ANRPO Research Needs, August 2022

	Ecosystem Restoration		
Taxonomic Group	**Research Topic**	**Management Objective**	**Notes**
Ecosystem Restoration	Designing monitoring strategies for the ecosystem restoration program	Increase efficacy of monitoring to inform adaptive management to increase survival of rare species	This is not direct research; however, the program would benefit from engagement with faculty and researchers to design montoring strategies for the ecosystem restoration program that would provide information necessary to answer specific management objectives, measure or assess progress towards meeting restoration objectives or targets, and inform adaptive management strategies.
Ecosystem Restoration	Measure rare resource response to threat control	Increase utility of monitoring data for rare species	ANRPO does extensive threat control to protect rare resources. Threat control measures are based on best practices and/or past research. However, ANRPO has limited capacity and/or ability to consistently measure rare resource responses to threat control. For example: the benefit of slug control for select rare plant taxa was established by Joe (MS Thesis, UH, May 2006), and ANRPO conducts slug control around susceptible rare taxa sites, however these sites are not monitored for rare resource response (many potential variables). How can we best monitor rare resource (plant, bird, snail, arthropod) response to a variety of threat control measures?
Ecosystem Restoration	Testing the relative suitability of the Hawaii Provisional Seed Zone Maps (Loomis and Keir) to inform seed transfer in ecological restoration	Increase survival of outplantings, preserve local plant variation.	For plant species important in ecological restoration, seed transfer zones have been developed in many parts of the country to inform the appropriate use of restoration plant materials to maximize the probability that sown seed will germinate, establish, persist, and reproduce without negatively impacting the genetics of remnant/wild plant populations. In the absence of empirically based seed transfer zones for Hawaiian taxa, Loomis and Keir developed provisional seed zone maps for each island based on ecological and climatic variables intended for use as proxies. Conducting common garden experiments (measuring variation in traits presumed to influence plant performance) using a subset of Hawaiian species found throughout the state and commonly used in ecological restoration is an important step to test the relative suitability of each seed zone map in delineating seed tranfer zones .
	Greenhouse Pests		
Taxonomic Group	**Research Topic**	**Management Objective**	**Notes**
Greenhouse Pests	Investigate chemical and physical barriers to the movement of alien snails and slugs in plant production settings.	Improve horticultural sanitation practices for the production of clean plants for outplanting	Biosanitation is important for restoration outplanting, to avoid inadvertent introduction of new pests to native forest areas. Alien snails and slugs can be persistent greenhouse pests. While a variety of control techniques and measures exist, multiple actions are generally needed to mitigate these pests. Are there other measures, such as physical barriers, that are effective, cost- and labor-efficient, and long-lasting?
	Invasive Plants		
Taxonomic Group	**Research Topic**	**Management Objective**	**Notes**
Invasive Plant	Herbicide efficacy and application techniques	Develop weed control techniques	Test herbicide efficacy and application techniques for various taxa as needed. Research into novel herbicides, control techniques, application methods. Research to support the the approval of Special Local Needs labels to support use of select products in wildland/forest areas in Hawaii. Some topics include but are not limited to: fern control techniques (variety of species); organic herbicides (evaluate efficacy); *Stapelia gigantea* control techniques; Fusilade DX - tests on priority grass taxa to support expansion of SLN.
Invasive Plant	Identify *Cenchrus setaceus* habitat requirements, and model appropriate range and potential spread, and how spread would impact future fire behavior, and rare plant habitat	Support incipient invasive plant control and management and reduce fire risk	Identify preferred *C. setaceus* habitat requirements from literature, ANRPO data, and OISC data. Create map showing suitable habitat for *C. setaceus* on Oahu. Then model the spread of *C. setaceus* from known locations across particular ahupua'a or moku to demonstrate the potential spread of this weed if no management is conducted. Look at how fire behvior changes if *C. setaceus* is widespread, and model potential fire impacts. Look at potential impact on cliff rare plant habitat. This would be useful for several reasons: justifying funding for ANRPO and partners; public outreach tool to build community and interagency support for control, including by aerial spray; reducing risk to rare taxa.
