina rubra*, a rare and still to be identified neritiliid snail species and other more common molluscs, and the orange/black Hawaiian damselfly *Megalagrion xanthomelas* (candidate). Anchialine pools are threatened by numerous anthropogenic activities, including the introduction of fish (tilapia, and topminnows or poeciliids), upslope and adjacent development, and ground-water withdrawal. Sea level rise is also of concern as numerous pools are within an elevation of two feet. A monitoring protocol is being implemented by the National Park Service Inventory and Monitoring Program to allow assessment of pool status, determine trends over time, and to evaluate restoration potential.

Marine Systems

P-54 Passive Acoustic Monitoring of Marine Ecosystems in the Pacific Islands Region

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Monitoring the changing state of marine habitats is a challenging task, especially when those habitats are in remote locations. Passive acoustic monitoring is an excellent, and often the only, means of gauging levels of biological and anthropogenic activities in such remote areas. Since 2006, the Pacific Islands Fisheries Science Center, in partnership with the University of Hawai'i, has been building a network of long-term acoustic monitoring stations across the Pacific Islands Region using Ecological Acoustic Recorders (EARs). The network is currently composed of 29 long-term monitoring stations located throughout the Hawaiian Archipelago, American Samoa, the Line Islands, Johnston Atoll, Wake Atoll, Guam and the Commonwealth of the Northern Mariana Islands. There are EAR monitoring sites in near-shore waters managed by the local jurisdictions, National Marine Sanctuaries Program, National Park Service, and the recently established Marine National Monuments of Rose Atoll, Mariana Trench, and the Pacific Remote Islands. EARs are deployed by scuba divers and may be refurbished by local partners and/or during research cruises to deployment locations. A wide range of natural and anthropogenic acoustic signals are monitored, including sounds produced by invertebrates, fish, cetaceans, vessels and surface weather events. The long-term trends in biological acoustic activity obtained through this network will be used to gauge the relative stability of the ecosystems associated with each location. Detections of vessels are common at many locations and provide a quantitative means of establishing levels of anthropogenic activity.

P-55 Evaluating Spatial and Temporal Patterns of Green Turtle Distribution at a Foraging Hotspot in Kailua, O'ahu

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In the summer of 2008 we initiated a year-long study in collaboration with NOAA Pacific Islands Fisheries Science Center to assess the significance of Kaimalino (Kailua, O'ahu) as an aggregation hotspot for green turtles (*Chelonia mydas*). This ongoing study has two primary objectives: (i) quantifying the number of turtles using the site throughout the year, and (ii) determining their spatial and temporal distribution patterns. Mark-resight techniques are used with the Peterson estimator to evaluate the resident turtle population that utilizes Kaimalino on a seasonal basis. To achieve four discrete population estimates, turtles were marked with identification numbers in November, February, and May; the fourth marking session is scheduled for August. The resighting surveys occur < 24 days post-marking and sample different combinations of tidal phases (rising, falling) and times of the day (morning, midday, afternoon). Additionally, twelve individual turtles are being tracked using acoustic tags, and their movements are assessed in relation to tidal phases, diel cycles, and seasons. This poster focuses on the results from fall (November 2008) and winter (February 2009). These population estimates indicate a 35% decline in turtle abundance from fall (62, 95% CI 50 - 75) to winter (40, 95% CI 29 - 56), which may reflect suboptimal seasonal conditions. Despite this, individual turtles have used the site consistently throughout the study period. Additionally, all tagged individuals returned to the study site after they were released, underscoring the importance of Kaimalino for green turtles that utilize Kailua Bay during the juvenile stages of their lives.

P-56 Summary of the Effects of a Warming Climate on Pacific Sea Turtles

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The effects of climate change on protected marine resources must be considered and incorporated into analyses of impacts of Federal actions on threatened and endangered sea turtles via consultations under Section 7 of the Endangered Species Act (ESA) conducted by NOAA Fisheries Pacific Islands Regional Office (PIRO). Three areas of analysis required under Section 7 where climate change should be considered include: environmental

baseline (past and present impacts of all state, Federal or private actions and other human activities in the action area), current status and trends (including current threats), and cumulative effects (effects of future, non-Federal actions that are reasonably certain to occur in the action area). A literature review summarizing major aspects of sea turtle biology and behavior that may be impacted by climate change is presented. This summary is intended for use by NOAA Fisheries resource managers in the Pacific Islands Region, whose jurisdiction includes Hawai‘i and the US territories of Guam, CNMI, and American Samoa, to acknowledge the effects climate change may have on sea turtles in the context of other anthropogenic impacts while making management decisions. The five most direct effects discussed include: 1) changes in hatchling sex ratios; 2) loss of nesting habitat due to sea level rise; 3) alterations to foraging habitats and prey resources; 4) changes in phenology and reproductive capacity that correlate with fluctuations in sea surface temperature (SST), and 5) potential changes in migratory pathways and range expansion.

P-57 The First Rehabilitation and Release of an Abandoned Endangered Hawaiian Monk Seal (*Monachus schauinslandi*) Pup in the Main Hawaiian Islands

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In 2008, an endangered, male Hawaiian monk seal pup (KP2) was abandoned on the island of Kaua‘i. After several unsuccessful attempts to reunite it with its mother, the seal pup was rescued and placed in captive rehabilitation by authorized National Marine Fisheries Service (NMFS) personnel. KP2 was 24-hours old, underweight, and appeared dehydrated. The Marine Mammal Center of California provided veterinary consultation and experienced personnel to direct the care and husbandry. Initial challenges were determining the correct nutrition for a mother’s milk substitute and to prompt KP2 to forage without aid. Challenges later included a mild, diffuse bilateral corneal edema. Empirial drug therapy for corneal edema was used with careful monitoring for treatment side effects. Rapidly progressing in severity in both eyes, the edema had an unknown cause, hypothesized to have been initiated or exacerbated by captive environmental factors. KP2 was moved to an ocean shoreline pen. Over the next two months, the ocular condition improved, and KP2 thrived. KP2 was instrumented with a satellite transmitter and radio tag. NMFS veterinarians and managers cleared the seal for release at Kalaupapa, Moloka‘i, chosen for its remoteness and limited human contact. Remotely monitored for approximately 120 days, KP2 exhibited normal foraging behavior. This was the first neonatal monk seal rehabilitation in the main Hawaiian Islands. KP2 provided invaluable information and management lessons, demonstrating that the capacity to rescue pre-weaned pups, provide captive care, and release back into the wild is essential for adaptive management in future recovery efforts for Hawaiian monk seals.

P-58 A Demographic Approach to Monitoring Change in *Acropora* Corals of the Hawaiian Archipelago

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Acropora corals in the Hawaiian Archipelago are unique, with presence limited to reefs between Kaua‘i and Pearl and Hermes Atoll and with abundance centered at French Frigate Shoals (FFS). Based on *Acropora*’s limited distribution and susceptibility to environmental stressors such as rising sea temperatures, disease, and predation, the status of *Acropora* may be an indicator of ecological change in the Hawaiian Islands. Thirty-five sites at FFS were surveyed in 2007 and 2008 to investigate the distribution, population density, and size structure of *Acropora cytherea*, the most common *Acroporid* coral in Hawai‘i. Density of *A. cytherea* was highest in reefs on the northwest and southwest sides of the atoll (5.3 colonies m^{-2}) and deeper pinnacle reefs on the west side of FFS (3.9 colonies m^{-2}). These areas also possessed a majority of the colonies with maximum diameters greater than 50 cm. Results were combined with current knowledge of *A. cytherea* demographics at FFS to explore the utility and potential application of a sampling design which collects population demographic data including: size-structure, size-specific fecundity, and recruitment, growth, and survivorship rates. Potential impacts from climate change (rising sea temperatures and ocean acidification), such as increased mortality, reduced reproductive output, and reduced calcification rates, are discussed to explore their modeling potential in hopes of providing resource managers with tools to predict future population levels of *Acropora* in the Hawaiian Islands.

