# *ISLES*

**JOINT VENTURE AGREEMENT 08JV-11100500-100**
**between the**
**USDA FOREST SERVICE, TONGASS NATIONAL FOREST**
**and the**
**UNIVERSITY OF NEW MEXICO**

Final Report September 2013

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## Introduction

**ISLES** (Island Surveys to Locate Endemic Species) focused on evaluating the occurrence and specific status of purported endemics on the southern third of the Tongass National Forest, Southeast Alaska. ISLES was a partnership of the Museum of Southwestern Biology (MSB) at the University of New Mexico (UNM), and the Tongass National Forest, other Alaska agencies and Alaska schools and universities. The partnership originally consisted of two primary efforts: a continuation of the inventory of Southeast Alaska small mammals started in 1991 as mandated by TLMP, and development of an interagency and interisland network to procure and archive for future study samples of game and furbearer mammal species of the Tongass National Forest and surrounding regions as a basis for informed natural resource management efforts. These network activities, although originally proposed, were significantly reduced due to reduced funding. Success of a prototype of the network was demonstrated nonetheless.

ISLES was successful as demonstrated by the relatively large number of graduate (4) and undergraduate students (12-most funded by other sources such as the National Science Foundation) that were mentored, the large specimen archive, and the number and quality of peer-reviewed publications generated (see below). These papers focus on diverse aspects of the status of wildlife and endemics of Southeast Alaska. Importantly, unlike most funded projects, the impact of this project will grow after the termination of this cooperative agreement, as additional publications and management initiatives will benefit from the large database and associated samples. Those future efforts will use the spatially-rich archive of samples (and associated GIS relevant data) that are now available to all qualified investigators, managers and educators because of the field expeditions sponsored under this agreement. This archive includes traditional museum specimens tied to a web-accessible database that tracks Tongass mammal and parasites specimens and their use (e.g., investigations, publications). This natural history library allows teachers, students, trappers, researchers, and the general public to learn about the complexity of Southeast Alaska's biomes. It also helps managers address issues such as endemism, emerging pathogens, wildlife disease, habitat conversion, and population viability. To date, these efforts have demonstrated that some island endemics are actually more widely distributed than early work indicated. Conversely, cryptic (previously unknown) forms have been discovered. These findings are not surprising given the lack of material available from the highly fragmented and complex landscapes of Southeast Alaska. This new information will be essential to prioritizing limited resources related to federally-mandated inventory and monitoring efforts for endemics. More generally, basic information on each island species and population is essential to prioritizing limited resources related to the management of wildlife.

ISLES consisted of two primary initiatives:

• Field Inventory of Small Mammals—ISLES continued mammal inventory work that started in 1991 in Southeast Alaska by S. O. MacDonald and J. A. Cook. The ongoing initiative to inventory the small mammal fauna endemic to the region has been conducted by field crews from the Museum of Southwestern Biology, University of New Mexico that included a mix of seasoned mammalogists and undergraduate students. Results of these efforts are available through reports, professional publications, presentations, and online through the ARCTOS specimen database.

Ongoing investigations of mammals in Alaska indicate inadequacies in our current understanding of diversity. Inventory and monitoring studies with rigorous protocols for the physical documentation of the data including the systematic collection, preparation, and preservation of modern museum specimens, provide an efficient ad economical way to investigate and manage biomes. Often the benefit of geographically extensive and site intensive collections is not immediately apparent, but over time, the value of specimen archives increases dramatically as these materials become one of our prime opportunity to view past environmental conditions. Some of our highest quality assessments of environmental impacts or emerging threats have been derived from museum specimens (and their related data) that were systematically collected years ago. Specimens also provide the physical documentation for species identifications and associated data on reproduction, habitat, pathogens and parasites, among others.

• Interagency Salvage Network for furbearer and other game animals from cooperating trappers and hunters from around the region. Key players in this initiative were local trappers and hunters who provided high quality frozen specimens (salvage carcasses) from their traplines or successful hunts. This effort was de-emphasized beginning in 2009 due to a lack funds from the agreement, but we attempted to keep the effort going. For the last four years, trappers were paid a minimal amount for each salvaged carcass from either museum foundation funds or from personal funds. These specimens are now processed and archived at the museum and also are reported herein.

To address the issue of endemism in game species on the Tongass National Forest, the Archival Inter-agency Network should be reconstituted and should cover all Alaska Department of Fish & Game Region 1 Game Management Units and USFS Tongass Ranger Districts. Relatively minimal coordination (and funding) of wildlife biologists and trapper/hunter cooperators would ensure maximum coverage. Deer check stations in the fall are an example of such efforts, whereby relatively little effort to preserve tissue samples would provide significant new information (e.g., monitoring chronic wasting disease, ecological genetics, or dietary change through stable isotopes) for real-time monitoring of Sitka Black-tailed Deer populations. A number of other game and furbearers could be monitored as well. Lack of archival materials that would be provided by annual sampling of wildlife on the Tongass National Forest remains a missing piece of key infrastructure that will be required if we hope to monitor and mitigate changing conditions.

A third ISLES-related initiative was stimulated by additional funding from the National Science Foundation through the AIM-UP! program.

• Education—Developing island-based science content for public school students. The Alexander Archipelago provides a fantastic opportunity to learn fundamental scientific concepts in geology, ecology and evolutionary biology. Charles Darwin and Alfred Russell Wallace are among the most influential and creative biologists known. Primary inspiration for their key contributions to our understanding of how organisms diversify and new species are created came from their detailed studies of islands. Processes such as natural selection, drift, population divergence and a host of other ideas can be explored across the islands of the Alexander Archipelago. Similarly, the eminent ecologists Robert MacArthur and Edward O. Wilson gained new insight into understanding how biological communities are assembled through time by studying island archipelagos. New views of the natural world continue to emanate from island studies.

Local students are fortunate to live in Southeast Alaska because it is one of the last remaining wild ecosystems on the planet. Numerous challenges will face local residents in the coming decades including increasing human populations (more tourists), invasive species, global demand for natural resource extraction, the need to develop sustainable local economies, changing climate that will impact ecosystem function, increasing toxins, emerging pathogens and a host of other issues. Enlightened management of wildlife and responsible development of natural resources in Alaska will depend on a mix of new and traditional ideas as implemented by the next generation of local leaders.

To assess the impacts of biotic change we must start with understanding our surroundings, so place-based education is one of the keys to appreciating local cultures and environments as we develop new solutions to challenges. Modern inventory studies and long-term monitoring programs, when tied to freely accessible databases and integrated into a variety of investigations, can provide a critical foundation for teaching students how to assess environmental change. Ideal partners for local monitoring efforts are public school teachers and students from around the region. By working with museum staff, local teachers can develop curricula aimed at educating young people as field naturalists, budding biologists, and citizen scientists.

