RCN: SEAPRE: **Sea**bird Islands and Introduced **Pre**dators: Impacts of Presence and Eradication on Island Function

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PROJECT SUMMARY

CORE PARTICIPANTS:
Coordinators: Christa Mulder (U. of Alaska Fairbanks) ; Wendy Anderson (Drury University).
USA: Vernon Byrd (USFWS); Don Croll (U.C. Santa Cruz), Josh Donlan (Cornell), Don Drake (U. Hawai'i), Tadashi Fukami (U. Hawai'i), Julie Ellis (Cornell), Stephen Kress (National Audubon Society), Bernie Tershy (UC Santa Cruz), Alexander Wait (Missouri State).
International: Peter Bellingham (Landcare Research, New Zealand); Robbie McDonald (Queen's U. Belfast); José Miguel Fariña (Catholic U. Chile); Dave Towns (Dept. of Conservation, New Zealand); Eric Vidal (U. Paul Cezanne, France); David Wardle (Swedish U. of Agricultural Sciences); Chris Wilcox (CSIRO, Australia).

INTELLECTUAL MERIT: Seabird islands (islands with large populations of seabirds) are crucial to the survival of native animals and plants due to the large subsidies provided by nutrient inputs of marine origin. Seabird predators have devastated seabird populations and drastically altered vegetation processes and ecosystem function all over the world. These predators are now being eradicated on hundreds of islands, but restoration plans usually do not include vegetation and ecosystem processes, nor are these processes monitored. Thus, although we know that many of the impacts of seabird predators on other species are indirect (mediated through changes in nutrient inputs and disturbance by seabirds), the impacts of removing seabird predators on these processes remain unstudied. The implicit assumption is that the removal of predators will result in the recovery of seabird populations and the restoration of seabird island community and ecosystem dynamics.

Despite the many studies of seabird islands, no cross-system comparisons have been done, and we are lacking answers to such basic questions as the extent to which seabird impacts are similar across systems versus determined by system-specific characteristics such as geographic location, moisture regime, or seabird species. This information is crucial for making predictions about the impacts of new invasions or predator eradications. This RCN will bring together scientists from across the globe to perform cross-system comparisons and syntheses, establish standard methodologies, identify crucial data that are lacking, and develop a conceptual framework for understanding and predicting impacts of seabirds and predators on island functioning, the consequences of their removal, and requirements for restoration of island functioning. We will hold three annual meetings and develop an interactive website. Products from these efforts will include an edited book with system-specific and cross-system chapters, manuscripts resulting from cross-system data analysis, and guidelines for island restoration based on scientific data.

BROADER IMPACTS will result from:1) Contributions to conservation and restoration biology by increasing incorporation of ecological knowledge of seabird islands into restoration plans, and producing guidelines for island restoration; 2) Increasing international collaboration, and collaboration between university, government, and NGO scientists; 3) Increasing training of junior scientists through site exchanges; 4) Increasing community involvement in island conservation and restoration through a central website, and through participation in meetings; 5) production of a multi-lingual public education video on seabird islands and their restoration.

INTRODUCTION

The role of seabird islands

Islands as "model ecosystems" provide important information on ecological and evolutionary processes (Darwin 1859, see reviews in Cushman 1995; Vitousek et al. 1995). More recently, island studies have addressed plant diversity – ecosystem function relationships (Wardle et al. 1997), food web interactions (Spiller & Schoener 1994; Schoener & Spiller 1997; Polis and Hurd 1995; Polis et al. 1997) and the importance of marine nutrient inputs to terrestrial systems (Anderson & Polis 1998, Anderson and Polis 2004). Islands are particularly useful for these types of studies due to their manageable size, reduced floras and faunas, unique assemblages of plant and animal species, and the capacity for proper replication over large spatial scales (Ewel & Högberg 1995; Vitousek et al. 1995; Wardle et al. 1997). Islands also play an increasingly important role in conservation biology. They often contain endemic species or remnant populations of species that have been eliminated from the mainland (e.g. Daugherty et al. 1994; Roy et al. 1999; Currie et al. 2003; Lawton et al. 2006), and they are increasingly being used to provide "safe havens" for translocated species (e.g. Abbott 2000; Blanvillain & Thorsen 2003; Jamieson et al. 2003; Towns & Broom 2003; Priddel et al. 2006).

Islands with colonies of seabirds – "seabird islands" – have received particular attention. Seabirds, which include Sphenisciformes (penguins), Procellariiformes (albatrosses, petrels, shearwaters, storm-petrels, and diving-petrels), Pelecaniformes (pelicans, boobies, cormorants, frigatebirds, tropic birds, anhingas), and Charadriiformes (shorebirds, skuas, gulls, terns, skimmers, auks), often act as ecosystem drivers on oceanic islands and along coastal areas. These birds feed at sea but nest on land, often at very high densities (Marchant & Higgins 1990; Furness 1991). Many studies have documented seabirds introducing large amounts of nutrients of marine origin into terrestrial systems through the deposition of guano (e.g. Burger et al. 1978; Mizutani & Wada 1988; Polis & Hurd 1996; Anderson and Polis 1999; Wainwright et al. 1998; Ellis et al. 2006). Seabirds may increase N deposition by 100 times and P deposition by 400 times relative to annual inputs from rain (Furness 1991). Unhatched eggs, feathers, and bird carcasses may also increase resource availability to scavenging invertebrates and detritivores (Williams & Berruti, 1978; Williams et al. 1978; Polis & Hurd 1996; Sanchez-Pinero and Polis 2000). Thus, seabirds "subsidize" terrestrial plant and animal communities (e.g., terrestrial birds, arthropods, reptiles, and marsupials) and surrounding intertidal communities with marine nutrients, usually resulting in larger populations and sometimes higher species diversity than is possible in their absence (e.g. Polis & Hurd 1996; Anderson and Wait 2001; Markwell & Daugherty 2002; Wolfe et al. 2004; Hawke & Holdaway 2005).