Invasive Plant	Identify *Chromolaena odorata* habitat requirements, and model appropriate range and potential spread	Support incipient invasive plant control and management	Identify preferred *C. odorata* habitat requirements from literature, ANRPO data, and OISC data. Create map showing suitable habitat for *C. odorata* on Oahu, and if possible, the other Hawaiian islands. Then model the spread of *C. odorata* from known locations across particular ahupua'a, moku, and or islands to demonstrate the potential spread of this weed if no management is conducted. This would be useful for several reasons: justifying funding for ANRPO and partners; public outreach tool to build community and interagency support for control and eventually biocontrol; inclusion in EA for biocontrol release, when testing is complete.
Invasive Plant	Incipient invasive plant taxa - seed biology	Improve eradication efforts for invasive plants.	Better understanding of seed biology would greatly inform control and eradication strategies for incipient taxa. ANRP currently has 40+ taxa that are considered incipient in certain sites, and are targeted for eradication. Research topics include but are not limited to: germination ecology, soil seed persistence, dormancy, seed presence and abundance in soil, movement of seeds in the landscape, utility of pre-emergent herbicides.
Invasive Plant	Investigate the viability and longevity of *Chromolaena odorata* seed at different levels of maturity.	Support incipient invasive plant control and management	ANRPO and OISC observations suggest that *C. odorata* seed is viable at young stages of maturity, including when floral parts are still present. Test the viability, germination rate, and longevity of seed collected at different stages of maturity. This would inform both control strategy and allow staff to set more realistic goals for eradication. Currently, staff clip and bag all flowers and seeds, a time-consuming task. If flowers or other reproductive parts could be left on the plant, the time saved would allow for additional control and/or surveys.

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Invasive Plant	Weed control effectiveness and success assessment	Improve weed management strategies	Assess efficacy/success of weed control efforts. This is a very broad topic, and includes a variety of sites and projects. Specific questions would need to be developed. Some examples: How long do *Coffea arabica* seeds remain viable, and should control of invasive monocultures be timed around the fruiting season? How long is *Rubus rosifolius* suppressed following weed control in mesic forest; when should follow-up visits be scheduled?
Invasive Plant	Which control technique provides the longest suppression of *Chromolaena odorata* ? Does outplanting of other species suppress *C. odorata* ?	Support incipient invasive plant control and management	Compare different weed control techniques for *C. odorata* including no management, manual control only, and various herbicides. Which provides longest suppression? What happens if no control is conducted? Does outplanting of select hardy common native plants (*Dodonea viscosa, Pandanus tectorius, Cordia subcordata*) and/or non-invasive plants (ulu, noni, ti) and/or thick groundcovers or dense shade producers (wedelia, ironwood) improve *C. odorata* suppression?
Invasive Plant	Which control technique provides the longest suppression of *crocosmia crocosmiiflora* ? Does outplanting of other species suppress *C. crocosmiiflora* ?	Support incipient invasive plant control and management	Compare different weed control techniques for *C.* x *crocosmiiflora,* including no management, manual control only, and various herbicides. Which provides longest suppression? What happens if no control is conducted? Are there any native plants that can outcompete *C.* x *crocosmiiflora?*
	Rare Birds - Elepaio		
Taxonomic Group	**Research Topic**	**Management Objective**	**Notes**
Rare Bird - Elepaio	Compare elepaio survivorship, nesting success, and general ability to thrive in alien dominated vs native dominated forest.	Increase nesting success of Elepaio and balance management needs	Oahu elepaio are known for their ability to thrive in alien plant-dominated forest, but it is unknown if survivorship, fecundity, or other measures of fitness would change in native-dominated forest. Certain alien forests (Psidium cattleianum) likely support elevated predator (rat) levels, or may have complex interactions (pigs, wallows, mosquitoes, avian malaria) which in turn affect elepaio health. Is there any benefit to pursuing native forest restoration in elepaio habitat?