Student programs associated with ISLES and AIM-UP! include:
- Education Modules
- Workshops/Presentations
- Monitoring programs
- Mentoring
- Student research

Herein, we provide the last quarterly ISLES report (September 2013) and the final report on the ISLES project for:

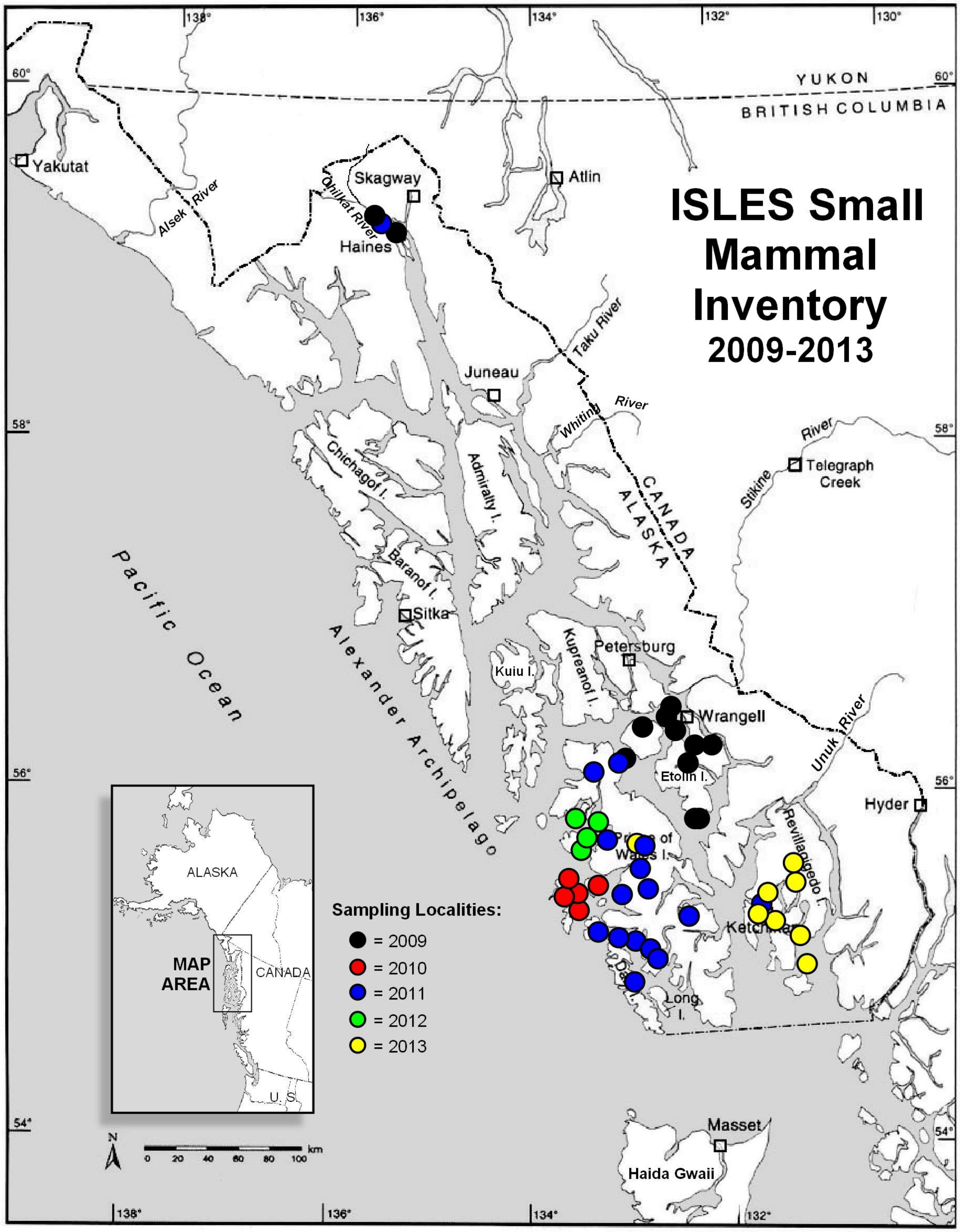
1) all field seasons with an emphasis on 2013;
2) status of pilot furbearer salvage program;
3) preliminary niche models based on specimens and developed for endemic mammals;
4) an overall report on publications, graduate student theses, and educational outreach,; and
5) link to websites (e.g., ARCTOS database that holds all geo-referenced specimens records) at the end of this phase of funding.

## ISLES Project Results

1) **Small Mammal  Field Inventories 2009-2013**

**ISLES Small Mammal Inventory Capture Results, 2009-2013**

| | 2009 | 2010 | 2011 | 2012 | 2013 | TOTAL |
|---|---|---|---|---|---|---|
| N. Flying Squirrel | | | 36 | 7 | 6 | 49 |
| red squirrel | 8 | | 3 | | 6 | 17 |
| m. jumping mouse | | | | | 3 | 3 |
| long-tailed vole | 13 | 8 | 31 | 1 | 11 | 64 |
| meadow vole | 10 | | 1 | | | 11 |
| S. red-backed vole | 82 | | 1 | | 10 | 93 |
| N. red-backed vole | 8 | | 8 | | | 16 |
| NW deermouse | 172 | 132 | 881 | 36 | 91 | 1312 |
| N. bog lemming | 5 | | | | | 5 |
| cinereus shrew | 64 | | 2 | | 38 | 104 |
| dusky shrew | 58 | 58 | 88 | 44 | 131 | 379 |
| water shrew | 1 | | | | | 1 |
| ermine | 1 | | | | | 1 |
| least weasel | 1 | | | | | 1 |
| TOTAL | 423 | 198 | 1051 | 88 | 296 | **2056** |




## 2009 ISLES Fieldwork

*Localities Sampled:*

- Haines area, 4-6 July 2009

- Wrangell Island, 8-15 July
- Onslow and Eagle islands, 17-22 July
- Zarembo Island, 23-29 July
- Shrubby Island, 29-31 July

*Highlights:*

- First vouchered specimen of Least Weasel (*Mustela nivalis*) for Southeast Alaska (near Haines).
- First specimen record with associated tissues for DNA analysis of ermine (*Mustela erminea*) from Zarembo Island.
- First records of meadow vole (*Microtus pennsylvanicus*) for Sokolof Island.
- Addition of two new and previously unsampled islands, Onslow and Eagle, to the known distribution of the southern red-backed vole (*Myodes gapperi*) in the Alexander Archipelago of Southeast Alaska. The two red-backed voles we were able to secure on Eagle Island appeared morphologically unique and worth of further study.
- Second record of water shrew (*Sorex palustris*) from Wrangell Island (Pats Lake).
- Our capture of five northern bog lemmings (*Synaptomys borealis*) along McCormack Creek, Wrangell Island, constitute the first small series of this species secured from this island since they were first discovered there (and subsequently described as a new species, *S. wrangeli*) by C.P. Streator of the US Biological Survey in 1895.
- First documented records (photos, mouth swabs to UAS) of western toad (*Anaxyrus boreas*) from Onslow and Eagle islands.
- First documented records (photos) of roughskin newt (*Taricha granulosa*) from Eagle Island.
- Opportunistic collection and preservation of ground beetles, land snails, and tissue samples of Pacific Banana slug (*Ariolimax columbianus*; tissues from nearly all localities visited). These materials will be loaned to researchers with expertise in these groups (e.g., land snails to malacologist Robert Forsyth in Smithers, British Columbia).
- Mouth swabs on all western toads encountered were sent to Jennifer Moore, UAS, Juneau. Island populations sampled included Wrangell, Onslow, Vank, and Zarembo.
- All captures were examined for ecto- and endoparasites and, when present, preserved in alcohol. Blood samples were also taken from every individual. For most islands and Southeast Alaska in general, these specimens provide new opportunities to screen for zoonotic human and wildlife parasites and pathogens such as babesia and hantavirus.

**2010 ISLES Fieldwork**

*Localities:*

- Baker Island, 10-13 August 2010
- Santa Rita Island, 10-12 August
- St. Ignace Island, 11-12 August
- Noyes Island, 13-16 August
- (W.) San Lorenzo Island, 17-20 August
- Cone Island, 20-23 August
- Lulu Island, 12-13, 24-27 August
- San Fernando Island, 27-30 August

*Highlights:*

- Initial analyses of sequenced DNA data from several of the marten specimens obtained from cooperating trappers on Dall Island during the past winter season suggest the co-occurrence of Pacific marten, *Martes caurina*, and American marten, *M. americana*, on this never-before-sampled outer island. Attempts to obtain additional specimens are being sought this upcoming season on this and neighboring islands to help shed further light on this exciting discovery. Prior to this finding, *M. caurina* was known only from Admiralty and Kuiu islands in the Alexander Archipelago, and considered an endemic taxa on neighboring Haida Gwaii (Queen Charlotte Islands) in British Columbia.
- Addition of two new islands to the small mammal inventory: Cone and the westernmost San Lorenzo Island. These had not been sampled previously. Dusky shrew and NW deermice were found on Cone Island, but no small mammals, despite considerable effort, were found on San Lorenzo.
- First records of western toad (*Anaxyrus boreas*) from Lulu, Noyes, Santa Rita, and Noyes islands.