P-59 Baseline Coral and Algal Species Composition at Necker Island, Northwestern Hawaiian Islands
Stephanie Schopmeyer, Peter Vroom, Jean Kenyon
JIMAR, University of Hawai'i, NOAA Fisheries, PIFSC, CRED, Honolulu, HI

The Northwestern Hawaiian Islands are considered to have among the most pristine and least anthropogenically impacted coral reefs in the world. Scientists are provided an opportunity to establish baselines for coral and algal biodiversity to measure "healthy" ecosystem fluctuations and responses to large-scale environmental changes. This study provides the first comprehensive species list for macro and epiphytic algae documented at Necker Island and investigation of spatial and temporal community patterns. Between 2002 and 2006, benthic communities were documented using photoquadrats at long-term Rapid Ecological Assessment (REA) monitoring sites. Percent cover of coral and algal species was determined by placing 100 stratified random points on each photoquadrat using CPCe and analyzing the benthos underneath. Results from photo analyses were then analyzed in PRIMER to determine spatial and temporal patterns. Additionally, macroalgal herbarium pressings and microscope slides of epiphytes were prepared from specimens concurrently collected along each transect. Eleven coral and 8 macroalgal species were identified at REA sites. Common in high energy reef environments, benthic percent cover was dominated by turf algae (79.1 + 11.7%) followed by coral (10.3 + 12.9%) and macroalgae (8.6 + 7.2%). Overall, percent cover was found to be similar between sites with slight variations (up to 14.5%) between NEC-02 and NEC-04 in 2006 due to the abundance of turf algae, the scleractinian coral, *Porites lobata*, and the macroalga, *Halimeda velasquezii*. Temporal differences were not detected possibly due to the small number of sites surveyed in multiple years.

P-60 Distribution of Mesophotic Macroalgae in Hawai'i: A Surprisingly Diverse Assemblage from the Deep
Heather Spalding, Isabella Abbott, Kimberly Peyton, Celia Smith
University of Hawai'i at Mānoa, Honolulu, HI

The mesophotic (low-light) coral ecosystem in Hawai'i ranges from ~50 to over 200 m. A conspicuous and yet to be described component of this ecosystem is the macroalgal flora. We used a combination of submersibles, remotely operated vehicles, and technical diving to survey mesophotic algae at 36 sites around the Main Hawaiian Islands (MHI). The deepest occurring alga was a filamentous chlorophyte (*Cladophora sp.*) at 212 meters. Expansive macroalgal meadows of siphonous green algae were found at multiple locations around O'ahu (*Avrainvillea amadelpha, Udotea sp.*) and the Maui Nui Island complex (*Halimeda kanaloana*) to 90 meters. Surprisingly, these meadows were distinct to these specific islands. Numerous new records and species of macroalgae were discovered, suggesting the deepwater flora is unique from shallow water. Deep water algae previously described as endemic to the Northwestern Hawaiian Islands (e.g. *Kallymenia spp., Codium spp*.), were found in the MHI deep flora as well, showing some algal distributions to be fairly continuous across the Hawaiian Island chain. In contrast, other species (*Halymenia* spp., *Grateloupia* sp.) appeared unique to the MHI, or represented significant range extensions (e.g. *Caulerpa filicoides, Caulerpa mexicana*). Overall, the deep water flora appears to be abundant and biogeographically diverse with a combination of temperate, subtropical, and tropical affinities. The current study contributes greatly to our understanding of marine biodiversity and biogeography in the Pacific, and has significant implications regarding the unique nature of mesophotic coral ecosystems in Hawai'i.

P-61 Controlling an Invasive Marine Algal Species in a Culturally Significant Hawaiian Fishpond
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Kaloko Fishpond, located in Kaloko-Honokōhau National Historical Park, is undergoing restoration to function as a traditionally-managed Hawaiian aquaculture facility. An unintentionally introduced alien marine alga, *Acanthophora spicifera*, invasive elsewhere in Hawai'i, was first documented at Kaloko Fishpond in 2000. This alga is degrading the pond's water quality and there is a risk of it spreading to nearby coral reefs. The University of Hawai'i Pacific Cooperative Studies Unit and the National Park Service initiated a project to control this alga in Kaloko Fishpond. Prior to removal efforts, the alga covered 66% of pond substrate and, after removal, decreased to 24%. Different removal methods were assessed and all showed a substantial initial decrease in algal density, but the long-term effect was minimal because of rapid re-growth. The use of shelters to boost local fish

populations appeared to be the most promising method. A management strategy to substantially reduce the algal biomass in the fishpond should include biological control and periodic manual removal of the algae.

P-62 Three Fish, Two Fish, One Fish, No Fish!
Terah T. Summers, Serena S.N. Perry
Baldwin High School, Wailuku, HI

Our project investigates the impact of fish on coral reefs in Maui. We hypothesized that a greater presence of fish correlates to a healthier coral reef. To test our hypothesis, we performed multiple line transects to record the fish population at two coral reefs that are in an area with fishing restrictions. The same amount of line transecting was conducted at two other coral reefs that were in areas with unrestricted fishing. Line transecting, is a methodical and consistent procedure to quantify the fish population within a designated area. To conduct our line transects, we snorkeled along a measured line over four selected coral reefs while tallying the number and types of fish sighted within a five meter belt transect. According to our line transect data, the coral reefs at the Marine Life Conservation District and Natural Area Reserve had a greater fish population, and reefs that were more vibrant in color and structure. Therefore, we concluded that our data supports our hypothesis that a thriving population of fish is vital to the health of coral reefs found on Maui.

Native Species

P-63 Digital Atlas of the Hawaiian Biota
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The Digital Atlas of the Hawaiian Biota has been produced as a way to distribute basic spatial information about the geographic ranges of native Hawaiian plant and bird species. We developed GIS models to construct potential range maps for over 1,000 native Hawaiian vascular plants based on current environmental conditions (specifically elevation, available moisture, and substrate age) for the documented locations of each species. Maps of projected ranges of bird species produced previously through the HIGAP project have also been incorporated. The Atlas will be available in printed form (limited number of copies) and via the internet. The web-based Atlas will make available JPEG images of maps, GIS shapefiles of each species' projected geographic range, and supplementary information on our modeling methodology. An extension of this project is the development of a GIS tool with which can be used to predict the potential species composition of a defined polygon. Eventually we envision a similar tool to estimate the likely vegetation of a defined area (in terms of structure and dominant species).

P-64 Biodiversity on Coastal Lands in Hawai'i
Stephanie Tom, Samuel Gon III, Jason Sumiye, Theresa Menard, Jody Kaulukukui
The Nature Conservancy, Honolulu, HI

Native biodiversity found on coastal lands in Hawai'i are threatened by rising sea levels due to climate change, as well as other critical threats. The Nature Conservancy has conducted a statewide assessment of seabird nesting sites, coastal vegetation, and anchialine pools in Hawai'i. The purpose of this assessment is to understand the distribution and viability of these coastal biodiversity targets, in light of anticipated change along coastlines due to development and climate. Factors considered in ranking viability include biodiversity richness, abundance, and landscape context. Information about locations and biology of coastal targets and their threats were collected from databases and reports generated by experts on seabirds, anchialine pools, and coastal vegetation, as well as personal communication with experts. We created a separate GIS shape file for seabird nesting sites, coastal vegetation, and anchialine pools, and organized the information by specific locations. Based on a better understanding of biodiversity on coastal lands, TNC has identified statewide conservation goals for these biodiversity targets and proposes a portfolio of sites where effective conservation is needed across the state in order to reach the conservation goal. The products of this effort include a statewide geospatial dataset for biodiversity on coastal lands, a clear idea of missing data, and a good sense of what is needed to effectively

conserve seabird nesting sites, coastal vegetation, and anchialine pools in Hawai‘i. These products can guide future efforts to conserve biodiversity on coastal lands statewide.