Rare Bird - Elepaio	How resilient are elepaio to disturbance in their territories, espeically from aggressive restoration?	Increase nesting success of Elepaio and balance management needs	Elepaio are highly territorial. If a territory is impacted by aggressive restoration (major weed removal, possibly followed by active outplanting), how resilient are the birds? Do they merely shift over, or do they seek new territories farther away? Do they utilize the cleared areas? Is fitness or fecundity affected in the short term and/or long term? This reasearch would help provide better guidance on working around elepaio territories in areas managed for mulitple rare taxa.
	Rare Insects		
Taxonomic Group	**Research Topic**	**Management Objective**	**Notes**
Rare Insect	Alien saprophage competition with *Drosophila*	Increase survival of Drosophila by decreasing competition with invasive species	Invasive *Libnotes* crane flies appear to compete with native *Drosophila* for larval food substrates. They are known to breed at least in *Cheirodendron* and *Urera* , the hosts of *D. montgomeryi* and *D. substenoptera* , and may also use *Chrysodracon* , the host of *D. obatai* . In *Cheirodendron* , *Libnotes* larvae have been anecdotally observed to consume nearly all the available rotting bark, with no native *Drosophila* emerging. At least two species are present, one of them not identified and probably undescribed. The effects have never been quantified, but doing so would fill in a major gap in understanding the threats to *Drosophila* .
Rare Insect	Bait attractiveness for *Drosophila* monitoring	Increase accuracy and efficacy of monitoring data for rare insects	Live baiting for flies is the main method for monitoring *Drosophila* populations, but the baits used are the same as those developed over 50 years ago. The attractiveness is often sensitive to the precise conditions under which it develops. Research into alternative baits, including both fermentation substrates and yeasts or bacteria grown on them, would potentially greatly enhance the accuracy of surveys.
Rare Insect	Damselfly predators and pathogens	Increase survival of damselflies by decreasing mortality caused by unknown predators and/or pathogens	A novel predator (*Hydra vulgaris*) or unknown pathogen (potentially fungal or bacterial) appears to have nearly wiped out the wild population of *Megalagrion xanthomelas* at Tripler and had serious impacts at the DOFAW rearing facility before being controlled with strict measures. DOFAW staff identified *H. vulgaris* as the potential culprit. Further study is needed to confirm *H. vulgaris* is the cause of the decline. Management tools, strategies, and sanitation measures are needed for *H. vulgaris* .
Rare Insect	*Hylaeus* nest box design	Increase nesting success in constructed nests in montane areas	Wooden blocks with plastic tubing work to attract nesting bees in coastal habitats, but not in mesic or wet forest, probably due to dampness. Plain wood doesn't seem to work much better. Need research to design appropriate and effective trap nests for use in montane areas.
Rare Insect	Impact of invasive ambrosia beetles on *Drosophila* host plants	Increase survival of Drosophila by decreasing tree mortality caused by invasive beetles	Invasive *Euwallacea* ambrosia beetles appear to be altering the dynamics and succession of native forests by attacking large *Pipturus* trees, causing frequent treefalls and light gaps. They also affect *Drosophila montgomeryi* by attacking *Urera glabra* , killing injured or damaged trees instead of allowing them to continue to grow. The specific identity of the beetles found in Hawaii is still unknown due to the extensive complex of invasive cryptic species and the lack of interest in them here since they primarily attack native trees. Assessing the impact of ambrosia beetles, the species identity, and whether they attack healthy or only injured trees would assist recovery planning for both general restoration and *D. montgomeryi* in particular.