**2011 ISLES Fieldwork**

*Localities:*

- Haines area, 11-14 July
- Revillagigedo Island, Ward Lake, 15-16 July
- Prince of Wales Island, 16 July-11 August
- Suemez Island, 20-23 July
- Shelikof Island, 23-25 July
- Dall Island, 25-28 July, 8-11 August
- Goat Island, 28 July-1 August
- Sukkwan Island, 2-8 August

*Highlights:*

- First records of the endemic Prince of Wales flying squirrel (*Glaucomys sabrinus griseifrons*) for Shelikof and Sukkwan islands. Prior to 2011, only 1 flying squirrel served as a specimen voucher for their occurrence on Dall Island.
- Roughkin newts (*Taricha granulosa*) were noted at several localities on Prince of Wales Island, and a western toad (*Anaxyrus boreas*) was encountered on Dall Island.

**2012 ISLES Fieldwork**

*Localities:*

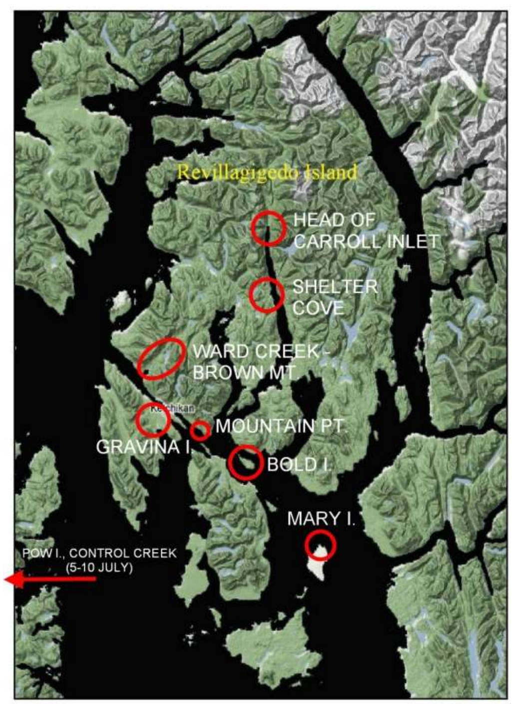
- Heceta Island: Indian Garden Bay (20-24 July); NE side (1-3 August)
- Tuxekan Island: NW end (24-28 July); Yahku Cove (3-6 August)
- White Cliff Island, 28-31 July
- Highlights:
- We documented a six-fold decline in small mammal abundance from the previous year, the lowest we've ever experienced in this region (with 2011 being the highest). While we did not trap on POW in 2012, a similar marked decline was experienced on this island by the University of Wyoming small mammal project that sampled POW in 2012 (Elizabeth Flaherty, pers. comm.).
- Despite considerable effort, no small mammals were documented on White Cliff Island; however, past efforts documented shrews and mice on nearby Eagle, Owl, and Hoot islands.
- We documented first records of roughskin newts (*Taricha granulosa*) on Heceta and Tuxekan islands. No western toads (*Anaxyrus boreas*) were encountered at any time during work on these islands.
- Mink and deer were seen at all localities. Black bear or their sign was not recorded either on Heceta or White Cliff islands. Wolf sign was noted on Heceta and Tuxekan islands. River otters were seen on Tuxekan Island.
- We heard Barred Owls (*Strix varia*) each night from our camp in Yahku Cove at the southern end of Tuxekan Island. This species is a relatively new arrival to Southeast Alaska's avian fauna, first reported near Juneau in 1977. Since then, they have rapidly expanded their range into the Alexander Archipelago (Kissling and Lewis 2009). Their impact on naive populations of insular flying squirrels and other prey species is unknown but may be significant.
- Our opportunistic collection and preservation of ground beetles and land snails were sent to researchers with expertise in these groups (ground beetles to Derek Sikes, University of Alaska Museum Entomology Collections, Fairbanks, and land snails to malacologist Robert Forsyth in Smithers, British Columbia).

## 2013 ISLES Fieldwork

### ISLES Small Mammal Inventory, 2013

| | N. Flying Squirrel | Red Squirrel | Meadow Jumping Mouse | Long-tailed Vole | Southern Red-backed Vole | NW Deermouse | Cinereus Shrew | Dusky Shrew |
|---|---|---|---|---|---|---|---|---|
| **PRINCE OF WALES ISLAND** | | | | | | | | |
| Control Creek, Eagle's Nest area | 5 | | | | | 6 | | 19 |
| **GRAVINA ISLAND** | | | | | | | | |
| SE side, S. of Airport | 1 | 1 | | | | 4 | 2 | 1 |
| **REVILLAGIGEDO ISLAND** | | | | | | | | |
| Ward Creek-Brown Mountain | | 3 | | 2 | 4 | 40 | | 20 |
| Mountain Point area | | | | | | 4 | | 2 |
| Shelter Cove | | | 3 | | 3 | 12 | 20 | 45 |
| Head of Carroll Inlet | | | | 9 | 3 | 15 | 12 | 44 |
| **BOLD ISLAND** | | | | | | | | |
| E. side | | 2 | | | | | | |
| **MARY ISLAND** | | | | | | | | |
| Anchorage Bay | | | | | | 10 | | 4 |

Map of Field Sites Visited 2013



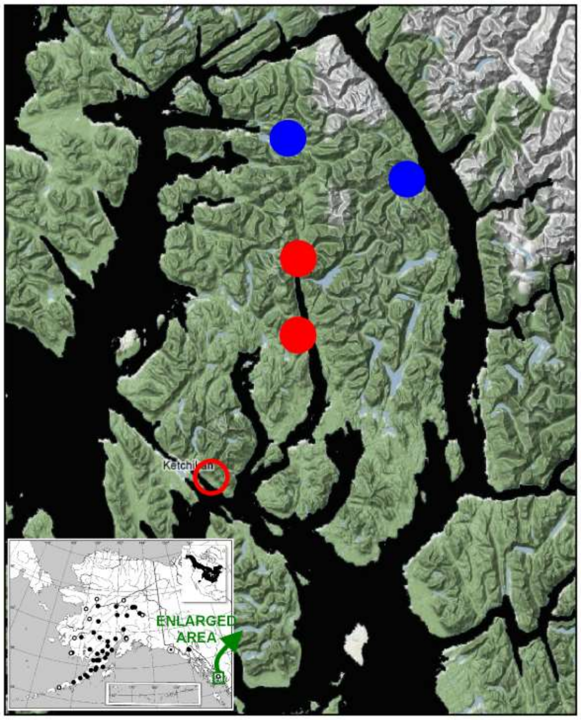
*Localities:*

- Prince of Wales Island, Control Creek. 5-10 July
- Revillagigedo Island:
    - Ward Creek area, 11-13, 27-30 July; Mountain Pt. area, 12-13 July
    - Shelter Cove, 19-23 July
    - Head Carroll Inlet, 23-26 July
- Gravina Island, 13-15 July
- Bold Island, 16-19 July
- Mary Island, 29 July-1 August

*Highlights:*

- The only small mammal found inhabiting Bold Island was red squirrel. NOTE: other islands we found lacking any small mammals were White Cliff and the westernmost of San Lorenzo Islands across from Hole-in-the-Wall.
- First specimen of northern flying squirrel for Gravina Island.
- Addition of Yuma Myotis (*Myotis yumanensis)* to Alaska's mammalian fauna from specimens previously collected in three localities in southern Southeastern.
- Kris Larson (ADFG) closely watched a water shrew (*Sorex palustris*) foraging along Ward Creek drainage on 21 July. From his email: "*Just wanted to drop you a quick note and say that I saw a water shrew up on Brown Mountain today. Well, I'm almost completely certain. It was about the size of a small* Peromyscus*, dark gray (almost black) with silver(ish) under trim. It ran past me on a gravel bar, on Brown Mtn. creek, ran to the upper end of the gravel bar, jumped in the creek, hugged the bank and swam quickly to an undercut bank and ducked in. I saw it three additional times on its route up stream. It would use the cutbanks to hide and where they would touch down to the water the shrew would shoot out and swim up to the next undercut section. I didn't see it dive, but I don't know that they do that. I know for certain that it was a large, dark shrew that swam fast."* This is the second unambiguous report of this species on Revillagigedo Island. Traps were left for Kris to secure a specimen.
- We expanded the range of the meadow jumping mouse on Revillagigedo Island as shown below. Closest other SE occurrence is Haines, some 400 km north of Revilla.