Although seabird-derived nutrient inputs are usually important in sustaining high densities of other species, seabirds impact terrestrial communities in more negative ways. Seabirds that nest in burrows in the ground (e.g. prions, petrels and shearwaters) may cause extreme disturbance of the soil surface, alter soil structure and increase erosion (Furness 1991; Bancroft et al. 2005a); and both burrowing and trampling activity may decrease seed germination and seedling survival of individual species (Gillham 1961; Campbell 1976; Mulder & Keall 2001). Reductions in the litter layer may alter relative competitive ability of native versus introduced plant species (McAlpine & Drake 2003; Kostel-Hughes et al. 2005), and may particularly benefit ruderal species (i.e. "weeds" - Vidal et al. 2000; Ryan et al. 2003; C. Mulder unpubl. data). Although nutrient inputs by seabirds may increase productivity (Bancroft et al. 2005b; Maron et al. 2006;

Anderson and Polis 2004), additional negative impacts of seabirds on the vegetation can occur at very high densities. High concentrations of guano can lead to extremely low soil pH (Ward 1961; Okazaki et al. 1993; Mulder & Keall 2001; Wait et al. 2005), thereby reducing nutrient availability to plants (Blakemore & Gibbs 1968; McLaren & Cameron 1990). Trampling and burrowing activity may damage roots to the point where tree and shrub productivity is visibly reduced (Zelenskaya & Khoreva 2006; C. Mulder, unpubl. data). Seabirds can also play a direct role in seed dispersal (Nogales et al. 2001; Burger, 2005). In general, seabirds have strong impacts on both plant and animal communities (Bancroft et al. 2005b; Maron et al. 2006) but the strength and direction of the impacts are likely to be density-dependent as well as system dependent (Ellis 2005).

Impacts of Seabird Predators

Many seabird populations have been negatively impacted by introduced predators, particularly rats (Rodentia: Muridae; see review in Atkinson 1985). Three *Rattus* species are commensal and readily become feral: *R. exulans* (Pacific rat), *R. rattus* (ship rat), and *R. norvegicus* (Norway rat) (Atkinson 1985). Although introduced rats have been present on some islands for > 2000 years (e.g. Martin et al. 2000; McConkey et al. 2003; Traveset & Riera 2005), the rate of invasion greatly accelerated in the1800s; approx. 45 island groups have been invaded since the mid 1800s (Atkinson 1985), and new islands continue to be invaded (IUCN ISSG 2006). Seabird populations have also been decimated by other introduced predators, including feral cats (*Felis catus*; e.g. Keitt et al. 2002; Rocamora et al. 2003; Simeone et al 2003), foxes (Dell'Arte & Leonardi 2005; Byrd et al. 2005), mink (*Mustela vison*, Clode & McDonald, 2002; Nordstrom & Korpimake 2004;), mice (*Mus musculus*; Cuthbert et al. 2004), and raccoons (Hartman et al. 1997). These predators often reduce or eliminate populations of other native animals; rats alone are responsible for approx. 21% of recorded avian extinctions, and the local extinction of many others (Atkinson 1985; King 1985; Blackburn et al. 2004). Seabird predators can also have severe negative impacts on reptile populations (Whitaker 1973; Towns & Daugherty 1994; Cree et al. 1995), large invertebrates (e.g. Ramsey 1978; Worthy 1984; Bremner et al. 1984; Lawrance & Samways 2003), and mammals (e.g. Burbidge & Manly 2002). Some seabird predators consume seeds or alter their dispersal (Allen et al. 1994; Delgado Garcia 2000; McConkey et al. 2003), thus altering vegetation dynamics beyond the impacts of reduced seabird populations.

Attempts to remove introduced predators from islands date back as far as the 1800s (e.g. biological control by mongooses on Pacific islands; IUCN ISSG). The eradication of rats through poisoning was pioneered in New Zealand, but it wasn't until the development of second generation anticoagulant poisons that these efforts consistently produced the desired results (Towns & Broome 2003), and it became feasible to eliminate rats from larger islands, including ones greater than 1000 ha (Fig. 1A). The technology and methods have recently been exported to many other countries, with the result that rats have now been successfully eliminated from over 200 islands, mostly in the southern hemisphere. Similarly, cats have been eradicated from at least 48 islands (Nogales et al. 2004; Fig. 1B), and other species have been eradicated from a few islands. These efforts have been greatly aided by effective networking and sharing of methods between groups, as reflected by the International Conference on the Eradication of Island Invasives (held in New Zealand 2001) and other meetings of the IUCN Invasive Species Specialist Group.

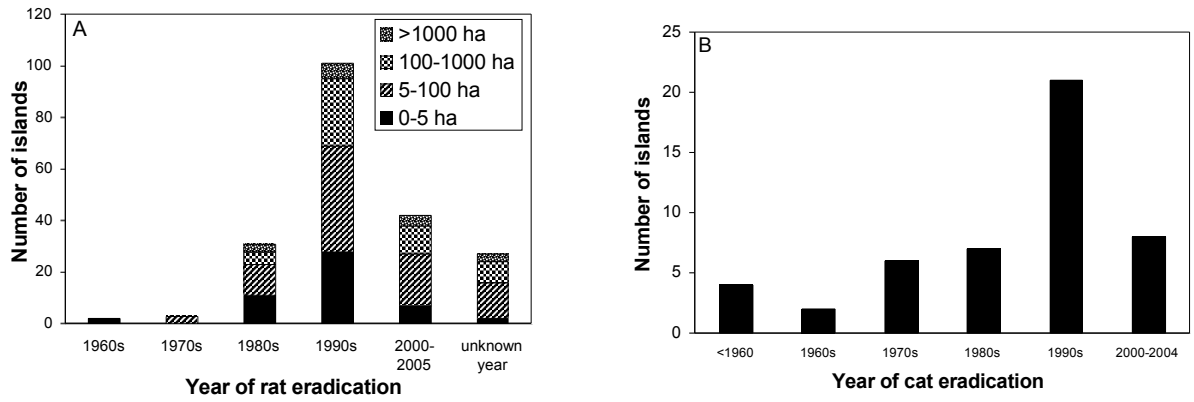

Figure 1. Eradications of seabird predators on islands by decade and island size. Data are organized by decade in which the effort was initiated. A. Rat eradication projects by decade and island size; data are from the the IUCN ISSG website (http://www.issg.org/) and include both successful and failed attempts. B. Cat eradication projects by decade; data are from Nogales et al. 2004.