P-65 USFWS Assists Landowners to Restore Habitat for Federally Listed Threatened and Endangered Species on Kaua‘i through the Conservation Partnerships Program

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The Conservation Partnerships Program is a collection of voluntary habitat restoration programs with the goal of restoring native Pacific Island ecosystems through collaborative projects. The Conservation Partnerships Program provides cost-share funds, as well as information on habitat restoration techniques, native species, additional funding sources, required permits, and potential vendors of restoration services. Kaua‘i currently has over 100 endangered species and about 23,190 hectares (57,300 acres) designated as critical habitat. Recently USFWS announced an ecosystem-based proposal to add an additional 48 species found only on the island of Kaua‘i to the federal endangered species list and designate critical habitat. The USFWS has entered into partnerships with the National Tropical Botanical Garden, the Nature Conservancy and the State of Hawai‘i, Department of Land and Natural Resources through the Conservation Partnerships Program to aid in the restoration of lowland wet, lowland mesic, montane mesic and montane wet ecosystem types to benefit many of Kaua‘i’s rare species. This presentation will highlight these projects and the conservation practices being planned and implemented.

P-66 Assessment of *Acacia koa* Forest Health and Dieback across Elevation and Rainfall Gradients in Hawai‘i Using Fine Resolution Remote Sensing

Rodolfo Martinez Morales, Travis Idol, James B. Friday
University of Hawai‘i at Mānoa, Honolulu, HI — Abstract Withdrawn

Koa (*Acacia koa*) is an important native tree species in Hawai‘i economically and ecologically. Koa forests can be found across a wide range of elevation and rainfall gradients across the Hawaiian Islands. Although koa productivity increases at higher temperatures/lower elevation, it becomes highly susceptible to diseases such as koa wilt that kill seedlings and young trees before they reach maturity. It can also cause partial to full canopy dieback of mature trees. Significant dieback of koa forests would greatly impact timber production, affect watershed health, reduce critical habitat for native flora and fauna, and allow for invasion by non-native species. Therefore, it is important to study the disease distribution and spread in order to implement monitoring strategies for early and efficient disease control and management. Since the disease occurs in patches, most research efforts have been focused on characterizing tree crown symptoms and understanding the role of pathogens in koa dieback within patches. Findings have been limited to plot-level assessments mainly in accessible areas. Additional research needs to be done to achieve a more complete assessment of dieback at the landscape scale and to relate patterns to changes in site conditions. We will present preliminary results on the use of multispectral and high spatial resolution satellite imagery to accurately map the potential distribution of koa dieback at the patch, stand, and landscape scales in the Islands of Hawai‘i.

P-67 *Acacia koa* Forest Classification and Productivity Assessment across Environmental Gradients in Hawai‘i using Fine Resolution Remotely Sensed Imagery

Rodolfo Martinez Morales, Travis Idol, Qi Chen
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Acacia koa (koa) forests are found across elevation and rainfall gradients in the Hawaiian Islands. The purpose of this study was to develop methodologies to differentiate these forests using fine resolution remotely sensed imagery and to relate image analysis parameters to indicators of forest productivity across these gradients. IKONOS satellite imagery was analyzed using advanced statistical modeling and compared to field measurements of productivity indices. The calculation of several vegetation indices that are commonly used in vegetation studies allowed classification of various koa forest types into micro-regions in wet and dry locations across elevation gradients ranging from 300-850 m. Vegetation indices and image texture parameters strongly related to tree height, leaf nitrogen and phosphorus concentration, and specific leaf area. Weaker relationships were seen with leaf area index and basal area. Statistical models were developed that can be used in the

assessment of koa forest productivity indices at landscape and regional scales. This will also allow for the evaluation and application of productivity responses to specific forest management strategies.

P-68 Experimental Restoration of Koa (*Acacia koa*) - ʻŌhiʻa (*Metrosideros polymorpha*) Forest in Former Pastureland, Hawaiʻi Volcanoes National Park

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The Kahuku unit of Hawaiʻi Volcanoes National Park (HAVO) contains seven thousand acres of active cattle pastures in former koa-ʻōhiʻa forest that will be phased out in 2009. Most of the forest was cleared by bulldozing in the early 1970s creating an open pasture with small remnant stands of native species. Methods to facilitate forest recovery must be determined to maximize native recovery in the presence of alien species. In 2005, four experimental ungulate-proof exclosures (4 hectares each) were constructed to evaluate forest recovery across a moisture and elevation gradient and proximity to intact forest. Within the exclosures three temporary grass removal methods (herbicide, soil turnover, and herbicide/soil turnover) were tested to facilitate natural recovery of native species. In addition, native recovery was augmented by direct seeding and planting. Two years following treatments native recovery was evident in grass removal plots; however, alien grasses still dominated all treatments. Natural recruitment of koa was 3-15 times higher in the herbicide/soil turnover than the other removal treatments with no koa seedlings found in the unfenced area. Planted seedling survival was high across sites and treatments (57-70%) one year following planting consequently increasing species richness. Based on these results, it is clear that animal removal and strategic use of grass removal techniques can greatly facilitate the restoration of koa-ʻōhiʻa forest habitat for native species once abundant in the Kahuku region to assure the perpetuation of park biodiversity.

P-69 Experimental Restoration of Lanaʻihale Montane Mesic Forest for ʻUaʻu (*Pterodroma sandwichensis*) Habitat and Watershed Enhancement

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[1]Pacific Cooperative Studies Unit, HI, [2]Hawaiʻi Division of Forestry and Wildlife, HI

The Lānaʻihale native montane mesic forest provides habitat for the endemic, endangered ʻUaʻu (Hawaiian petrel, *Pterodroma sandwichensis*) and forest structure to optimize recharge of the Lānaʻi aquifer. Invasive alien weed species, primarily strawberry guava (*Psidium cattleianum*) are severely compromising the habitat for the seabirds and the ability of the forest to provide optimal aquifer recharge. Pacific Cooperative Studies unit of the University of Hawaiʻi and The Hawaiʻi Division of Forestry and Wildlife, with the guidance of the Hawaiʻi Comprehensive Wildlife Conservation Strategy, are working to restore 1.214 ha.of Lānaʻihale. Twelve 100 square meter plots were established prior to work commencing to document existing plant species, densities and size classes. Native vegetation comprised 97 species in 46 families, including trees, shrubs, lianas, ferns, grasses and sedges. *P. cattleianum* was estimated at 70,415 stems on the 1.214 ha.site. The only non-native tree species to be left on the site is the Cook Pine due to its documented ability to capture moisture from clouds, fog drip. On-island staff assisted by staff of the Maui Invasive Species Committee and volunteer groups, use mechanical and chemical control techniques to achieve habitat transformation. Existing native plants are protected and seed bank regeneration is encouraged. Uluhe fern (*Dicranopteris linearis*) exists on the site in scattered patches. This fern provides essential cover for the ʻUaʻu from the threat of predation from cats and barn owls. After clearing of invasive plants, propagation and out-planting of native species (i.e.: *Wikstroemia bicornuta*, and *Bobea sandwichensis*) enhances recovery goals.