Meadow Jumping Mouse (*Zapus hudsonius*)




● = previous record ● = 2013 record ○ = 2013 sight record

2) **<u>Furbearer & Game Animal Salvage</u>**

2009-2010

- 15 wolverine northern SE
- In April, Craig Ranger District shipped 179 specimens (heads, femurs and whole carcasses) of eight different species to the MSB: 3 wolves, 21 ermine, 7 beaver, 4 mink, 4 river otter, 11 flying squirrels, 5 deer and 128 marten, including 72 marten from Dall Island.
- >500 Southeast Alaska black bear specimens were finally processed, data based, and archived from Lilly Peacock's doctoral dissertation study. We are now processing more than 1000 furbearer specimens from southeast Alaska collected by Jack Whitman and hope to have these available on-line by the end of the year.

2011-2012

- 108 samples of marten plus several river otters, ermine and flying squirrel for the ISLES project from Dall, Suemez, Sukkwan, and Prince of Wales islands. These were stored in freezers in Craig and Hydaburg. Prior to fieldwork in 2012, all were necropsied for parasites and prepared for permanent archiving.
- From Jon Martin at UA Southeast-Sitka, we obtained the following specimens:

  Baranof Island
    - 30 Marten
    - 2 Sitka deer
    - 1 Ermine

- 1 Mink
- 1 River Otter

Chichagof Island
- 23 Marten
- 1 Sitka deer
- 1 River otter

Partofshikof Island
- 1 Marten

Mainland SE
- 5 Marten

2012-2013

- POW (Ray Slayton)
  - 1 Mink
- 

- From Jon Martin at UA Southeast-Sitka, we obtained the following specimens:

Baranof Island
- 48 Marten
- 1 Sitka deer
- 3 Ermine
- 1 Mink
- 2 River Otter
- 1 Mtn Goat

Chichagof Island
- 22 Marten

Partofshikof Island
- 2 Marten

Kruzof Island
- 1 Marten

Mainland SE
- 10 Marten

**3) Preliminary Niche Modeling Projections for Endemic Mammals**

In the coming decades, how species will respond to climate change and a host of other stressors is unclear (Moritz and Agudo 2013). Species on islands are particularly vulnerable because species cannot shift their ranges far. This is problematic because the most common response to change is for species to shift geographically to track their climatic niche. We know from paleontological studies that small and large refugia are especially important landscapes for long-term persistence, and these should be accorded special protection on the Tongass National Forest. By understanding the history of refugia we can begin to identify the processes involved in diversification and endemism, essential processes to conserve. How did these species get to their current locations and what were the mechanisms that determined their distribution and diversification?

Unfortunately studies of refugial effects are just beginning in Southeast Alaska, But in the past 20 years, our understanding of the past 200,000 years along coastal Southeast Alaska has been completely turned upside down due to new geological, paleontological and molecular genetic information. Wider availability of specimens from throughout the region has been especially important as we attempt to document species distribution and ecology. Specimens also facilitate molecular genetic studies of coastal organisms to test their origin and relationships. Extra emphasis should now be placed on minimizing population stressors (in addition to climate change) for species of concern such as endemics. Managing and restoring eco-evolutionary dynamics across highly fragmented landscapes such as the Alexander Archipelago and adjoining coast, will require identifying and characterizing long-term climatic refugia, and then understanding the habitat and conserving the connections to these refugia. Species and ecosystems are naturally dynamic so our conservation goals should be to manage this island ecosystem in a way that will avoid large-scale state changes. Such an approach will require much more fundamental information and sampling of species and populations than currently exists. By recognizing that the region is extremely complex and fragmented, we should generalizations across the region because they will be extremely tenuous. Given this complexity, it is important to emphasize again that relatively little work has been done so far and too few specimens exist. The simple fact that we are still at the most fundamental step of identifying species composition for many islands, suggests more effort is needed. For example, *Martes caurina* remains poorly characterized and there are large islands like Heceta where they are of unknown status and apparently few in number on this very heavily deforested island. And how much do we know about the endemic ermine, *Mustela (e.) haidarum* on Heceta or other nearby islands. Only in the last 3 years have we documented the occurrence of the Pacific marten (*Martes caurina*) on Dall Island.

For Species Distribution Model development, we focused on 3 species that represent multiple endemic subspecies or lineages. We used current, past, and future monthly climate data (2.5'; 4

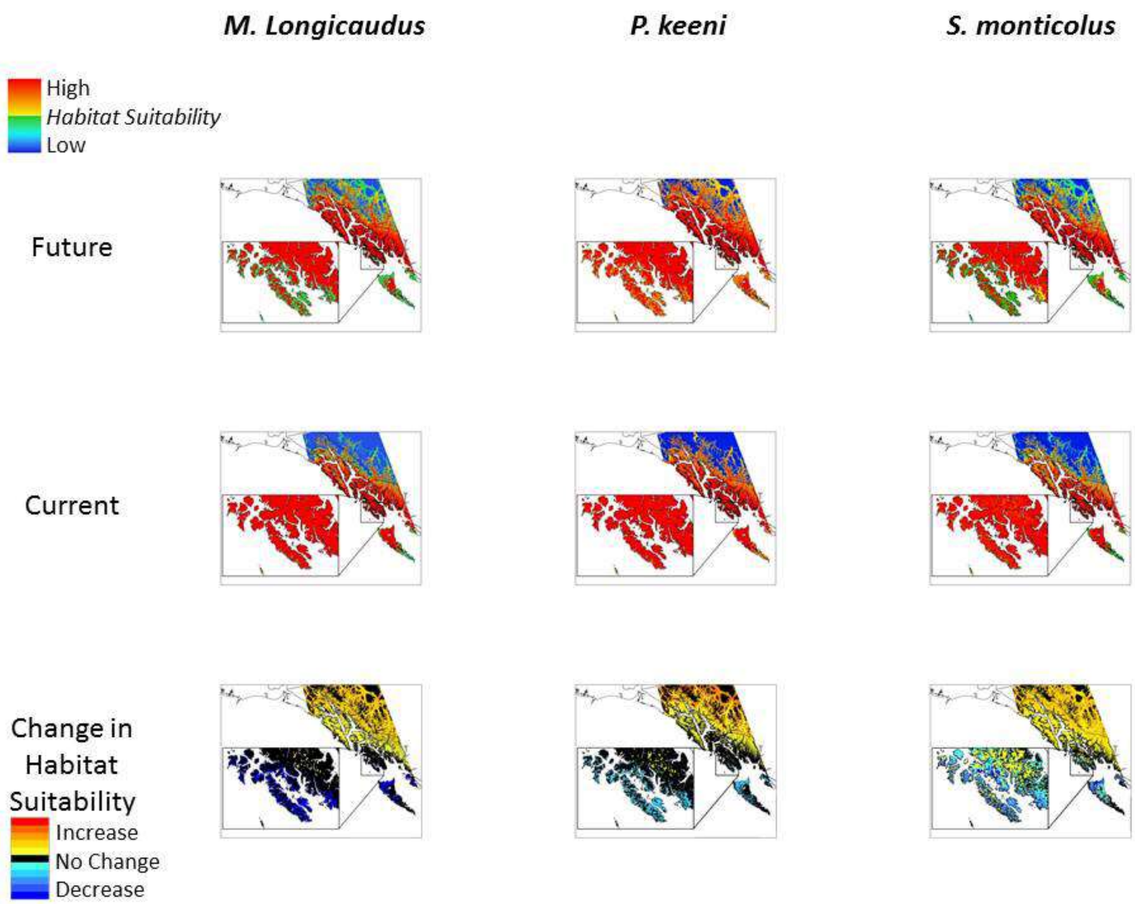
km). Bioclimatic variables, representing summaries of means and variation in temperature and precipitation were first examined for multicollinearity, excluding those with a Pearson's $R^2 > 0.8$ with another variable. SDMs were developed within geographic masks where bounds correspond to distribution of study lineages. For species locality data, we collated georeferenced occurrence points using natural history collection data. Multiple options are available for assessing model uncertainty from SDMs including examination of results across multiple algorithms. We focus on optimization of present-day models using Maxent and generated SDMs using only presence records, contrasted with pseudo-absence data resampled from the remainder of the study area. We used 5 replicates under the "crossvalidate" option, and generated summary maps in ArcGIS 9.3 by averaging Maxent outputs (see Supplementary Material). Past models were made for Last Glacial Maximum (LGM), Last Interglacial (LIG) and mid-Holocene. Future predictions were made for 2070-2099. For LGM and future time periods, we show predicted habitat for which 50% or more of the GCM models indicate suitable habitat. We then compare changes between current and future to provide an assessment of change in habitat suitability for these species. Note that these very preliminary models are based on georeferenced specimen information and provide a foundation for additional predictive exercises for species changes on the Tongass National Forest.