Studies of seabird islands and predator removals: the need for integration

The eradication of seabird predators (hereafter "predators") is often followed by monitoring native populations of island fauna . The focus is usually on populations of seabirds and terrestrial birds, but reptiles, amphibians, and sometimes invertebrates are also monitored, although often in a very casual way (Fig. 2). However, other aspects of restoration have received scant attention. In particular, vegetation processes and ecosystem functioning, including nutrient cycling, have been almost completely ignored. This is particularly striking considering that these processes have been the focus of the majority of the studies of seabird island ecology (Fig. 2), and that many of the impacts of seabirds on other species' populations are driven by their very large nutrient inputs. Thus, although we know that many of the impacts of seabird predators on other species are indirect, mediated by changes in nutrient inputs and disturbance by seabirds, the impacts of removing seabird predators on these processes remain unstudied.

The implicit assumption is that the removal of predators will result in the recovery of seabird populations and the restoration of seabird island community and ecosystem dynamics. However, there are several reasons why this may not be the case. First, seabird colonies do not necessarily recover by themselves (Gaze 2000). Although methods for attracting seabirds are being used at a few locations (e.g. "social attraction"; Kress 1983; Kress & Hall 2004), they are not usually part of restoration plans. Second, if functioning of islands is highly dependent on seabird densities, then even if islands are recolonized by seabirds, building up densities high enough to re-establish this process may take a long time. Third, islands from which seabird predators have been eradicated may move along a trajectory that is fundamentally different from those of both seabird islands and islands that still contain the predators. Species of invertebrates and plants that are an integral part of seabird island function may have been lost (either through direct impacts of the predators, or through altered conditions following seabird reductions), while invasive species that were previously controlled (either by the predators or by high disturbance activity) may now be able to gain ground.

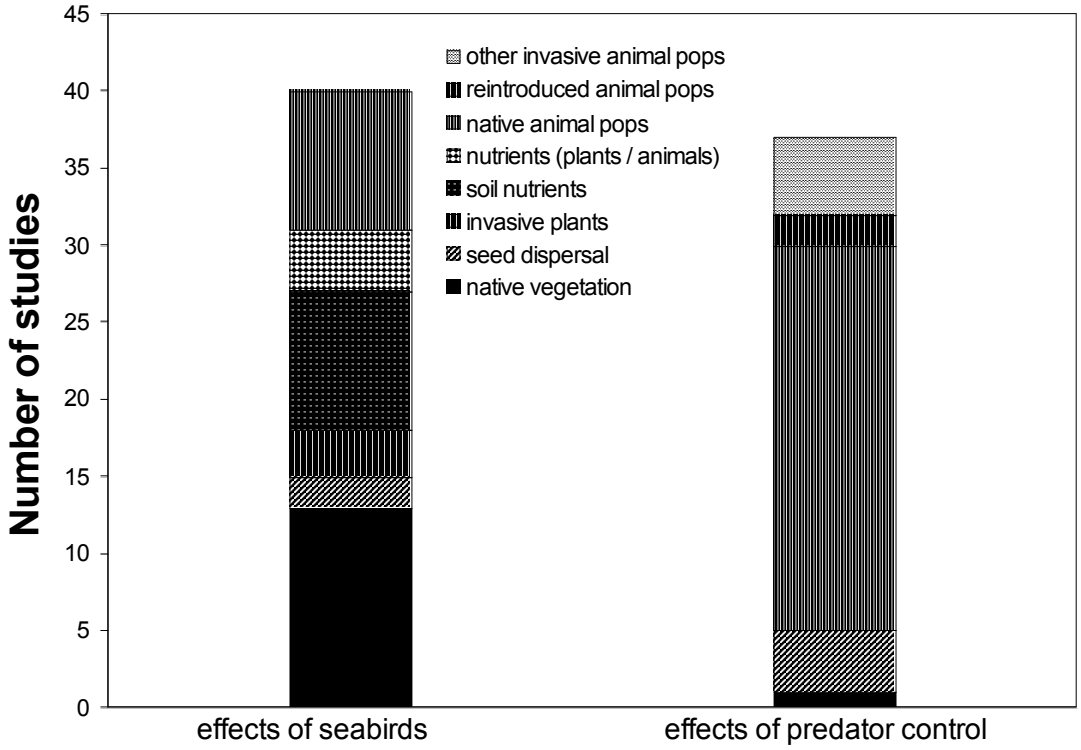

Figure 2. Subject of seabird island studies versus eradication follow-up studies. Numbers are based on a search of Web of Science using the terms ISLAND* + SEABIRD* and the terms RAT* (or CAT*)+ ERADICATION + ISLAND.

The need for a Research Coordination Network

The need for a Research Coordination Network (RCN) is driven by two primary concerns:

1. Despite the large number of studies on seabird islands, we are still remarkably ignorant of how seabirds affect island functioning in general. The best approach to studying impacts of seabirds is to compare groups of islands with and without seabird colonies; however, due to the inaccessibility of most seabird islands, this is both expensive and logistically challenging, and has only been accomplished a few times. Most studies have taken place on one or a few islands, and they are almost always restricted to one geographic location. To date there has been no integration of results from multiple systems, or coordination of methods so that comparisons between systems can be easily made. **As a result we have little knowledge of the extent to which impacts of seabirds are similar across systems, and the extent to which they are determined by system-specific characteristics, such as geographic location, size, isolation, moisture regime, or seabird species.** A recent review paper on the impacts of seabirds on vegetation dynamics (Ellis 2005) pointed out that the majority of studies were entirely descriptive and that more quantitative sampling and manipulative experiments are needed to improve understanding of how seabirds affect plant communities. This review also suggested that the direction and magnitude of seabird effects depends on climate and on seabird density, but that there was insufficient data to go beyond this very general statement. Thus, it is very difficult to make predictions about the role of seabirds on unstudied seabird islands, or to understand what is likely to change following the loss of seabirds from an unstudied system.