Rare Insect	Impact of invasive ants on *Drosophila* and their control	Increase survival of Drosophila by decreasing mortality due to invasive ants	Ants are the primary threat to most native insects. Those in native mesic and wet forests have generally considered fairly benign, but previous work by Paul Krushelnycky and his students has shown that *Solenopsis papuana* causes significant reduction in emergence success in picture wing *Drosophila.* This needs to be followed up with further work on how widespread the problem is across sites and habitats, and what kind of control methods are effective without having serious non-target effects.
Rare Insect	Limiting factors for *Drosophila* populations	Increase reproduction and survival of Drosophila	The most important part of management is dealing with the most effective threat, and there is very little natural history information on the picture wing *Drosophila* to tell us what that is. Fecundity, host availability, larval mortality, adult mortality, and adult longevity may all play a role. The limiting factors are likely to be different for different fly species. This could be tackled as one comprehensive project for each species or broken down by subject (such as other topics listed under Rare Insect) and done for multiple species.
Rare Insect	Reproduction of *Drosophila* host plants	Increase reproduction and survival of *Urera glabra* and *Chrysodracon* spp.	*Urera glabra* and *Chrysodracon* spp. have little natural recruitment from either wild or outplanted plants. Investigate the reasons for reproductive failure, including seed predation by birds, rats, and insects, poor germination, poor growth, and seedling mortality due to slugs, rats, and birds.
	Rare Plants		
Taxonomic Group	**Research Topic**	**Management Objective**	**Notes**
Rare Plant	*Austropuccinia psidii* resistance in *Eugenia koolauensis*	Increase survival of rare plants by decreasing mortality due to disease	Due to the rapid decline of founders in the wild, ANRPO's approach to genetic storage for E. koolauensis has been building and maintaining a living collection of clones and whole plants representing wild founders. ANRPO currently maintains the largest genetic collection of E. koolauensis, representing 159 individual founders. Because effective control mechanisms for A. psidii in situ are lacking, there are no future plans to reintroduce this species. Research could focus on developing strategies to manage this species in situ by investigating potential means of resistence to identify foliar endophytic fungi that may play a role in microbe induced resistance or by investigating potential genetic resistance within the ANRPO living collection.
Rare Plant	Best reintroduction strategies for critically endangered species: determining the consequences of integrating/mixing multiple populations in reintroductions	Increase survival of rare plants through increasing genetic diversity and adaptation	Investigating levels of inbreeding depression, outbreeding depression, and heterosis within and between populations of rare plant taxa to determine whether single-source or mixed-source reintroductions are appropriate in recovery efforts.
Rare Plant	Determining limiting factors for ANRPO rare plants. Overcoming limiting factors for ANRPO rare plants	Increase survival of rare plants through improved threat management	Effective rare plant stabilizaion requires a thorough understanding of the challenges faced by ANRPO managed taxa. A systematic investigation of limiting factors would elucidate challenges faced by each taxon. Limiting factors of five rare plant species in mesic forests of Hawaii Volcanoes National Park (Pratt et al. 2010, Technical Report HCSU-015) is an example of one such approach, wherein stand structure, patterns of reproductive phenology, success of fruit production, potential pollinators, germination rates, presence of soil seed banks, impacts of seed-predating rats, seed predation by insects, seedling predation by Kalij pheasants, and seedling survival with different treatments were investigated. Though ANRPO has extensive data for laboratory germination rates, information for other potential limiting factors remains largely anecdotal or otherwise unknown. Following a determination of limiting factors to ANRPO rare plants, investigations of practical means to overcoming those limitations should be investigated to effect rare plant stabilization.