Resulting graphic depictions of the dynamic nature of these species distributions suggest significant changes in the near future under climate warming scenarios. Habitat suitability is predicted to change throughout the region for these three species with projected decreasing suitability especially prominent on the outer southern islands (Prince of Wales archipelago).

Moritz, C. and R. Agudo 2013. The future of species under climate change. Science 341:504-508.

Barnosky, A. D., et al., 2012. Approaching a state shift in Earth's biota. Nature 486: 52–58.

Millar, C. I., N. L. Stephenson, S. L. Stephens. 2007. Climate Change and Forests of the Future: Managing in the Face of Uncertainty. Ecological Applications 17: 2145–2151.




Ecological Niche Models developed for 3 species of small mammals on the Tongass National Forest demonstrating changes in habitat suitability between current distributions and projected future distributions at 2050 based on climate warming estimates. Note that the bottom panel helps to identify locations where habitat will likely be less suitable for these species.

### 4) <u>Education and Data Development</u>

New GPS units were used in the field in 2012 and 2013 that allowed us to automate and refine georeference data capture and storage for each specimen. Additional development in the 2013 season included implementation of a betaversion of ArctosAir, database software currently under development that will allow real-time upload to Arctos from field research via satellite uplink.

AIM-UP! and ISLES both continue on-line content development allowing educators access to into the data and management questions being developed in this project (see websites). Cook spent a few weeks in Fall 2013 in Sitka on a Scientist in Residency Fellowship at the Sitka Sound Science Center (one month) to further development of ISLES resources with local educators Kent Bovee, Jon Martin, Scott Harris, Scott McArthur, Chola Moll, and Kitty LaBounty in Sitka (Sitka High School, Mt Edgecumbe High School, UA Southeast). During the month he presented Tongass research and used the island curriculum in 6 classrooms, delivered an informal evening lecture in the Natural History Seminar Series at the University of Alaska Sitka (> 110 in attendance), a seminar as part of the Alaska Coastal Rainforest Center Brown Bag series at the University of Alaska Southeast in Juneau, gave 2 radio interviews about our work in the Tongass and participated in WhaleFest.

## Why Focus on Endemism and Islands in Research and Education?

An endemic is a distinct, unique organism found within a restricted area or range. A restricted range may be an island, or a group of islands, and in the case of some endemic mammals within the Alexander Archipelago, a restricted region such as the North Pacific Coast. The term "endemism" holds special importance on island systems, because many organisms are restricted in distribution to a single island or groups of islands. For example, of the known bird species throughout the world, 20% are considered "island endemics" because they are found only within island systems. The North Pacific Coast is a hot spot for endemism because of its historical isolation, ecological complexity, and narrow distribution between the Pacific Ocean and coastal mountain ranges. Within Southeast Alaska, almost 20% of known mammal taxa (species and subspecies) have been described as endemic to the region (see list to right). The long-term viability of these endemic populations is unknown, but of increasing concern. Island endemics are extremely susceptible to extinction because of restricted ranges, specific habitat requirements, and sensitivity to human activities such as species introductions. They usually experience high rates of inbreeding resulting from small population sizes and therefore suffer from the consequences of reduced genetic variation. Finally, the land masses of islands are smaller than those of nearby continents, and are more susceptible to random climatic events (such as storms) or massive habitat disruption. More than 81% of mammalian extinctions in the last 500 years have been insular endemic mammals. Islands, which tend to harbor extremely high biodiversity concentrated in a relatively small area, may be major driving forces in diversification and ultimately speciation. Therefore, archipelagos such as the Alexander Archipelago of Southeast Alaska are essential to maintaining and increasing global biodiversity. It is impossible to measure the current susceptibility of endemics within the Alexander Archipelago because little information is known about their occurrence, distribution, population sizes, and vulnerabilities. Current research on endemics throughout the Alexander Archipelago is primarily focused on mammals, but should include other organisms. The number of endemic plants, birds, amphibians, and invertebrates are not known for this archipelago. Because mammals often have the lowest percentage of endemics within an island system, other organisms may show much higher levels of endemism within the Alexander Archipelago.

Early explorers and naturalists identified the Alexander Archipelago as a distinctive geographic region, the "Sitkan District." Distinctive organisms were described on several islands in the archipelago even though fewer than 25 islands were visited. Some endemics were described from only one specimen found on one island (for example, Suemez Island ermine *Mustela erminea seclusa),* while others were described from multiple islands (*M. erminea celenda* on Prince of Wales, Dall, and Long islands). Altogether, 24 of 107 mammal taxa were recognized as endemic based on morphological characteristics (MacDonald and Cook 1996). Recent technological advances provide independent perspectives on these endemics based on molecular genetic characters. Many of these new techniques provide a more rigorous assessment of levels of divergence among island endemics and mainland populations than the early surveys described above. These new approaches successfully evaluated the status of endemics on archipelagos elsewhere across the globe and now are being applied to endemics within the Alexander Archipelago. Molecular studies have uncovered hidden diversity and are providing new insight into the status of island populations as endemics. Eight endemic mammalian lineages have been identified within the Alexander Archipelago. More mammals and a suite of other organisms need to be examined to paint a more accurate picture of endemism within this archipelago.

One of the main facets of maintaining biodiversity is the ability to recognize and conserve unique endemic organisms. Endemic types or species are especially likely to develop on islands because of their geographical isolation. Island endemics, in particular, can easily become endangered or extinct because of their restricted habitat and vulnerability to the actions of man, including the introduction of exotic organisms and associated pathogens (see attached tables), over-exploitation, and secondary ripple effects.