2. Conservation considerations create a practical need for integration of knowledge. First, without a good understanding of how seabirds alter island functioning, it is difficult to know what the impacts of the future predator invasions of currently uninvaded islands are likely to be. Second, the "restoration" of islands through eradication of predators is occurring with almost no knowledge of how either the predators themselves or the seabirds were altering vegetation processes and ecosystem functioning, thus making it very difficult to determine how to restore functioning, how to assess the success of such restoration, or even if restoration should be attempted. The reintroduction of native birds and reptiles from other seabird islands following eradication is a common practice, but if these populations are normally dependent on vegetation processes and nutrient inputs that have not been restored, then populations may not be sustainable. For example, removal of tern predators in the Gulf of Maine resulted in increased growth of an invasive grass, which negatively impacted the tern population (J. Ellis, pers. com.). Since the impacts of seabirds have been studied on different sets of islands (and usually in very different geographic locations) than those where predators are being eradicated, results cannot be applied directly to restoration projects. Instead, a conceptual framework and set of general principles must be developed to determine whether community processes and ecosystem functioning are likely to be restored without further management, whether they need to be restored to support other restoration efforts, and how this can be accomplished.

The highly successful coordination of efforts among eradication specialists is in large part responsible for the rapid rates at which predators are being eradicated from islands worldwide, and has demonstrated how effective networking can be in enhancing restoration efforts across the globe. **A similar network that focuses on understanding biological impacts of seabirds and predators on island functioning, the consequences of their removal, and the requirements for restoration of seabird island functioning following predator eradication is urgently needed if these eradication efforts are to result in the re-establishment of the seabird island systems that are so important to maintaining biodiversity in numerous countries around the world.** This will require the collaboration of scientists from many different disciplines: as population ecologists working with seabirds and native animal populations, plant ecologists, soil ecologists, community ecologists, and ecosystem ecologists. It will also require the involvement of the conservation biologists and resource managers in charge of the development of restoration plans. We have little doubt that there is strong interest in the scientific community in such a network. A conference entitled "The Ecology of Insular Biotas", held in Wellington, New Zealand in 2001 (and timed to allow attendees to also participate in the predator eradication conference) drew over 200 participants from 16 countries. Although it was not limited to seabird islands, such islands were the focus of many of the presentations and discussions. A second conference, entitled "Rats, Humans & Their Impacts on Islands: Integrating Historical and Contemporary Ecology" is being organized by Don Drake (one of our core participants) and will be held in March 2007. The timing of this RCN takes advantage of the momentum built by these conferences to increase interest and participation.

In addition to professional biologists, participation by the public will be vital to the success of the network. Members of the public often take a strong interest in the research and the eradication / restoration projects because the islands are highly visible and a great source of pride to their owners. For example, *Friends of Maine Seabird Islands* is a community-based group "committed specifically to conservation and restoration of seabirds and the island habitat on

which they depend" (http://www.maineseabirds.org/html/home.html). A similar group of local residents in Bahia de los Angeles, Baja California, Mexico regulates tourist and research activities, and conduct trash clean-ups and other monitoring efforts on the archipelago of islands inside their bay in the Gulf of California. Not only do island owners and local residents often initiate and fund eradication efforts (IUCN ISSG), restoration efforts frequently depend on the labor provided by volunteers and prevention of reinvasion requires public education. This RCN would provide an opportunity to link not just scientists but also non-scientists interested in the preservation and restoration of seabird islands.

SEAPRE FOCI

Within the wider topic of the impacts of seabirds and their predators on island functioning, we have identified five foci for the RCN. Here we present the general topics we will address, and some examples of questions appropriate to each:

1. Direct effects of *seabirds* on terrestrial population dynamics, community structure and ecosystem functioning across island systems.
    a. Are there general patterns in how seabirds alter plant diversity and species composition, including both native and invasive species (e.g. by trampling, burrowing, altering soil chemistry or dispersing seeds)?
    b. Are there general patterns in how seabirds affect nutrient cycling and soil processes, including nutrient availability to plants, invertebrates, and vertebrates?
    c. Can we predict impacts of the presence of seabirds on other vertebrate species?
    d. Are there general patterns in how seabirds affect population dynamics of other trophic levels (e.g. detritivores)?
    e. How much do impacts of different groups of seabirds (e.g. burrowing vs. surface nesting) or different species of seabirds differ?
2. Direct and indirect effects (mediated through reduction in seabird populations) of *seabird predators* on terrestrial community structure and ecosystem functioning across island systems:
    a. To what extent do seabird predators reverse the impacts associated with seabirds?
    b. How do seabird predators directly affect community structure, e.g. by consuming or dispersing seeds, by consuming herbivores or detritivores, or by competing with other animals species?
    c. To what extent are impacts of different predator species additive (complementary) and to what extent are they non-additive (emergent)?
3. Effects of *seabird predator removal* ("natural" recovery):
    a. How do community structure and ecosystem function change over time following seabird predator removal? How comparable is this across systems?
    b. How much does restoration of plant community structure and ecosystem function depend on reintroduction of seabirds?
4. *Restoration* of islands following seabird predator removal ("managed recovery"):
    a. Which of the ecological patterns identified in 1) should be preserved or restored?
    b. How and when should seabird species be reintroduced or actively managed?
    c. What plants and invertebrate species affected by predators should be reintroduced?

d. What order should reintroductions follow, and how much does order matter (priority effects), both within and across taxa?
e. What time scales are associated with different aspects of restoration? Can the rate of restoration be increased?