P-70 The Hawaiʻi Experimental Tropical Forest: New Opportunities for Research in Hawaiʻi

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The Hawaiʻi Experimental Tropical Forest offers exciting new opportunities for research in Hawaiʻi. Established in 2007, the HETF is comprised of two forest units on the Big Island. Puʻu Waʻawaʻa extends over 35,000 acres on the west side of the island, including tropical dry forest and a designated bird sanctuary alongside pasture and ranch lands. Available study areas range from the anchialine ponds at Kiholo Bay to nearly the summit of Hualalai. On the northeastern slope of Mauna Kea, over 12,000 acres of wet and mesic forest make up the

Laupāhoehoe unit, which contains a Natural Area Reserve (the highest degree of protection in the state) and a Forest Reserve. Both units contain numerous rare, threatened and endangered species of plants and animals and multiple substrate types and vegetation zones. Collaborative research in the HETF has employed new technology developed through the Carnegie Airborne Observatory to map canopy vegetation and areas of species invasion. Other current projects include employing elevation gradients as a model to predict the effects of climate change on Hawaiian forests, establishing permanent plot networks through the HIPPNET project, and plans for a National Ecological Observatory Network (NEON) core site at Laupāhoehoe. Researchers are encouraged to apply for study in the HETF, particularly with projects which support the HETF focus on monitoring, preserving, and sustainably managing tropical forests. HETF is managed through a cooperative agreement between the USDA Forest Service-Institute of Pacific Islands Forestry and the Hawai'i DLNR Division of Forestry and Wildlife.

P-71 Leaf Culture as an Alternative Method for Native Hawaiian Plant Propagation

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Vegetative propagation through the use of cuttings is a common horticultural practice, where whole plants are regenerated from plant parts (root, stem, leaf, leaf bud). It has been demonstrated that many plant species, including both monocots and dicots, possess the capability to produce plants initiated by leaf cuttings. From leaf cuttings, both roots and shoots must develop. Available propagative material is often limited when working with threatened native Hawaiian plants, and must be used efficiently and judiciously. Leaf culture is a novel approach to maximize the use of material taken from field collected native plant specimens. In our investigations, leaf cuttings are treated with a rooting hormone and placed under a greenhouse mist system. At the Lyon Arboretum and Pahole Rare Plant Nursery, we have demonstrated successful root and shoot induction for *Cyrtandra* and *Pepperomia*. Our trials have expanded to include *Schiedea*, *Scaevola*, and *Isodendrion*, and preliminary observations show rooting, but thus far no shoot formation. Any native Hawaiian plant with the potential to propagate by leaf culture should be investigated. Leaf culture could provide an efficient method to greatly bolster numbers of threatened and endangered native Hawaiian plants available for reintroduction. As with any propagation of native Hawaiian plants, genetic implications must be considered. Plant hormones and growing conditions are controlled to maintain genetic integrity of regenerated tissue.

P-72 Resilience-Windward East Maui Subalpine Shrubland Exhibits Upslope Shift

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Non-metric multidimensional scaling (NMDS) analysis, repeated measures ANOVA, and t-tests on modified point-intercept permanent plot data sampled in 1994 and 2008 indicated upslope shifts in subalpine vegetation in Waikamoi Preserve, Windward East Maui. Subalpine habitat 0to1m layer bryophyte increased ($p<0.001$) by three fold and lichen jumped ($p<0.001$) over nine times; alien grass abundance ($p<0.001$) was cut in half; in the 1to2m layer, native fern increased ($p<0.01$) and native shrub abundance ($p<0.001$) tripled. The increase we observed in sensitive bryophytes and lichens both on the ground in the forest and subalpine habitat and epiphytically in the 1to2m forest layer supported the fact that the system was recovering from animal disturbance. In addition, māmane (*Sophora chrysophylla*) was rapidly growing from seed. A NMDS bi-plot demonstrated high elevation plots in 2008 closely resembled lower elevation plots sampled in 1994. Plot species abundance moved away from shrubland dominated by alien grass *Holcus lanatus* and native grass *Deschampsia nubigena* toward a native shrubland dominated by *Leptecophylla tamieamieae* and the fern *Sadleria cyatheiodes* in the 1to2m layer with bryophytes and lichen increasing in the 0to1m layer. Large scale, highly effective ungulate control programs on Windward East Maui released resilient woody vegetation that shifted up the mountain. Bryophytes and epiphytes increased in subalpine and forested transitional habitat indicating characteristics conducive of cloud forest regeneration and the absence of animals. The current and future upward elevation potential of East Maui forest has positive management implications for forest birds and highlights subalpine/forest transition as a management and research front.

P-73 Investigating Population Age Structures with Herb-Chronology
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Population age structures of herbaceous species can provide valuable insights into the invasion patterns of introduced species. However, this is time-consuming with conventional methods of marking plants, and estimates based on plant size are not always correlated to plant age across steep environmental gradients. Population structures can now be investigated with herb-chronology, a fairly new method developed in temperate systems. Similar to dendrochronology in trees, herb-chronology uses annual rings in roots, however there are no published data for tropical environments, where seasonal changes may be less pronounced. I present first data of herb-chronology in tropical systems; these data clearly indicate that annual rings do form in the tropics. Besides several species showing false rings, there may be a correlation with rainfall events in seasonally arid habitats. Some introduced species provide clear evidence for front invasion, whereas other species randomly exhibit a patchy distribution of age classes, thus indicating that seeds are likely wider distributed. The latter group may be harder to eradicate, where as plants establishing seedlings primarily close to the mother plant may be targeted easier in conservation efforts. To improve our understanding of plant invasion patterns, it will be helpful to look at population age structures across steep gradients, such as the elevational gradients of Hawai'i. First data suggest that population structures vary markedly with elevation, and further research may help to elucidate factors influencing phenotypic or adaptive diversity.

P-74 Preservation of Hawai'i's Culturally Significant Native Flora through Seed Banking
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Recent research shows that seeds of many species of native Hawaiian plants are readily storable for years. Our objective is to collect seeds of target species from DLNR and Forestry land on Maui, Kaua'i, Moloka'i, Lāna'i, O'ahu, and Hawai'i to be stored at the Seed Storage facility at Lyon Arboretum. This project targets culturally significant native plant species with declining populations, for which there are no current conservation programs. These species include, but are not limited to, the plants Native Hawaiians used for food and drink, medicines, cordage, building, tools, clothing, canoes, fishing, warfare, and recreational or religious ceremonies. Communication between the seed bank and land owners will allow for future reforestation projects. These reforestation projects will have a direct effect on the native ecosystem by providing habitat for native fauna, curbing erosion, and maintaining watershed preserves. By revitalizing native forests, cultural practitioners will have access to the plants their ancestors have used for thousands of years. Economic and educational programs will also benefit from this project through out planting projects and maintenance of Hawai'i's natural landscape. Generations to come will be able to enjoy Hawai'i's unique flora and fauna because of collaboration between conservation groups and private community organizations to accomplish a common goal. This program is a collaborative effort with PBRC, CCRT, Lyon Arboretum, and other conservation groups, and is generously supported by the Hawai'i Community Foundation's Lennox Fund.

P-75 The Species of Mangrove Forests in Hainan, China
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Mangrove is considered to be the most important ecosystems in tropical and subtropical coastal regions throughout the world. When considering the similarity between Hainan and Hawai'i Islands, management of mangroves in Hainan could be a good example of management and protection of Hawaiian coastal ecosystems. Mangroves in Hainan are dispersed along the coastline and consist of 23 families and 41 species. Mangroves are generally classified into mangrove forest and mangrove associate forest. The mangrove forests include tree species averaging 3.5m tall and can reach up to 10-12m and are mainly distributed in occlusive bays or estuaries with deep and thick silt below the tidemark. Mangrove associate forests are mainly distributed as a belt along the beach above the tidemark and neighboring the mangrove forest. Although their area is usually smaller, the number of species is even more than that in the mangrove forest. Large areas of mangrove forests were destroyed for cultivation after the liberation of China in 1949, and many kinds of crops, such as rice, sugarcane, vegetables, and coconuts were planted on the land from the 1970s to 1990s, but few of them have been

successful. Now the coconut is the only crop remains, though they do not bear fruit well. Most of the areas finally were taken over by just a few species of wild weeds such as *Panicum repens, Setaria sp*., *Paspalum distichum*, and *Axonopus compressus*.