Islands are special places, especially for scientists. Islands are isolated and are essentially a living laboratory of evolution. Islands harbor the greatest number of endemic species. The relative isolation of many islands has allowed populations to evolve in the absence of competitors and predators, leading to the evolution of unique species that can differ dramatically from their mainland ancestors. The down side of island life is that they are places of concentrated extinction. Of 724 known animal extinctions in the last 400 years, about half were island dwellers. Furthermore, the proportion of endemics on islands is positively correlated with this intrinsic vulnerability.

Island species are especially vulnerable to extinction because they have a small geographic range. They are limited to the island or a particular part of the island, they usually have low population numbers, and they often are especially susceptible to new (introduced) competitors, predators or pathogens. These factors make them more likely to become extinct as a result of factors such as disease, fire, and population fluctuations. Habitat destruction, direct hunting, competition for food, and other factors also put intense pressure on island species.

Island biogeography is essentially the study of the distribution and dynamics of insular species. It provides a theoretical and operational foundation for the design of research and management plans for wildlife in Southeast Alaska. Such plans in this highly insular region still have not tuned in to the special attributes of island life. To date, the vast Alexander Archipelago has played a limited role in the evolutionary, ecological, and conservation biology literature, although this system is one of the largest temperate archipelagos worldwide with 7 of the 15 largest US islands. With enlightened management, the region could become a model system for testing fundamental hypotheses and monitoring and mitigating issues to environmental change.

**Five Recommendations for Future Work on Tongass Biodiversity (modified from Cook and MacDonald 2013)**

1. Interagency, intergovernmental (i.e., including universities and natural history museums) and new international agreements and specialized working groups should focus on establishing a comprehensive management plan aimed at preserving the endemic biota and natural ecosystems of the Alexander Archipelago. Substantial physical and personnel infrastructure already exists, but coordinated action on island issues is lacking. Because agencies are mandated to manage resources wisely, this infrastructure could be used to implement island centered management plans.

2. Rigorous, integrated inventories of all islands over 500 hectares. There is a pressing need for specimen-based, all-taxa inventories of these islands. Prior work opens productive opportunities to expand seminal studies along the Pacific Northwest Coast on mosses (Schofield, 1989), flowering plants (Calder and Taylor, 1968), ground dwelling beetles (Kavanaugh, 1992; Clarke et al., 2007), birds (Martin et al., 1995; Topp and Winker 2008), and fishes (Moodie and Reimchen, 1973; Reimchen, 1989, 1994). Spatially extensive and site intensive archives of insular organisms are critical to stimulating investigations that will form the basis for careful management (Chapman, 2005). Sophisticated and varied technologies (e.g., stable isotopes, molecular genetics, biotoxins assays) have transformed wildlife management recently. Specimen archives are fundamental to the development of multidisciplinary views of diversity as all of these studies can be tied together through individual voucher specimens.

3. Monitoring efforts should be designed to provide information **and sampling** necessary to assess environmental change. Elements of the environment to be monitored could include species that: are most susceptible to impacts such as fragmentation (e.g., endemics), are introduced exotics, span multiple trophic levels, have complex lifecycles, are sensitive to climate change and have limited ability to move, or are key to human subsistence.

4. Build partnerships to investigate and monitor the region, by involving subsistence hunters, trappers, resource agencies, rural K-12 schools, citizen scientists, and academia if you want to have a lasting impact on resource management in southeast Alaska.

5. Introductions must be more thoroughly regulated (MacDonald and Cook, 2007; Gaston et al., 2008). The best way to manage these pests is to deny their entry. If they become established, detect them quickly and eradicate them or manage them at acceptably low densities to prevent significant negative effects (Simberloff, 2002). Raccoons now found on POW are an important example.

**Recent ISLES-based Publications**

1. MacDonald, S. O. and J. A. Cook. 2009. Recent Mammals of Alaska. University of Alaska Press, Fairbanks. 387pp.

**Book Chapters**

1. Cook, J. A. and S. O. MacDonald. 2013. Island life: Coming to grips with the insular nature of North Pacific Coastal Forests. Pp. 19-42, *In* Conservation of North Pacific Coastal Forests, G. H. Orians, and J. W. Schoen, eds. Univ. Washington Press, Seattle.

2. Dawson, N. G. and J. A. Cook. 2012. Behind the genes: Diversification of North American marten (*Martes americana* and *Martes caurina*). Pp. 23-38 *In* Biology and Conservation of Marten, Sables and Fisher. A New Synthesis. *In* Aubry, K., W. J. Zielinski, M. G. Raphael, G. Proulx, and S. W. Buskirk, eds.

3. Hoberg, E., A.V.A. Koehler, and J. A. Cook. 2012. Complex host-parasite systems in Martes: Implications for conservation biology of endemic faunas. Accepted. *In* Biology and Conservation of Marten, Sables and Fisher. A New Synthesis. Pp. 39-57. *In* Aubry, K., W. J. Zielinski, M. G. Raphael, G. Proulx, and S. W. Buskirk, eds.

**Journal Articles/Reviews based on Specimens from ISLES**

**1.** Malaney, J. L. and J. A. Cook. 2013. Using biogeographic history to inform conservation: The case of Preble's jumping mouse. Molecular Ecology.

**2.** Greiman, S. E., V. V. Tkach, and J. A. Cook. In press. Description and molecular differentiation of a new *Staphylocystoides* (Cyclophyllidea: Hymenolepididae) from the dusky shrew Sorex monticolus in Southeast Alaska. Journal of Parasitology.

**3.** Dawson, N. G., A. G. Hope, S. L. Talbot, and J. A. Cook. 2013. A multi-locus evaluation of ermine (*Mustela erminea*) across the Holarctic, testing hypotheses of Pleistocene diversification in response to climate change. Journal of Biogeography.

4. Deardorff, E.R., R. A. Nofchissey, J. A. Cook, A. G. Hope, A. Tsvetkova, S. L. Talbot, G. D. Ebel. In press. Serological Evidence of Powassan Virus in Mammals from Russia, Alaska and New Mexico, 2004-2007. Emerging and Infectious Diseases.

5. Malaney, J. L., C. J. Conroy, L. A. Moffitt, H. D. Spoonhunter, J. L. Patton, and J. A. Cook. 2013. Phylogeography of the western jumping mouse (*Zapus princeps*) detects deep structure in the southwestern United States. Journal of Mammalogy, in press.

6. Hope, A. G., N. Takebayashi, K. E. Galbreath, S, L. Talbot, and J. A. Cook. 2013. Temporal dynamics of speciation among amphi-Beringian small mammals. Journal of Biogeography 40: 415-429.

7. Sonsthagen, S., G. Sage, M. Fowler, A. Hope, J. A. Cook, S. L. Talbot. 2012. Development and characterization of 21 polymorphic microsatellite markers for the barren-ground shrew, *Sorex ugyunak* (Mammalia: Sorcidae), through next-generation sequencing, and cross-species amplification in the masked shrew, *S. cinereus*. Conservation Genetics Resources. Published online: 10 October 2012. DOI 10.1007/s12686-012-9792-5.

8. Hope, A.G., K. A. Speer, J. R. Demboski, S. L. Talbot, and J. A. Cook. 2012. A climate for speciation: rapid spatial diversification among the *Sorex cinereus* complex of shrews. Molecular Phylogenetics and Evolution, 64:671-684.

9. Hoberg, E. P., K. E. Galbreath, J. A. Cook, S. J. Kutz, and L. Polley. 2012. Northern Host–Parasite Assemblages: History and Biogeography on the Borderlands of Episodic Climate and Environmental Transition. Advances in Parasitology, 79:1-97.

10. Malaney, J.L., J. K. Frey, J. A. Cook. 2012. The biogeographic legacy of an imperiled taxon provides a foundation for assessing lineage diversification, demography and conservation genetics. Diversity and Distributions 18:689-703.