5. *Human impacts* on current community dynamics and restoration potential:
   a. How do humans currently influence seabird populations? Will this help or hinder restoration efforts?
   b. How can we harness public interest in island restoration effectively, reduce the likelihood of reintroductions of seabird predators, and increase the rate of restoration?

SEAPRE GOALS

We have identified several conceptual approaches to achieve our objectives; more are likely to materialize as the project progresses.

1. *Across-system comparisons*.
   We will identify what our island systems have in common (i.e. what predictions or principles can be applied across the globe) and where they differ (where location or species composition-specific information is necessary) in both discussions and in more quantitative comparisons (see #4). Likely questions we will address include: How much does it matter what the seabird species are? How much do seabird predator effects differ between predator species? Are systems in some parts of the world more resistant or resilient than others? Does this depend on climate (e.g. tropical vs. temperate or subarctic) or on total productivity? For areas with rapid climate change, is this likely to affect current dynamics?

2. *Identification of and reduction in large gaps in the information required for comparisons*.
   Specific mechanisms for accomplishing this will include 1) the exchange of people with different expertise between groups, 2) the development of standardized methods for cross-system comparisons, and 3) the development of new grant proposals to address gaps in understanding.

3. *Development of a database with multi-system information*.
   We will develop a database for multi-system comparisons that will be available to the scientific community as a whole. We will hire a database technician to set up the database, enter existing data, and add additional data as they are gathered (see details under "Website development").

4. *Synthesis of data from multiple systems*
   Once the database has been established, the data will be available for working groups to perform cross-system comparisons.

5. *Development of recommendations or guidelines for restoration of islands*. These will include guidelines that are general enough to be applied anywhere, and recommendations for how to determine system specific plans. Furthermore, they should include the

participation of the public and provide a model for scientist – community partnerships that can be applied to other situations.

6. *Production of an edited multi-author book focused on seabirds, their predators, and the effects of both on islands*. This book would include both system-based chapters (written by separate research groups) and synthetic chapters (which would result from the cross-system comparisons).

7. *Production of multi-system comparison manuscripts*. In years 2 and 3, we expect to produce manuscripts that focus on quantitative comparisons of multiple island systems.

8. *Enhancement of student training opportunities*. This RCN provides an opportunity for graduate and undergraduate students involved in the various projects to be exposed to scientists from across the world, and to add multi-system components to their own research projects. The strong cultural and geographic diversity of the core participants and their systems will be particularly important in broadening the perspectives of all involved. We anticipate increasing student training by 1) strongly encouraging participation of both undergraduates and graduates in the meetings and working groups; 2) facilitating student exchanges between sites; 3) increasing involvement of faculty at other universities in graduate student committees and informal mentoring; and 4) developing an NSF REU program proposal that would allow undergraduates to perform research in any of the focal systems.

9. *Enhancement of public understanding of seabird islands and the effects of seabird predators, and increasing public involvement in conservation and restoration efforts.* Many of the research groups have strong ties with local communities. Members of these communities may be owners or members of boards approving research projects, and they often supply the volunteer labor used in predator eradication, planting, and other restoration activities. People are often very proud of these islands and the species they harbor and feel a strong sense of ownership. We hope to improve understanding of the research, increase interest and participation in restoration activities, improve effectiveness of public participation in conservation and restoration, and enhance the sense of ownership of not just the physical islands but also the ecosystem services they provide by 1) Including, for annual meetings held close to research sites, a public session to which we will invite all local participants; 2) Establishing a website, parallel to the scientific one, which can be used to provide information and allow members of the public to exchange information and ideas; 3) Production of a multi-lingual video for the general public that addresses the impacts of seabird predators and restoration of islands across the world, as well as showcasing each set of islands in a wider context; 4) Sponsorship of exchanges. More details on each of these activities are provided in the Broader Impacts section.

PARTICIPANTS and MANAGEMENT STRUCTURE

Coordinators. The RCN will be coordinated by Christa Mulder (University of Alaska Fairbanks; principal coordinator) and Wendy Anderson (Drury University; co-coordinator); they have

overall responsibility for the management of the project, including production of annual reports, attendance of NSF RCN meetings, budget management, and supervision of personnel. Mulder is one of the lead researchers of the RASP group (PI on an NSF grant and Co-PI on a Royal Society of New Zealand Marsden Fund grant); she was also one of the organizers of a conference held in Wellington, New Zealand, in 2001 that focused on insular biotas. She has experience with multi-group networks of a similar size as a post-doctoral fellow in the highly successful European BIODEPTH project. Anderson is one of the lead researchers of the Gulf of California islands group (PI on a past Andrew Mellon Foundation grant). She has co-organized an ESA Organized Oral Session on subsidized food webs, and participated in numerous workshops and symposia on island ecology, subsidized food webs, and pulsed systems. In 2005-06, as the director of a year-long convocation series on Sustainability at Drury University, she organized 24 different one to three-day campus events for internationally known speakers.

Steering committee. The steering committee will consist of the directors and one member of each research group. Additional members can be added as more research groups join SEAPRE. The steering committee is responsible for making broad decisions such as determining the goals and timing of annual meetings. This committee will also select participants whose attendance at annual meetings will be supported (beyond the minimum per group – see below) and be involved in other decisions regarding budget allocation. The steering committee will regularly review progress and redirect efforts as needed.