P-76 Habitat Occupancy and Detection of the Pacific Sheath-tailed Bat (*Emballonura semicaudata*) on Aguiguan, Mariana Islands

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The Pacific sheath-tailed bat (*Emballonura semicaudata*) was once common and widely distributed across the southwestern tropical Pacific, and the subspecies that occurred throughout the Mariana Islands (*E. s. rotensis*) now occurs only as a single remnant population on Aguiguan Island. Occupancy analysis is a fairly new technique only recently being applied to bat studies in which echolocation calls are used as a measure of occurrence and activity. We used the approach to quantify the species' foraging activity and its relationship to forest structure and proximity to cave roosts on Aguiguan. Bat occurrence was most closely associated with canopy cover, vegetation stature and distance to known roosts. The metrics generated by this study can serve as a quantitative baseline for future assessments of status following changes in habitat due to management activities (e.g., feral goat control) or other factors (e.g., typhoon impacts). Additionally, we described the search-phase echolocation calls produced by *E. s. rotensis*, and found them to be characterized by a relatively narrow bandwidth and short pulse duration typical of insectivores which forage close to and among vegetative clutter. Given the island's very limited resource base and size (7 km^2), its vulnerability to typhoons, the extreme isolation of the population, and the species' narrow habitat preference and specialized foraging strategy, it is imperative that native limestone forest on Aguiguan be restored to ensure the long-term survival of the Pacific sheath-tailed bat in the Marianas.

P-77 The Timing of Hawaiian Hoary Bat (*Lasiurus cinereus semotus*) Echolocation Activity by Season on Windward Hawai'i Island

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The endangered Hawaiian hoary bat (*Lasiurus cinereus semotus*) annually migrates along the windward slopes of Mauna Loa and Mauna Kea volcanoes. Although most abundant at lower elevations during the summer and fall seasons, bats are believed to migrate to higher elevations in winter. This upland movement, possibly coupled to opportunistic torpor, may be used as a means to conserve energy and to avoid wet lowland weather when foraging for aerial prey is difficult. We investigated the seasonal nature of bat activity in both summer and winter foraging areas over a two year period by deploying automated ultrasound detectors along transects at a major wintering area (Hakalau Forest National Wildlife Refuge, and the nearby Mauna Kea State Park) and an important summer site (Laupāhoehoe Natural Area Reserve). We examined the timing and patterns of nightly echolocation activity by season to determine its relationship to roost proximity and movement. Our monitoring program is continuing for a third year to provide wildlife managers with additional information about how this species uses seasonal habitats and how it may respond to climate change.

P-78 Status and Trends of the Land Bird Avifauna of Saipan, Tinian, Aguiguan, and Rota, Mariana Islands

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Island-wide bird surveys using the variable circular plot or point transect technique were first conducted on the four southern islands of the Commonwealth of the Northern Mariana Islands in 1982, all of which were recently resurveyed; Saipan in 2007, Tinian and Aguiguan in 2008, and Rota in 2004. These surveys, along with those conducted over the last two decades, allowed us to examine the status and trends of land bird populations on and

among these islands. In general, bird population trends varied across islands, with the majority of species on Aguiguan showing an increase since 1982 and the majority on Rota exhibiting a decline. Only one species, the Micronesian Starling (*Aplonis opaca*), showed significant increases across all four islands and none of the species showed consistent declines across all four islands. Some of these trends may be related to land cover changes on each island over nearly the past three decades. Since the 1980s, the amount of open field on all four islands has decreased while secondary forest has increased. Additionally, urban areas have increased on all of the inhabited islands (Saipan, Tinian and Rota) while native forest has declined on Saipan and Rota. Other potential factors in bird population trends include the spread of invasive species such as Scarlet Gourd (*Coccinia grandis*), and potential changes in predation rates.

P-79 Post-delisting Monitoring of the Tinian Monarch

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The Tinian Monarch (*Monarcha takatsukasae*) is a medium sized flycatcher endemic to the island of Tinian in the Mariana Islands. The monarch, formerly listed as endangered, was removed from the Federal endangered species list in September 2004. The Endangered Species Act requires that any species delisted due to recovery be monitored for no fewer than five years. Here we present data collected on survival, territory occupancy, and the population status and trends of monarchs between 2006 and 2009. Monarchs were mist-netted and color-banded at three sites on Tinian to assess territory occupancy and estimate survival using mark-recapture models. In addition, territory mapping in selected habitats and an island-wide Variable Circular Plot (VCP) survey were conducted in 2008. Based on results from the three monitoring plots, both survival and site fidelity of Tinian Monarchs are high. However, the 2008 surveys indicate monarch populations have declined significantly since 1982 and 1996 while most other birds on Tinian have remained stable or increased. VCP based densities of monarchs were similar to those produced via territory mapping for secondary forest and tangantangan habitats. The decline may be due to habitat loss and degradation, predation, or disease. At least one more year of monitoring is planned and another VCP survey is proposed for 2010.

P-80 Hawaiian Owl Conservation

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The Hawaiian Short-eared Owl, or Pueo, (*Asio flammeus sandwichensis*) is an open-country, ground nesting species that inhabits marshes, grasslands, and open forest throughout the Hawaiian Island chain. Found from sea level to 10,000-foot elevations, the Pueo tolerates a wide variety of climatic conditions, and is reported ranging from open grasslands and agricultural areas to rain forests and urban settings. Considered an island endemic, this once abundant species is thought to be in decline largely due to habitat destruction and predation by introduced mammalian predators. On the island of O'ahu, the Pueo is listed by the State as endangered based upon loss of open grassland habitat due to development and conversion to agriculture. As with many of Hawai'i's endemic bird species few studies have been done to address the Pueo's biology, ecology, and life history. Comprehensive statewide surveys designed to derive population estimates, specifically for Pueo, are needed. Given the species' State endangered status on O'ahu establishing a monitoring and conservation program on O'ahu should be a priority. This poster will discuss what is currently known about Hawaiian Owls and proposed plans for conservation of the species both on O'ahu and statewide.

P-81 Using Discriminant Function Analysis to Accurately Sex Maui Alauahio

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The Cardueline finches, from which Hawaiian honeycreepers are derived, exhibit sexual and age related differences in plumage. Distinctive plumage differences are found in many honeycreepers, including both extinct and extant forest species endemic to the island of Maui. Historically, plumage has been used to assign sexes to Maui Alauahio, or Maui Creeper, (*Paroreomyza montana*) as part of banding and re-sight studies. However, with growing field evidence, we have found this method to be unreliable. To investigate this further, we genetically

sexed known-age individuals using blood samples collected in Hanawi Natural Area Reserve and used discriminant function analysis to assess the strength of morphological variables (e.g. mass, and wing, culmen, and tarsus length), that could be used to predict sex. Although models were unable to unambiguously sex all birds in our data set based on the variables used in our analysis, they were able to predict the sex of an individual with relatively high accuracy; particularly for after second year birds. Thus it seems that while alauahio may have lost their ancestral sexual dichromatism, differences in plumage between males and females, there are morphological characters that can still be used sex them. The ability to confidently discriminate between male and female alauahio will allow a variety of questions on social structure, parental investment, disproportionate survival and mating system to be investigated and will aid in recovery efforts for this species.