11. Weckworth, B.V., N. G. Dawson, S. L. Talbot, M. J. Flamme, J. A. Cook. 2011. Going coastal: Shared evolutionary history between coastal British Columbia and Southeast Alaska wolves (*Canis lupus*). PLoS One 6: e19582.

12. Galbreath, K. E., J. A. Cook, A. A. Eddingsaas, E. G. DeChaine. 2011. Multi-locus tests of paleodistributional models reveal different facets of the complex demographic history of arctic ground squirrels in Beringia. Evolution 65:1879-1896.

13. Weckworth, B., S. Talbot, J. A. Cook. 2010. Phylogeography of wolves (*Canis lupus*) in the Pacific Northwest. Journal of Mammalogy. 91:363-375.

14. Galindo, E., L. Broncho, E. Keeley, R. Inouye, S. Galindo, V. Winston, L. Farrell, J. Cook. 2009. Compassion: A Hearts-on Paradigm for Transiting Native American Students into a STEM University Environment. Journal of Mathematics and Culture 4:1-22.

15. Runck, A., M. Matocq, and J. A. Cook. 2009. Historic hybridization and persistence of a novel mito-nuclear combination in red-backed voles (genus *Myodes*). BMC Evolutionary Biology 9:114.

16. MacDonald, S. O., E. Waltari, R. Nofchissey, Y. Sawyer, and J. A. Cook. 2009. First records of deermice in southcentral Alaska. Northwestern Naturalist. 90:243-247.

17. Koehler, A. V. A., E. P. Hoberg, N. E. Dokuchaev, N. A. Tranbenkova, J. S. Whitman, D. W. Nagorsen, and J. A. Cook. 2009. Phylogeography of a Holarctic nematode, *Soboliphyme baturini* among mustelids: Climate change, episodic colonization, and diversification in a complex host-parasite system. Biological Journal of the Linnaean Society. 96:651-663.

18. Koehler A. V. A., E. P. Hoberg, F. Torres-Pérez and J. A. Cook. 2009. A molecular view of the superfamily Dioctophymatoidea (Nematoda). Comparative Parasitology 76:100-104.

19. Talbot, S.L., S. A. Sonsthagen, G. K. Sage, S. D. Farley, N. G. Dawson, and J.A. Cook. Island bears: insularity and gene flow among coastal brown bear populations of southeast Alaska. In Revision, Journal of Mammalogy.

**In Preparation**

1. Cook, J. A., S. Edwards, et al. In preparation. Integrating museums into undergraduate education: informatics meets emerging environmental and human health concerns. Bioscience.

2. Hope, A. G., S, Y. W. Ho, J. L. Malaney, J. A. Cook, S. L. Talbot. In preparation. Calibrating molecular evolutionary rates for comparative demographic inference of multiple species. Evolution.

3. Sawyer, Yadéeh E. and J. A. Cook. In preparation. Secondary contact within lineages of *Microtus longicaudus.* Molecular Ecology

4. Sawyer, Yadéeh E. and J. A. Cook. In preparation. Diversification of *Sorex monticolus.* Systematic Biology

5. Yadéeh E. Sawyer, S. O. MacDonald, T. Jung, and J. A. Cook. In preparation. Diversification of northern *Peromyscus*. Journal of Mammalogy.

**Education:**
**Graduate Students Whose Work Was Based In Part on ISLES specimens (since 2008)**

1. Natalie Dawson, Ph. D., University of New Mexico (2008)

2. Andrew Hope, Ph. D., University of New Mexico (2011)

3. Jason Malaney, Ph. D. University of New Mexico (2013)

4. Brooks Kohli, M. S., University of New Mexico (2013)

**In Progress**

5. Ph.D.--- Yadeeh Escobedo Sawyer
6. M. S.--- Jocelyn Colella

**Web-based Educational Modules Based In Part on ISLES specimens**

http://www.aim-up.org/educational-modules/educational-module-1-island-biogeography

**Educational Websites**

http://www.msb.unm.edu/mammals/ISLES_website_final_20091028/isles_home.html

A newly established Research Coordinating Network (National Science Foundation) among the University of New Mexico, University of Alaska Fairbanks, Harvard University, and University of California Berkeley is called Advancing Integration of Museums into Undergraduate Programs (AIM-UP!) (w/ E. Lacey-Berkeley, S. Edwards-Harvard, S. Ickert-Bond-UAF). This grant allows us to convene meetings and working groups of educators and researchers to explore and develop ways to incorporate specimens, such as those arising from USDA sponsored ISLES, into undergraduate courses. The Tongass island module has been the prototype for developing education resources in this network.
**See** http://www.aim-up.org/

**Invited Scientific Presentations and Symposia:**

1. "The role of climate in structuring mammals and their associated parasites in northwestern North America." University of Alaska Southeast and Alaska Coastal Rainforest Center, Juneau, October 2013.
2. "Mammalian Phylogeography of Northwestern North America." Biogeography Symposium, 11th International Mammal Congress, Belfast, UK Aug 2013.
3. AIM-UP! Advancing the Integration of Museum Collections into Undergraduate Education. CollectionsWeb Symposium, Smithsonian Institution, May 2013.
4. "Integrated inventories shed new light on the role of Beringia in the diversification of high latitude species." Texas Tech University, Lubbock, May 2, 2012.
5. "Beringia: A molecular perspective on mammals and parasites." University of Alberta, Edmonton, April 2012.
6. "AIM-UP!-Advancing the Integration of Museums into Undergraduate Programs", CollectionsWeb Education Symposium, Radford, VA Oct 2011.
7. "Beringia: Climate and History Structure High Latitude Mammals and Parasites" in High Latitude Host-Parasite Symposium, American Society of Parasitologists, Anchorage, Alaska June 2011.
8. "Molecular genetic perspectives on the Arctic". Gilleje, Denmark. Arctic Biodiversity Workshop, Conservation of Arctic Fauna and Flora. March 2010.
9. "An overview of mammalian phylogeography in North America." Tenth International

Mammal Congress, Mendoza, Argentina. August 2009.

**Invited Presentations to Public Audiences**

"Island Life: A mammalogist's perspective on what's cool about living in isolation at the western edge of North America." Sitka Sound Science Center, Scientist in Residence Public Lecture, Sitka, Alaska. October 2013.

"Building Durable Scientific Infrastructure". Prince William Sound Science Center, Cordova, Alaska September 2011.

"Coming to Grips with the Insular Nature of Southeast Alaska" Dahlem Conference on Management of the Tongass National Forest, Juneau Alaska, February 2009.

**Presentations (and Published Abstracts)**

1. Kohli, B., V. B. Fedorov, E. Waltari, and J. A. Cook. 2013. Phylogeography of a Holarctic rodent (*Clethrionomys rutilus*). American Society of Mammalogists, annual meeting, Philadelphia, June.
2. Arbogast, B., K. Schumacher, A. Bidlack, J.A. Cook, and G. J. Kenagy. 2013. Analysis of nuclear and mitochondrial DNA reveals cryptic speciation in North American flying squirrels. American Society of Mammalogists, annual meeting, Philadelphia, June.
3. Bell, K., J. A. Cook, and E. Lacey. 2013. Incorporating natural history collections into undergraduate education. American Society of Mammalogists, annual meeting, Philadelphia, June.
4. Salazar-Miralles, F., S. L. Talbot, E. R. Deardorff, and J. A. Cook. 2013. Alaskan hantavirus: Insights into viral evolution. Research Day, Biology Department, University of New Mexico March.
5. Malaney, J.L. and J.A. Cook. 2013. Laying a solid foundation for effective conservation action: historical biogeography informs conservation of the controversial jumping mice of western North America – (Invited Seminar) Western Section of the Wildlife Society, Davis CA
6. Malaney, J., A. Hope, Y. Sawyer, S. MacDonald & J. A. Cook. 2013. Exploring signals of historical demography in North American boreal mammals through statistical comparative phylogeography. International Biogeography Society, January 10, Miami, Florida.
7. Malaney, J.L. and J.A. Cook. 2012. Historical biogeography informs conservation. Annual Meeting of the American Society of Mammalogists, Reno, NV. June
8. Dawson, N. G., C. Koch, S. O. MacDonald and J. A. Cook. 2012. Seeing the Forest for its Islands: Research highlights endemism on the Alexander Archipelago. Alaska Coastal Rainforest Center Symposium, Juneau, Alaska, April.
9. Dawson, N. G., Y. Sawyer, S. O. MacDonald and J. A. Cook. 2012. Island Surveys to Learn About Endemics. Alaska Coastal Rainforest Center Symposium, Juneau, Alaska, April.
10. Kang, H. J., S. N. Bennett, J. A. Cook, and R. Yanagihara. Ancestral sooricomorphs as

early reservoir hosts of primordial hantaviruses. European Meeting on Viral Zoonoses. St. Raphaël, France. August 2011.