Participants. Table 1 provides an overview of the participants: members of research groups with existing research programs on seabird islands or other systems of direct relevance to this RCN, many of whom have been involved in the development of the ideas in this proposal. Current Activities Reports for the "core participants" are attached as Supplementary Documents. Additional individuals ("secondary participants") have expressed interest in the project but may not participate in all aspects. The list of participants is highly diverse in many respects: it includes people with a wide range of approaches (e.g. physiological, population, community, and ecosystem ecologists) and taxonomic expertise (plants, vertebrates, invertebrates and microbes) from a variety of organizations (universities, conservation NGOs, and governmental organizations) and geographic locations (U.S., Canada, Chile, New Zealand, Australia, France, and U.K.). The initial group consists of approximately nine research groups (the exact number is difficult to define as there is considerable overlap among groups). We aim to keep the number of members small enough to facilitate effective discussion . At the same time we welcome additional participants with experience in seabird island research or related topics, and we expect the number of participants to increase substantially over the three years.

Working groups. Given the wide range of interests of the various participants and the diversity of goals, we anticipate that working groups who focus on particular topics or species will naturally emerge. For example, such groups might focus on comparisons across island systems of particular groups of organisms or processes (e.g. soil processes, seabirds, invasive plants) or on particular applications (e.g. what the goals of restoration should be). This will also likely include a working group on enhancing scientists – community interactions. These groups will be small, and participants are likely to be members of multiple working groups. Working groups will be established during the first annual meeting but may change over time.

Table 1. SEAPRE research groups and participants. Names in **bold** are core participants.

Research Group & Location of Islands	Participants	Institution(s)	Interests
RASP (Rats and Seabirds Project): New Zealand	**Christa Mulder**	U. of Alaska Fairbanks	Plant ecology, plant-animal interactions
	David Wardle	Landcare Research (NZ); Swedish University of Agricultural Sciences	Soil ecology, links between above- and belowground terrestrial systems
	Peter Bellingham	Landcare Research (NZ)	Disturbance ecology, biological invasions
	Dave Towns	Dept. of Conservation (NZ)	Herpetology, restoration
	Tadashi Fukami	U. of Hawai'I	Community assembly
Desert Islands: Gulf of California; Galapagos, Chilean coast	**Wendy Anderson**	Drury U.	Plant community ecology, landscape ecology
	Alexander Wait	Missouri State U.	Soils, plant ecophysiology
	José Miguel Fariña	Catholic U. of Chile	Reptiles, Arthropods,
Northeast Temperate Islands: Gulf of Maine	**Julie Ellis**	Cornell U. (Shoals Marine Laboratory)	Plant-animal interactions, seabird ecology /conservation
	Stephen Kress	National Audubon Society	Seabird conservation & restoration
Island Conservation: Baja California, Mexico, Australia	**Don Croll**	UC Santa Cruz	Seabird ecology and conservation
	Bernie Tershy	UC Santa Cruz	Behavioral ecology of marine birds and mammals; invasive species
	Chris Wilcox	CSIRO and U. of Tasmania	Population biology of pelagic species
	Josh Donlan	Cornell University	Restoration biology
Aleutian Island Conservation,: Alaska	**Vernon Byrd,**	US Fish & Wildlife Service	Invasive species management
	Steve MacLean	The Nature Conservancy	
	Peter Dunlevy	US Fish & Wildlife Service	
Med. Inst. for Ecology & Paleoecology: Mediterranean, French overseas isl.	**Eric Vidal**	University Paul Cezanne, Aix-en-Provence	Plant-animal interactions, seabird ecology /conservation, introduced mammals
Pacific Islands Group: Tonga, Hawai'i	**Don Drake**	U. Hawai'i	Seed ecology, Pacific plant ecology
	Alex Wegmann	U. Hawai'i, USFWS Hawai'i	Plant-rat-crab interactions on islands
	Earl Campbell	USFWS Hawai'i	Invasive species eradication
Quercus: Northern Ireland	**Robbie McDonald**	Quercus Queen's U. Belfast	Impacts of invasive mammal removal. Evolutionary ecology, invasive mammals
	Stuart Bearhop		Stable isotopes; trophic cascades.
Cooperative Islands Initiative,: New Zealand	Alan Saunders	Univ. of Auckland	Bird and reptile restoration
	John Parkes	Landcare Research (New Zealand)	
	James Russell	Univ. of Auckland	Rat invasion and population dynamics
	Tim Blackburn	U. Birmingham	Seabird extinctions
Canada	Louise Blight	Parks Canada	Nutrient cycling; endangered species
San Juan Islands: Chile	Peter Hodum	San Juan Islands Conservancy	Conservation, public education
Reef Islands: Australia	Susanne Schmidt	U. of Queensland	Plant ecophysiology, nutrient relations

OUTLINE OF ACTIVITIES

We will hold a SEAPRE workshop each year. In between annual workshops, electronic networking will be used to develop ideas and products. The RCN will support the workshop expenses for core participants currently included in Table 1 (including travel for U.S.-based participants). Travel grants for additional U.S.-based participants, with priority given to junior scientists, will be awarded for each meeting based on applications submitted to the Steering Committee. All annual meetings will follow a similar format: an initial half-day session involving all participants, more focused sessions in working groups (approx. 2 days), and a final all-participant session in which working group results are presented and goals for the remainder of the year are established (approx. _ to 1 day). Below is an outline of what we intend to accomplish over the course of the project. However, we expect that some of the details are likely to change as the project develops, particularly in years 2 and 3.

YEAR ONE

Annual Meeting I: Identification of goals and development of cross-system comparisons (Spring 2007; Springfield, MO).

Meeting preparation:

1) Each participating group will submit overviews of their research with a) a summary of main results, b) areas where they would like to see cross-system synthesis c) research areas where they feel additional work is needed to answer urgent questions.
2) Coordinators and the Steering Committee will suggest potential working group topics and ask for preliminary expressions of interest in participating in these.
3) Website coordinator will be hired by co-coordinators.