P-82 Use of Spatial Analysis to Evaluate the Effect of Climate Change on Numbers of Maui Parrotbill

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The Maui Parrotbill (*Pseudonestor xanthophrys*) is a critically endangered honeycreeper endemic to the island of Maui. Sub-fossil evidence suggests that parrotbill ranged across the island's dry forests and on Moloka'i. Human impacts such as the introduction of alien species and habitat destruction have drastically reduced the population to approximately 500 individuals on the northeastern slope of Haleakalā. Within the remaining 50 km^2 of parrotbill habitat, the majority of recent studies have focused on birds inhabiting wet, 'ōhi'a-dominant forest, which is thought to be core habitat. Using resights of marked parrotbill, breeding home range size was estimated geospatially. This home range estimate was used to quantify the current effective breeding population in 'ōhi'a forest. Finally, we add factors of climate change to our model, including rise in elevation of the avian malaria boundary in accordance with global warming and contraction downwards of wet forest, to estimate effects on parrotbill numbers. We discuss conservation implications such as the need for translocation efforts to establish a second parrotbill population on the leeward slope of Haleakalā.

P-83 Stepping Stone Speciation in Hawai'i's Flycatchers: Molecular Divergence Supports New Island Endemics Within the 'Elepaio

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The 'Elepaio (*Chasiempis sandwichensis*) is a monarch flycatcher endemic to the Hawaiian Islands of Kaua'i, O'ahu, and Hawai'i. 'Elepaio vary in morphology among and within islands, and five subspecies are currently recognized. We investigated phylogeography of 'Elepaio using mitochondrial (ND2) and nuclear (LDH) markers and population structure within Hawai'i using ND2 and microsatellites. Phylogenetic analyses revealed 'Elepaio on each island formed reciprocally monophyletic groups, with Kaua'i basal to other 'Elepaio. Sequence divergence in ND2 among islands (3.02-2.21%) was similar to that in other avian sibling species. Estimation of divergence times using relaxed molecular clock models indicated elepaio colonized Kaua'i 2.33 million years ago (95% CI 0.92-3.87 myr), O'ahu 0.69 (0.29-1.19) myr ago, and Hawai'i 0.49 (0.21-0.84) myr ago. LDH showed less variation than ND2 and was not phylogenetically informative. Analysis of molecular variance within Hawai'i showed structure at ND2 (fixation index = 0.31), but microsatellites showed no population structure. Genetic, morphological, and behavioral evidence supports splitting elepaio into three species, one on each island, but does not support recognition of subspecies within Hawai'i or other islands. Morphological variation in elepaio has evolved at small geographic scales within islands due to short dispersal distances and steep climatic gradients. Divergence has been limited by lack of dispersal barriers in the extensive forest that once covered each island, but anthropogenic habitat fragmentation and declines in elepaio population size are likely to decrease gene flow and accelerate differentiation, especially in the endangered O'ahu 'Elepaio.

P-84 Forest Bird Survey Methods and Changes in ‘Elepaio Range at Pōhakuloa Training Area, Island of Hawai‘i

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Annual forest bird surveys have been conducted at Pōhakuloa Training Area (PTA) since 1998 as part of an effort to monitor the ecosystem and protect the endangered species that occur at PTA. These surveys conform to the U.S. Fish and Wildlife Service Hawaiian Forest Bird variable circular plot methodology which has allowed PTA's forest birds counts to be represented in a larger interagency database which facilitates data sharing statewide. The data collected will be analyzed to determine relative abundance, density, and trends in bird populations at PTA. Since birds can often act as indicator species the analysis of the annual bird surveys is an important part of analyzing overall ecological changes at PTA. One example of how this information can be used to influence management is tracking the changes in the ‘Elepaio (*Chasiempsis sandwichensis*) population and the habitat that they occupy. The ‘Elepaio population is geographically isolated from other island populations and has been in decline for at least the past decade. Historical data suggests that the ‘Elepaio were once relatively common and widespread at PTA. The ‘Elepaio range has contracted significantly in recent years and in 2009 no ‘Eleapio were detected during forest bird surveys or incidentally. In addition to annual surveys, three remote acoustic recording stations were recently installed at PTA to monitor bird community composition. This technology provides a 24 hour live feed of bird activity and is currently in the trial stage at PTA.

P-85 Bringing Home the Trash: How Differences in Foraging Lead to Increased Plastic Ingestion in Laysan Albatross.

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With increasing amounts of marine debris in the worlds oceans, the diets of top marine predators, are increasingly comprised in large part of plastics. Indeed, the highly vagile Laysan Albatross, which forages throughout the North Pacific, are well known for their tendency to ingest plastic. Here we examine whether Laysan Albatross nesting on distant islands exploit resources closer to their breeding colony, despite having a much higher dispersal potential, and whether this leads to differences in plastic loads in their chicks. Eighty-five tracking devices were deployed for two years on adults on Kure Atoll and O‘ahu, 2,150 km away. Boluses were collected from chicks to compare the amount of plastic vs. natural food. Laysan Albatross from Kure Atoll ingested almost ten times the amount of plastic compared to chicks on O‘ahu despite both colonies having similar amounts of natural food. The complete segregation of their foraging ranges during the breeding season, which in turn contributed to the differences in plastic ingestion, indicate that Laysan Albatross were able to assess resource variation and alter their foraging strategies accordingly. These results demonstrate how a marine predator that is not dispersal limited alters its foraging strategy throughout the reproductive cycle to maximize energetic gain and how this has led to differences in plastic ingestion. Determining how and where marine organisms come into contact with marine debris has important conservation implications for how we choose to mitigate its environmental impact and can in turn help locate new sources of marine debris.

P-86 Kaua‘i Humane Society’s Contribution to Fledgling Shearwater Health on Kaua‘i

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Save Our Shearwaters has worked with Kaua‘i residents for over 30 years, together rescuing the federally threatened Newell's shearwater (*Puffinus newelli*), which seasonally suffers from a phenomenon termed “fall-out.” Newell’s are highly susceptible to light attraction when they first fly to sea from their colony burrows in Kaua‘i’s upper elevation. Kaua‘i’s citizens commonly find hundreds of these affected seabirds grounded from exhaustion island-wide. In total, citizens have picked up over 30,000 seabirds and deposited them in shearwater aid stations. Save Our Shearwaters staff retrieves and releases these birds. Save Our Shearwaters recently completed its first year under the umbrella of the community's only humane society: Kaua‘i Humane Society. The Society hopes to further the Newell's cause by providing an isolated recovery facility (currently a room within Kaua‘i Humane Society) to treat seabirds injured from fall-out. This recovery effort relieves some of the pressure

to ship state and federally protected seabirds off-island for care. This past season, Save Our Shearwaters picked up 198 hatch-years Newell's, the vast majority banded and released without rehabilitation. Weights and wing chords collected provided insight on Newell's health at fledge. The treatment room replenished any fledglings lacking sufficient fat and nutrient reserves (exhibiting poor keel scores or a weight 10% below the species' mean), and rehabilitated minor fractures and other issues. Next season, blood values will be taken for all seabirds in care. With total protein, pack cell volume, and glucose readings, the Program will provide a yearly picture of community fledgling health.