Rare Plant	Gut passage and possible seed germination/dispersal by native and non-native birds of Army-managed Lobeliods	Increase survival and persistence of rare plant populations.	Understanding viability of endangered fruit digested by different species of forest birds and whether they can help spread fruit of certain Army-managed lobeliods such as Cyanea superba, Cyanaea longifolia, and Delissea waianaensis
Rare Plant	Improved plant health and disease resistance through beneficial fungal associations	Increase survival and vigor of rare plants; decrease mortality caused by disease	This is an example of a possible research need for the following genera/taxa *Phyllostegia, Plantago, Stenogyne, Kadua degeneri var degeneri, K. parvula.*
Rare Plant	Investigate the potential of Cryostorage as a long-term storage solution for recalcitrant/intermediate/exceptional seeds: *Eugenia koolauensis* and *Pritchardia kaalae*	Identify optimal storage methods for exceptional rare plants, to preserve genetic material	Lyon Microprop and Cincinnati Zoo and Botanic are currently researching the cryostorage of tissues of exceptional species (species whose seeds cannot be stored in conventional seed bank conditions) including Eugenia koolauensis and Pritchardia kaalae; however, as Lyon Arboretum now has the capacity for research cryostorage, the opportunity exists to investigate whether or not whole seeds or embryos of these species can be stored successfully at cryogenic temperatures. This research could also be expanded to investigate whether or not cryostorage is appropriate for freeze-sentive taxa.

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Rare Plant	Some rare plant taxa are pollinator limited or have lost their mutualist partners and may rely on non-native or non-traditional pollinators and/or fruit/seed dispersers to sustain reproduction. Can pollinator and disperser visitation be encouraged and how? Potential pollinators: birds, arthropods. Rare Plant taxa of interest: *Hesperomannia* spp., *Cyanea* spp.	Sustain natural reproduction for rare taxa whose pollinator or disperser mutalisms have been interrupted.	Better understanding of pollinator and disperser services (native or introduced), if any, to rare plant taxa and if these services can be encourged through management.
Rare Plant	Understanding the implications of soil structure, chemistry and biota for rare plant conservation, management and successful reintroductions.	Increase survival of rare plants through improved identification of optimal soil characteristics for rare plants in propagation and field	As a program we are generally lacking information on soil and the role soils play in our rare plant conservation and management efforts. Do rare plants species have a narrow habitat preference for soil parameters as compared to more common species? Do invasive species alter these narrow habitat preferences? Where do soils preferred by a particular rare plant taxon occur? A more in depth understanding of soils in ANRPO management areas could improve management strategies for rare taxa, particularly in site selection for new reintroductions.
Rare Snail	Detection and elimination of Euglandina rosea in predator-proof enclosures	Decrease mortality of native tree snails within enclosures	Detection and elimination of E. rosea within predator proof enclosures to improve efficency of threat control and minimize habitat destruction. Current methods of E. rosea removal are labor-intensive, slow, result in high impact to vegetation, and are estimated to have low rates of detection.
	Small Vertebrate Pests		
Taxonomic Group	**Research Topic**	**Management Objective**	**Notes**
Small Vertebrate Pests	Understanding the scale of impacts that rats, mice, mongooses, and game birds have on our rare resources.	Determining impacts by non-native predators	ANRPO has controlled rats at both Management Unit and small-scale levels for going on 20 years. Mouse control has been done on a very limited basis and scale. No mongoose or game bird control has occurred. Mice are believed to be consuming a variety of native and non-native plants and possibly snails. ANRPO has antecdotal evidence of mongoose predating forest birds and believe they consume snails. ANRPO has observations of game birds predating rare plants and believe they consume snails. However, the scale of impact from most small vertebrate pest animals on rare taxa is poorly understood. With the advent of EDNA we may have a tool to understand the impacts that these threats are having.
	Statistical Analysis		
Taxonomic Group	**Research Topic**	**Management Objective**	**Notes**
All	Evaluation of statistical analyses being used in various ANRPO programs	Improve utility of data to better inform improved management actions	While not a research topic per se, data analysis can be quite complex and challenging, and ANRPO analyses (especially those used on a recurring basis for the same types of datasets, e.g. MU vegetation monitoring) could benefit from evaluation by UH faculty with expertise in biostatistics.