Meeting agenda:

1) Introductory session: introduction of participants and information on their research systems.
2) General discussion of overall goals of RCN and presentation of working group topics
3) Working groups. These are charged with:
    a. Identifying potential areas for synthesis across studies
    b. Identifying information lacking and how to obtain it
    c. Identifying need for common research methods
    d. Identifying further links to the research as a whole
    e. Identifying short-term (1-year) goals
4) Presentation of individual working group results to the whole group
5) Identification by the whole group of short, medium, and long-term goals.
6) Identification of authors for system- specific and synthetic book chapters
7) Meetings between video producer and working groups

Post-meeting work:

1) Research groups submit data to the SEAPRE website
2) Working groups initiate synthesis of existing data
3) Working groups develop common methods and submit to SEAPRE website
4) Researchers submit applications to the Steering Committee for the exchange program
5) Steering committee selects participants in exchange program

6) Directors identify a publisher for the seabird island ecology book
7) Initial development of video.

YEAR TWO

Annual Workshop II: Synthesis of existing results across systems (Spring 2008; Santa Cruz, CA)

Pre-meeting preparation:

1) Research groups develop first drafts of system-specific summaries for book
2) Working groups develop outlines for a cross-system synthethic chapters

Meeting agenda:

1) Presentation by working groups of initial results to all participants
2) Presentation of video to date and discussion of changes
3) Working groups' session goals:
    a. Cross-system comparisons:
        i. Refinement of goals and plans for cross-system analyses
        ii. Continued work on cross-system synthetic chapters
    b. Further discussions of cross-group grant development
4) All participants: integration of the cross-system chapters into final book chapters
5) All participants: discussion of restoration goals and need for guidelines
6) Public session (with remote participation):
    a. how to improve public knowledge of and access to information about island systems being restored
    b. public exchange of ideas

Post-meeting work:

1) Continued work on cross- system data analysis and writing of synthetic chapters
2) Continued submission of data to the joint database
3) Researchers participate in exchange programs
4) Writing of multi-group grant proposals
5) Working groups: development of guidelines based on cross-system comparisons
6) Workshops and symposia at national and international meetings with larger audience

YEAR THREE

Annual Workshop III : Presentation of quantitative comparisons across systems and development of restoration guidelines (Spring 2009; Shoals Marine Laboratory).

Pre-meeting preparation:

1) Development ofdrafts of cross-system comparison manuscripts by working groups
1) Submission of ideas for restoration guidelines following predator eradication by scientists and by members of the public

Meeting agenda:

1) General scientists meeting:
    a. Review of progress on book and final edits
    b. Reports on workshops held at national and international meetings

c. Final revisions of the video

2) Scientists + members of the public (with remote participation)
    a. Whole-group discussion on developing guidelines for restoration
    b. Development of goals for working groups
3) Working group meetings
    a. Writing of restoration guidelines
    b. Work on drafts of quantitative comparisons of systems
4) Final whole-group meeting:
    a. Compilation of results from working groups
    b. First draft of guidelines

Post-meeting work

1) Submission of book
2) Submission of cross-system manuscripts
3) Production and distribution of restoration guidelines

COMMUNICATION AND EVALUATION

Authorship. Several different products are likely to result from SEAPRE, and determination of authorship will vary by type of product. Authorship on peer-reviewed manuscripts resulting from comparative work will be determined by the level of involvement of the participants (i.e. the first author will be the person spearheading a particular effort) and will be limited to those actively involved in producing the manuscript. For system-specific book chapters, each research group will determine authorship, while for cross-system comparison chapters authorship will be as for manuscripts. Finally, for less formal products (e.g. restoration guidelines), in which we expect input from most members, we will list the lead authors followed by all participants, including members of the public where appropriate (in alphabetical order) or by "and the SEAPRE group" (depending on outlet).

Website. The SEAPRE website (Fig. 3) will form the nerve center of the network. It will provide general information, summaries of findings, and standardized methods to all those interested. It will also serve as the repository of data contributed to the collaborative dataset, allow for participants to access data, facilitate preparation for meetings and ongoing discussions, and facilitate production of document drafts. This scientific network will be run in parallel with a network aimed at members of the public. The website will allow island owners, managers, volunteers and others interested in seabird islands to contact each other, exchange ideas, and develop their own standardized methods.

There will be three levels of access (Fig. 3). The open access area will be available to anyone, but will not allow direct inputs (other than via email contact with participants). Scientists or members of the public who are interested in joining the network can register by contacting the coordinators or website manager. Data that have already been published and that scientists have agreed to make public will be available to registered participants, as will more detailed information on activities. Access to some activities (e.g. ongoing analyses of unpublished data, drafts of papers in progress, etc.) will be limited to active members of the SEAPRE community (including some non-scientists). Within that limited access area, special log-in passwords may be required to further limit access to specific data sets and manuscript drafts that are under active analysis and development. We expect new research groups to join this community as the project

progresses. The Institute of Arctic Biology has agreed to support the maintenance of the website beyond the life of this RCN (see support letter from Dr. Barnes), thus ensuring that the impact of the network will continue beyond the three years of the project.