P-87 Breeding Phenology of Hawaiian Petrels and Newell's Shearwaters on Kauaʻi, Hawaiʻi: Insights from Radar, Auditory, and Visual Surveys

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Hawaiian petrels (*Pterodroma sandwichensis*) and Newell's shearwaters (*Puffinus auricularis newelli*) are endemic to the main Hawaiian Islands, and considered federally endangered and threatened, respectively. For both species, regular monitoring is required by management to determine population trends. Since direct measures of population size and breeding success have proven impractical on Kauaʻi Island at many of the steep and densely vegetated breeding sites, monitoring for both species to date has relied upon indirect measures of activity, primarily movement rates during June (incubation) using ornithological radar. Interpretation of these results and informed decision making about survey design can be improved with an understanding of how indirect measures such as movement and calling rates vary with major breeding tasks. From March-December 2008, we undertook weekly ornithological radar (both species), auditory (Newell's shearwaters only) and visual surveys (Hawaiian petrels only) to monitor intra-annual variation in movement and calling rates throughout an entire breeding season. Results were compared against a comprehensive literature review of predicted breeding phenology. All three measures showed correlation with major breeding tasks, including decreased activity with pre-laying exodus and peak activity during chick-rearing and presence of non-breeders. Ornithological radar data consistently showed the lowest coefficient of variation, suggesting this method would have the greatest statistical strength as an annual monitoring tool, with incubation and guard surveys likely to yield reliable annual monitoring data. The combination of radar, auditory and visual surveys provided most information when determining the timing of breeding tasks for each species separately.

P-88 Remote Acoustic Surveying for Hawaiian dark-rumped petrel at Pōhakuloa Training Area

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The Hawaiian dark-rumped petrel (*Pterodroma phaeopygia sandichensis*) is nocturnal during the breeding season and is active at nesting colonies from one hour after sunset until one hour before sunrise. Remaining petrel colonies have been moved to the upper elevations of their range, making surveying difficult and time consuming. This has been particularly true at Pōhakuloa Training Area (PTA), on Hawaiʻi Island, where remote colonies, difficult terrain, and lack of roadways, complicate researchers' efforts to survey for nesting petrels. In the past, marine radar was piloted as a method to survey for petrel presence, while managing access challenges. Marine radar, however, did not allow for accurate identification of detected objects. In 2008, a pilot study was initiated using remote autonomous recording units (ARUs), a form of bioacoustic technology. They are used to collect a contiguous data set to determine if petrels are present on PTA. Bioacoustics can remain at a site for extended periods of time, conserving cost and personnel time while collecting a superior data set with precise species identification. ARUs are deployed at the southern end of PTA at elevations between 7,000 and 8,500 feet to acoustically survey for petrels. ARUs are rotated between 12 survey points throughout the breeding season to capture each area during the intra-seasonal variation in calling activity. Non-breeding adult petrels vocalize at nesting colonies and are the target of this survey method, reliable call intensity drops off with their departure. The use of ARUs may address issues other researches encounter with surveying remote locations.

P-89 Passerine Bird Trends At Hakalau Forest National Wildlife Refuge, Hawai‘i

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Hakalau Forest National Wildlife Refuge, Hawai‘i Island, was established in 1985 to protect native forest birds, particularly endangered species. Management includes removing feral ungulates, controlling invasive alien plants, reforesting pastures, and supplementing endangered plant populations. To assess effects of this habitat improvement for birds, we calculated annual density estimates from point transect surveys and examined population trends for eight native and four alien passerines over a 21 year period (1987-2007). We tested for changes in bird density in three study areas: (1) middle elevation forest that had been heavily grazed, (2) upper elevation pasture that was reforested during the study, and (3) lower elevation forest that was formerly lightly grazed. In the middle area, Hawai‘i ‘Elepaio and the endangered ‘Akiapōlā‘au and Hawai‘i Creeper increased, and all other native birds showed stable trends and exhibited no evidence of declining trends. Except for declines in House Finch density, trends for all alien birds were also stable. In the lower area, Hawai‘i Creeper, Hawai‘i ‘Ākepa and Japanese White-eye showed increasing trends, whereas densities had declined for the other native species and Red-billed Leiothrix. Within the reforested upper area, densities increased for three common natives-Hawai‘i ‘Amakihi, ‘i‘iwi, and ‘Apapane-and two aliens-Japanese White-eye and House Finch. Bird trends at the Hakalau refuge provide some of the first results of habitat improvement for forest birds in Hawai‘i. Restoring understory vegetation in native forest and tree cover in open pasture benefits both endangered and abundant native birds.

P-90 Diet of Endangered Forest Birds at Hakalau Forest National Wildlife Refuge

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Most endangered Hawaiian honeycreepers are food specialists, and changes in the availability of caterpillars and other arthropod prey, among other threats, have likely contributed to their decline. Among the many interacting factors possibly influencing prey abundance is competition with alien invertebrates and birds. To understand how resources may affect bird populations, we identified prey items from fecal samples of birds captured at Hakalau Forest National Wildlife Refuge, Hawai‘i, during the mid 1990's. Caterpillars were most important for the endangered bird species, comprising between 40% of all prey for Hawai‘i Creeper (*Oreomystis mana*) and ‘ākepa (*Loxops coccineus*) to 70% for ‘Akiapōlā‘au (*Hemignathus monroi*). Spiders ranked second in abundance in samples of ‘ākepa (16%) and Hawai‘i Creeper (18%) but were rare in ‘Akiapōlā‘au samples (3%). Instead, beetle larvae comprised 11% of prey taken by this specialized bark-forager. In contrast, the diet of Japanese White-eye (*Zosterops japonicus*), a ubiquitous introduced species, was highly varied, with spiders most frequent (21%), followed by homopterans (18%), caterpillars (16%), hemipterans (12%) and adult beetles (6%). These results suggest that diet overlap between Japanese White-eye and the endangered birds is relatively small. A more substantial threat to caterpillars likely comes from alien parasitoids, which kill about 25% of native Scotorythra caterpillars at Hakalau. Our results indicate that caterpillars are a critical food of endangered forest birds at Hakalau and that understanding the factors constraining caterpillar populations is a key dimension to managing these birds.

P-91 Release of Captive-Bred Palila (*Loxioides bailleui*) on the North Slope of Mauna Kea, 2003-2009

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The Palila (*Loxioides bailleui*) is an endangered finch-billed honeycreeper endemic to Hawai‘i and currently found only on Mauna Kea in māmane-naio forest between 2,000 and 3,000m elevation. Nearly all of the population resides on the west slope of Mauna Kea with an estimated population of 2,640 in 2008, according to the annual survey led by the Hawai'i Division of Forestry and Wildlife. A second population has been re-established on the northern slope through pilot releases of captive-bred Palila by the Hawai‘i Endangered Bird Conservation

Program (HEBCP) and translocations by U.S. Geological Survey Biological Resource Division. In the years of 2003, 2004, 2005, and 2009 the HEBCP released a total of 28 Palila on the northern slope of Mauna Kea at Pu'u Mali, using "soft release" methods. Palila were held at the release site in two acclimation aviaries for between eleven and nineteen days to habituate to their new environment and to increase the probability that the birds would stay in the area of the aviaries after release. Supplemental food was provided for the Palila at the aviaries for fifteen to thirty days after release. All birds were fitted with radio transmitters and were monitored by HEBCP staff for fifteen to thirty days post-release. Currently the population is not self-sustaining and is estimated at fewer than twenty individuals. However, encouraging evidence suggests that long-term survivability and reproduction are possible. Additional releases of larger cohorts will be necessary to realize the goal of a self-sustaining northern slope population.