11. Hope A. G., K. A. Speer, J. R. Demboski, S. L. Talbot, J. A. Cook. A climate for speciation. American Society of Mammalogists, Portland. June 2011.
12. MacDonald, S.O., Y. E. Sawyer, N.G. Dawson, J. L. Dunnum, B. Truett, and J A. Cook. Island Surveys to Learn about Endemic Species. The Wildlife Society, Regional Meeting, Juneau Alaska February 2011.
13. Sawyer, Y.E., and J.A. Cook. Comparative phylogeography and management of the Tongass fauna. The Wildlife Society, Regional Meeting, Juneau Alaska February 2011.
14. Galbreath, K., J. A. Cook, A. Eddingsaas, E. G. DeChaine. Colonization and climate in Beringia: Multilocus tests of paleodistribution models reveal deep and shallow histories for arctic ground squirrels. American Society of Mammalogists annual meeting, Laramie, Wyoming June 2010.
15. Hope, A., N. Takebayashi, S. L. Talbot, and J. A. Cook. Comparative phylogeography of small mammals across Beringia. American Society of Mammalogists annual meeting, Laramie, Wyoming June 2010.
16. Malaney, J. and J. Cook. Statistical phylogeography of the western jumping mouse (*Zapus princeps*): Testing alternative hypotheses. American Society of Mammalogists annual meeting, Laramie, Wyoming June 2010.
17. Malaney, J. and J. A. Cook. Distribution modeling and statistical phylogeography of the western jumping mouse (*Zapus princeps*): Admixture vs. vicariance. Tenth International Mammal Congress, Mendoza, Argentina. August 2009.
18. Fleming, M. A., & J. A. Cook Genetic differentiation and the evolution of late breeding in coastal mink (*Neovison vison*). American Society of Mammalogists, Fairbanks AK, June 2009.
19. Cook, J. A., S. O. MacDonald. N. Dawson, Y. Sawyer. 2009. Insularity along the North Pacific: Endemics and Colonizers of the Alexander Archipelago. International Biogeography Society Conference, Merida, Mexico January 2009.

**Media**

**ISLES Participants and Support**

**Field Collectors (Many supported by NSF* or NIH** internships)**

- Robert A. Nofchissey, UNM Health Sciences Center, Division of Infectious Diseases
- John P. Kavanaugh, UNM
- Randle D. McCain*, UNM undergraduate student
- Kendra N. Pesko, UNM School of Medicine, Ph.D. student
- Dr. Diane Goade, UNM Health Sciences Center and School of Medicine
- Dr. Cal Lee, UNM Health Sciences Center (8-15 July)
- Dr. Jon Dunnum, MSB Mammals
- Brad Truett, MSB Mammals
- Ashley Smiley*, UNM undergraduate student
- Hyatsi Bassett*, UNM undergraduate student
- Dr. Natalie Dawson, University of Montana

- Jon Martin, Assoc. Professor of Biology, UA Sitka
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- Sadie Yurista, UNM graduate
- Quinn Huber-Heidorn, Humboldt State University undergraduate
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- Craig Ranger District—Melissa Cady, Rusty Reynolds, Mike Sheets, Marla Dillman, Francisco Sanchez; Thorne Bay Ranger District: Ray Slayton, Jim Baichtal
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- Thomas Hanley, USFS Pacific Northwest Research Station, Juneau
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- ADFG, Ketchikan—Boyd Porter, Dave Person, Kris Larson
- ADFG Nongame Program— Karen Blejwas, Region 1

Other Individuals
- Amy Russell (Ketchikan), and Brian Castle, Ellen Hannan, and Kevin Castle (Craig)

**Excel Files** of all ISLES specimens **(> 2300** small mammals and salvaged furbearer specimens) **can be customized and downloaded ARCTOS**

## The Mammalian Fauna of Southeast Alaska

Including human beings, 83 mammal species, representing 63 genera, 28 families, and 8 orders occur or have recently occurred in Southeast Alaska. They comprise 116 subspecies and monotypic species. Twenty-seven of these taxa are essentially endemic to the region. Carnivores and rodents, with 22 and 21 extant species respectively, comprise the most speciose groups, followed closely by whales with 20 species. Seventy-six species are native and extant. Four extant species are not native (exotic) to the region.

Thirty-four species of land mammals (listed below), were considered in our "small mammal" inventory project (* denotes a non-native species):

RODENTIA - Rodents
Sciuridae
- *Glaucomys sabrinus*, Northern Flying Squirrel
- *Marmota caligata*, Hoary Marmot
- *Spermophilus parryii*, Arctic Ground Squirrel
- *Tamiasciurus hudsonicus*, Red Squirrel

Castoridae
- *Castor canadensis*, American Beaver

Dipodidae
- *Zapus hudsonius*, Meadow Jumping Mouse
- *Zapus princeps*, Western Jumping Mouse

Cricetidae
- *Lemmus trimucronatus*, Brown Lemming
- *Microtus longicaudus*, Long-tailed Vole
- *Microtus oeconomus*, Root Vole
- *Microtus pennsylvanicus*, Meadow Vole
- *Myodes (Clethrionomys) gapperi*, Southern Red-backed Vole
- *Myodes (Clethrionomys) rutilus*, Northern Red-backed Vole
- *Neotoma cinerea*, Bushy-tailed Woodrat
- *Ondatra zibethicus*, Common Muskrat
- *Peromyscus keeni*, Northwestern Deermouse
- *Phenacomys intermedius*, Western Heather Vole
- *Synaptomys borealis*, Northern Bog Lemming

Muridae
- *Mus musculus*, House Mouse*
- *Rattus norvegicus*, Brown Rat*

Erethizontidae
- *Erethizon dorsatum*, North American Porcupine

LAGOMORPHA - pikas and hares
Ochotonidae
- *Ochotona collaris*, Collared Pika

Leporidae
- *Lepus americanus*, Snowshoe Hare

SORICOMORPHA - shrews
Soricidae

*Sorex alaskanus*, Glacier Bay Water Shrew
*Sorex cinereus*, Cinereus Shrew
*Sorex monticolus*, Dusky Shrew
*Sorex palustris*, American Water Shrew

CHIROPTERA - bats
Vespertilionidae

*Lasionycteris noctivagans*, Silver-haired Bat
*Myotis californicus,* California Myotis
*Myotis keenii*, Keen's Myotis
*Myotis lucifugus*, Little Brown Myotis
*Myotis volans*, Long-legged Myotis
*Myotis yumanensis*, Yuma Myotis

CARNIVORA - carnivores
Mustelidae

*Mustela erminea*, Ermine
*Mustela nivalis*, Least Weasel

**APPENDICES**

- Table 1. List of all exotics for Southeast Alaska.
- Table 2. List of potential pathogens from throughout the entire North Pacific Coastal region.