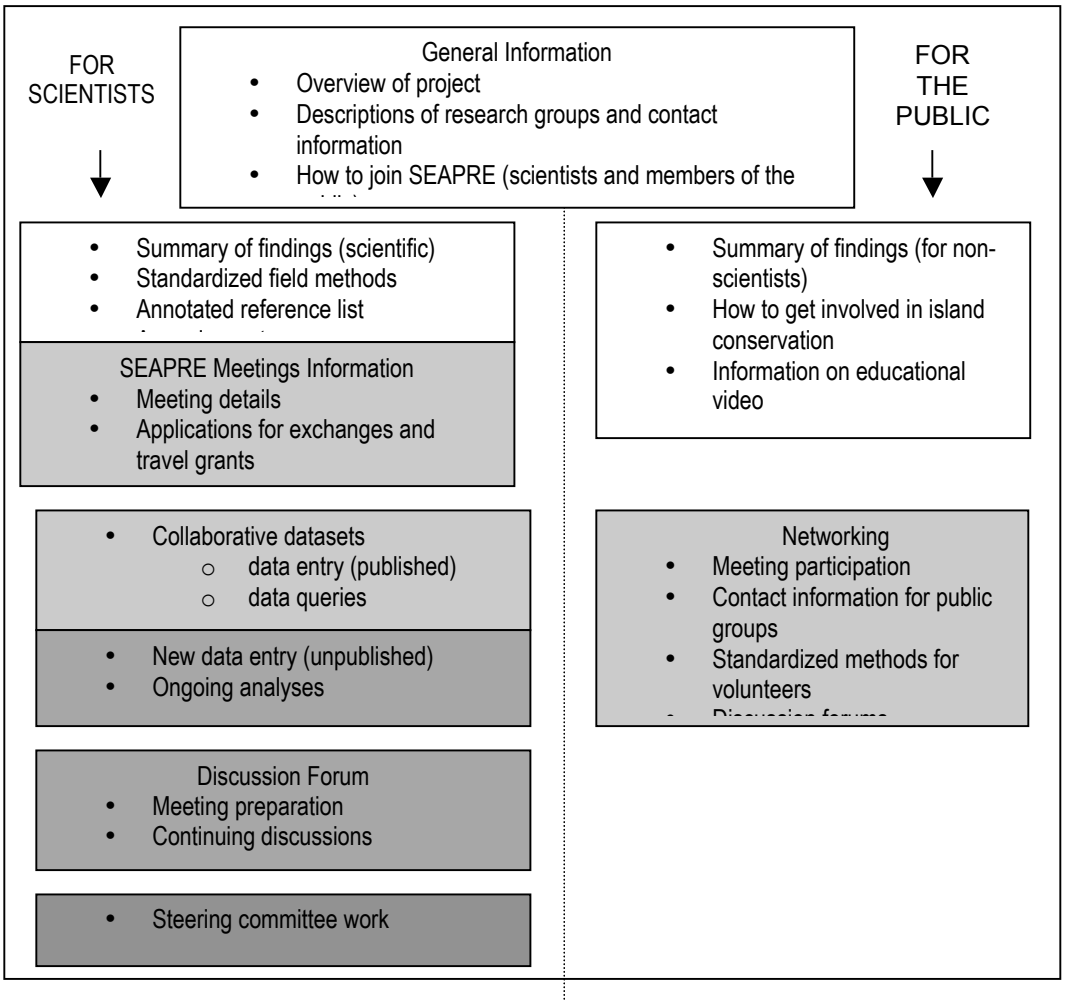

Figure 3. Proposed structure of the SEAPRE website. Boxes with white background indicate information available to all; those with a light grey background require registration (but not active participation); those in dark grey are limited to current active SEAPRE participants.

Evaluation of Progress. Responsibility for ensuring that SEAPRE meets its stated goals rests with the Steering Committee. The Steering Committee will meet briefly before and after each annual meeting to determine whether the nine main goals are being met, and how to alter course if they are not. These goals (rather than the details of the "Outline of Activities") will drive any changes made.

BROADER IMPACTS

Contributions to conservation and restoration biology. Most seabird islands, former seabird islands with predators, and islands in the process of being restored have not been studied. By drawing on the collective experience and data gathered by many different research groups we will be making available information that allows stakeholders (owners, managers, those who use the islands for recreation) to understand what attributes their islands are likely to have (if undisturbed), and whether and how to restore them (if seabird colonies have been reduced). This information is complementary to that provided by groups focused on predator eradication and is

crucial for the successful maintenance and enhancement of biodiversity, particularly of species that do not occur on the mainland. Specific products that will help accomplish this include the guidelines to island restoration, which will be available online as well as in booklet form, and will be updated beyond the lifespan of the RCN. By including members of government agencies and NGOs, we hope to encourage the incorporation of information gathered by such organizations but often not published in an accessible form.

Training and international collaboration. This RCN will enhance collaboration between different types of organizations (academic, government, and NGOs) and increase international collaborations. First, we will actively encourage students (graduate and undergraduate) to participate in meetings and in the development of papers, book chapters and other products. Second, we will provide partial funding for six exchanges (three each in years 2 and 3) between research groups. These travel grants will be aimed primarily at junior scientists (students and postdoctoral fellows) and will be awarded on a competitive basis by the Steering Committee. The purpose of these exchanges is to expose participants to different systems and increase their understanding of the global context in which their own projects take place.

Community participation in island conservation and restoration. Participation by non-scientists is a vital component of the SEAPRE activities. Many members of SEAPRE have links with public groups interested in island conservation (e.g. Earthwatch) or are part of organizations that depend heavily on volunteer participation (e.g. New Zealand Dept. of Conservation, The Nature Conservancy). We will take advantage of these existing links to as follows:

1) Members of the public will be encouraged to participate in the second and third meetings, which will be held at locations near islands. They will provide input on what information would be helpful to them, as well as participate in the development of the restoration guidelines. We will provide opportunities for remote participation (over the phone and the web) to increase accessibility.
2) The public section of the SEAPRE website will facilitate exchanges between different stakeholders on topics of interest to them.
3) We will produce a multi-lingual video (with English, Spanish, and French options, and possibly others depending on participants) that provides information on what seabirds do on islands, how predators change island functioning, and how predator eradication and restoration activities help restore functioning. A central focus of this video will be the role played by the public in aiding the conservation and restoration of these islands: owners and managers providing access to researchers, volunteers aiding in restoration activities, or the role of public awareness in preventing re-invasions. We have identified a potential videographer: Aaron Hoffman, a biologist who runs a small media outreach company and whose primary interests lie in public scientific education, has already produced a video for the RASP group and is ideally suited to lead this effort.

SUMMARY: The efforts of SEAPRE will result in the development of common methods, cross-system comparison and synthesis, and a conceptual framework on the ecological functioning of seabird islands. This is turn will allow for the development of restoration principles and guidelines and predictions for impacts of new invasions or predator eradication. A strong ecological understanding of island functioning is crucial to the success of restoration efforts already underway on islands across the globe.

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