P-92 Hawaiian Sea Eagle and Other Extinct Bird Fossils Recently Discovered at the Pearl Harbor National Wildlife Refuge-Kalaeloa Unit

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The U.S. Fish and Wildlife Service (FWS) launched Phase II of the Anchialine Pool Restoration Project in March 2008. While restoring the anchialine pools, the FWS received a shocking surprise in October 2008 when they recovered two large raptor talons and numerous large bones. They had unearthed a treasure chest of bird fossils! Preliminary analysis of all fossils collected to date by Carla Kishinami (Bishop Museum, Vertebrate Collection Manager) and Dr. Helen F. James (Smithsonian Institution, Curator of Birds) suggests a wide range of birds from small song birds to sea birds and raptors may have once occupied this area. Radio carbon dates from prior excavations near Barber's Point suggest the bones are from the latter half of the Holocene. A few species and families recovered but not confirmed are, eagle, crow, nēnē like bird, species of petrel, 1-2 species of shearwaters, long legged owl, moa-nalo, albatross, drepanidini (Hawaiian Honeycreepers), and Cheatoptila. In addition to bird fossils being present, there are also fossilized wood pieces, crab claws, various sizes of mollusks, and fish bones.

P-93 Diversity of Class II Genes of the Major Histocompatibility Complex (MHC) in Hawaiian Honeycreepers

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Class I and class II genes of the *MHC* encode proteins responsible for eliciting adaptive immunity in vertebrates. The distribution of *MHC* alleles in honeycreeper populations may play a role in susceptibility to disease. We conducted two sequencing studies involving the *MHC* class II peptide-binding region in 'amakihi (*Hemignathus virens*) and 'iwi (*Vestiaria coccinea*). To evaluate gene copy number and allelic segregation, 263 clones were sequenced from a captive family of 'amakihi. The finding of 19 distinct alleles from a single individual suggests that 'amakihi possess a minimum of 10 *MHC* class II genes. A total of 35 unique alleles were identified among all members of this family. To evaluate diversity between species and among subpopulations of 'amakihi, a total of 158 clones were sequenced from eight 'amakihi and 154 clones sequenced from eight 'iwi. 98 distinct alleles were isolated from 'amakihi and 66 distinct alleles from 'iwi. The number of alleles/individual ranged from 10-15 with an average of 13.5 in 'amakihi, and from 6-14 with an average of 10.6 in 'iwi. Within 'amakihi, subpopulations from low and high elevations appear distinct, with only one allele in common. Sequences were used to design 33 probes for a microarray-based population level analysis of *MHC* diversity in approximately 1,000 individuals of three native species. Analysis is currently ongoing, but preliminary results suggest at least one species-specific allele in 'iwi. Our current studies may enhance our understanding of the relationship between *MHC* diversity and disease susceptibility in native species.

P-94 Knemidokoptic Mange in Hawai‘i ‘Amakihi (*Hemignathus virens*): One Year Later

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Knemidokoptic mange (caused by the mite *Knemidokoptes jamaicensis*) on two Hawai‘i ‘Amakihi (*Hemignathus virens*) was first observed while mist-netting wild passerines at low-elevation (595 m) in the Manuka Natural Area Reserve (NAR) on the island of Hawai‘i in June, 2007. During subsequent mist-netting in the Manuka NAR in 2008, we found Hawai‘i ‘Amakihi with knemidokoptic mange at all elevations (305 m, 595 m, 863 m, and 1585 m) sampled. The prevalence of mange among Hawai‘i ‘Amakihi was highest at lower elevations with 15% (2/13) at 305 m, 22% (8/36) at 595 m, 5% (1/20) at 863 m, and 4% (1/23) at 1585 m. Also in 2008, we detected 2 out of 36 Hawai‘i ‘Amakihi with knemidokoptic mange in the Keauohana Forest Reserve (293m) approximately 95 km from the Manuka NAR. No other native or non-native species caught at these sites have been found with mange. These data show that *K. jamaicensis* is not restricted to the Manuka area. The presence of this parasite over a large elevational gradient and spatial range indicates a potential threat to high elevation native bird communities in such key conservation lands as the Kahuku Unit of Hawai‘i Volcanoes National Park and the South Kona Unit of Hakalau Forest National Wildlife Refuge. The focus of further investigations should be placed on the transmission of *K. jamaicensis* to prevent further spread of this parasite on the island of Hawai‘i and neighboring islands.

P-95 Efficacy of a Commercial Canarypox Vaccine (Biomune Poximmune C®) in Hawai‘i ‘Amakihi

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Three variants of avian pox virus are present in Hawai‘i - Fowlpox from domestic poultry and two genetically distinct variants of the virus (Pox Variant 1 and Pox Variant 2) that are most similar to Canarypox based on sequence of the virus 4b core protein. We tested whether Hawai‘i ‘Amakihi can be protected from wild virus isolates with an attenuated live Canarypox vaccine. Thirty ‘Amakihi were collected on Mauna Kea from high elevation habitats with low pox prevalence and randomly divided into two groups. One group of 15 was vaccinated with Poximmune C® while the other group received a sham vaccination with virus diluent. Five of 15 vaccinated birds developed potentially life-threatening disseminated lesions or lesions of unusually long duration. After vaccine-associated lesions healed, vaccinated birds were randomly divided into three groups of 5 and challenged with either Fowlpox, Pox Variant 1 or Pox Variant 2. Similarly, three random groups of 5 unvaccinated ‘Amakihi were challenged with the same virus isolates. Vaccinated and unvaccinated ‘Amakihi challenged with Fowlpox had transient infections with no clinical signs of infection. Vaccinated ‘Amakihi challenged with Variant 1 and Variant 2 had mortality that ranged from 0% (0/5) for Variant 1 to 60% (3/5) for Variant 2. Mortality in unvaccinated ‘Amakihi ranged from 40% (2/5) for Variant 1 to 100% (5/5) for Variant 2. While the vaccine provided some protection against Pox Variant 1, serious side effects and low efficacy against Pox Variant 2 make it risky to use in captive or wild honeycreepers.

P-96 How to Use Seabird-Friendly Lighting Strategies to Protect Hawai‘i’s Nocturnal Seabirds

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The impact that outdoor lights can have on night-flying seabirds is significant, affecting numerous species and hundreds of individual birds in Hawai‘i. Species such as ‘A‘o (*Puffinus newelli*) and ‘ua‘u (*Pterodroma sandwichensis*), are harmed by attraction to lights and collisions with overhead utilities on Kaua‘i. Developing and monitoring seabird-friendly lighting strategies and best management practices for island-wide use is the primary focus of avoidance and minimization of the Kaua‘i Seabird HCP. The poster will provide an overview of the KSHCP and present practical information about seabird-friendly lighting styles (ie. fully shielded full cut-off fixtures, mounting angle, shielding etc.) and architectural considerations as well as collaborative efforts to

examine how different lights affect seabird behavior. Handouts on seabird-friendly-lighting and best practices for minimizing risk to seabirds will be provided.

P-97 DNA Barcoding in a Diverse Hawaiian Insect Group: Both Heteroplasmy and High Identification Success in *Hylaeus* Bees

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DNA barcoding - the use of standardized gene fragments for species identification - is potentially an extremely useful technique for conservation in Hawai'i, with its many diverse insect and plant lineages that are difficult to identify morphologically and are of high conservation interest. Although a large number of studies have been published on barcoding, there have been relatively few papers examining its effectiveness where it is both most useful and most vulnerable to error: separating closely related species in a comprehensively-sampled, taxonomically known group. In order to test this situation, we sequenced 49 species of Hawaiian *Hylaeus* bees, including all but one of those known to be extant. Twenty-one species were exhibited heteroplasmy, with multiple mitochondrial DNA haplotypes in a single individual. In some individuals, the polymorphism rate exceeded the average level of divergence between species. Despite this problem, only two small species complexes could not be reliably separated by DNA sequences, and many island populations were differentiated as well. The identification success of DNA barcoding in this case is higher that critics claim, but the effort and expertise required is also greater than is often stated by proponents. Thus, it is likely that barcoding will find application among the most morphologically difficult groups, where it is almost impossible for non-experts to reliably identify species, and for identification of fragmentary material.

NOTES

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