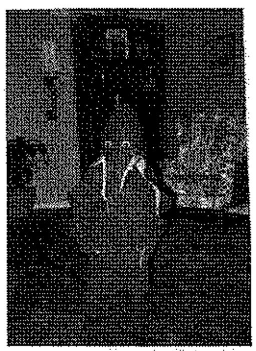
When I was a little girl, I wanted to grow up to be a dinosaur. And not much has changed. I now make car payments and have a credit card, but given the opportunity I would still choose *Velociraptor* over academic. Twenty years ago, I was disappointed to learn that, not only could I not become a dinosaur, but that their extinction had prevented the development of dinosaur-focused wildlife careers. But by that point I had already been seduced by the world of biology. So I accepted my limits (dinosaurs were extinct after all) and refocused my attention on creatures currently in danger of disappearing. I pursued research in conservation biology because I believed the most important questions have practical as well as intellectual merit: The use of sound ecological and evolutionary theory to inform species conservation seemed imminently relevant.

At Northwestern University I pursued majors in biology and philosophy. My focus on evolution and conservation was fueled by an interest in the processes driving species extinctions. I developed this through an internship at Chicago's Field Museum of Natural History and as a Fellow at the Lincoln Park Zoo. While biology provided a solid foundation with which I could pursue graduate work in conservation, coursework in philosophy encouraged my skills in analytical argument and abstract thought; teaching me seemingly confounded lines of evidence could be disentangled and synthesized. Most importantly, training in philosophy kept me from panicking when tackling problems without one clear answer; allowing me to use uncertainty as a muse for insight.

When I started graduate school, I was presented with a decade of unprocessed data on a small population of endangered birds. I was given one succinct instruction: understand. I have dedicated my graduate work to investigating the forces driving the dynamics of small populations. Although this question has an essential biological foundation, it is also one for which 'an answer' really means the synthesis of many answers. I have approached my investigation as a student of philosophy, using pre-existing data to test my hypotheses and weave explanations for patterns I have observed.

When conducting post-hoc analysis of existing datasets one often encounters hiccups some consider 'challenges': ideal data were not collected, datasheets are missing, sloppy handwriting, coffee stains, etc. Over the life of a long-term study many individuals will be responsible for collecting data, bringing to the job their various interests, talents and complexities. Analyzing such a dataset becomes an exercise in looking through underwear drawers – you learn as much about your predecessors as the organisms of study. Rather than deter me, these qualities have endeared me to the task. I have as much fallen in love with the process of coming to interpret and understand these data (and the statistical methods involved) as the birds from which they were originally collected.

Learning how to analyze long-term datasets with tenacity, creativity and humor has given me a unique skill to offer my field. Budgetary constraints, rare study species and difficult field conditions mean conservation research requires a 'make do with what you have' attitude. My prior experiences and strengths have well prepared me for the uncertainty and complexity associated with the academic life. Upon completing a PhD in Conservation Biology I will pursue a post-doc and then a tenure-track academic position. I will continue to focus on the application of my understanding of small population dynamics to the development of scientifically informed recovery strategies for endangered avian and mammalian populations. And, if it is ever socially acceptable to do so, I will dress as a dinosaur.



Survival and Population Structure in the Endangered Great Lakes Piping Plover

Background –

Come summer the Lake Michigan shoreline attracts an eclectic cast of characters: weekend warriors, granola toting backpackers, Carhart-clad anglers and a beach nesting bird seemingly oblivious to the property values associated with its preferred habitat. The Piping Plover (*Charadrius melodus*) is a rare shorebird currently restricted to three isolated nesting populations in the Great Lakes, Great Plains, and Atlantic Coast of North America[1, 2]; the Great Lakes population is federally endangered, numbering only 17 breeding pairs when listed in 1985. Conserving and rebuilding a small population like the Great Lakes piping plover, requires consideration of two topics: affect of small size on population persistence (the small population paradigm) and diagnosis of factors causing small size (the declining population paradigm)[3].

Once a population is already small, random events such as severe weather or genetic diversity caused by mating between closely related individuals (i.e. inbreeding), can have a pronounced effect on population persistence. An understanding of how small size influences population dynamics is imperative to designing effective conservation strategies and may guide use of techniques (e.g. captive-rearing) to alleviate small size and inbreeding depression (i.e. lowered survival or reproduction due to loss of genetic diversity)[3].

To reverse small population size, researchers must focus on determining the original and ongoing causes of population decline[3]. Population change results from four factors: birth, death, emigration and immigration. Despite their documented importance to population dynamics[4], the influence of immigration and survival are challenging to measure because both require a population of marked individuals. With > 80% of breeding adults uniquely banded, the Great Lakes piping plover population offers a unique opportunity to investigate the influence of both factors.

Goals and objectives – My dissertation research simultaneously investigates the demographic forces reinforcing small population size in the Great Lakes (Research Questions 1-3) while addressing the affect of small population size on population persistence (Research Questions 4-5). My intent is to offer management strategies which can be used to redress the imperiled status of the Great Lakes population.

Declining Population Paradigm –

1. **Which portion of the annual cycle is most influential to adult survival?**
   Adult survival has the greatest influence on population growth rate in most vertebrates, including piping plovers[4]. The annual cycle can be divided up into four periods: the breeding season, fall migration, the overwintering period, and spring migration. I am using resighting information to estimate survival of plovers during each of these periods in order to identify the period (and associated habitat) that was driving patterns in annual adult survival.
2. **Is mid-incubation nest abandonment evidence of breeding season mortality?**
   Mid-incubation nest abandonment was the most common source of nesting failure for Great Lakes piping plovers during 1993-2008. I investigated whether these nest abandonments represented breeding season adult mortality and suggested management strategies to prevent these events.

3. **Is there genetic exchange among North American piping plover populations?**
We band > 90% of all chicks fledged in the Great Lakes, ensuring when these individuals return as adults we can trace their ancestry. However, there are also more unbanded adult plovers annually nesting in the Great Lakes than should result from the 1-2 chicks known to escape banding in any given year. I am genotyping unbanded individuals nesting in the Great Lakes (2006-2008) and comparing these to individuals of known Great Lakes lineages to determine whether unbanded nesting plovers represent evidence of immigration from other populations.

Small Population Paradigm –

4. **Is there evidence of inbreeding depression in pre- and post-fledge plover survival?**
Multiple generations of inbreeding often lead to depressed survival or reproductive rates[7, 8]. With < 150 breeding adults for the past 3 decades the Great Lakes population is at risk for manifesting such inbreeding depression. I am testing whether a high degree of ancestor relatedness corresponds with decreased probability of survival of plovers during their first year of life.
5. **What is the contribution of captive-reared plovers to Great Lakes population growth?*(5)***
Efforts to recover the Great Lakes piping plover include population supplementation with captive-reared young raised from abandoned eggs[6]. I am comparing survival rates of captive-reared vs. wild-reared plovers to determine if captive-reared plovers could be used to help augment wild populations.

Methodology –

Field Methods – At the beginning of each breeding season, my field assistants and I survey historical, recent and potential nesting habitats to locate breeding pairs which we then monitored from nest initiation through departure for migration. I am continuing a banding effort initiated in 1993; we band all plovers with U.S. Geological Survey (USGS) metal bands and color bands. We collect feather samples from all birds during banding (2005-2008). We collect eggs abandoned as a result of mate-loss, storm damage or disturbance and transported them to the salvage captive-rearing facility at the University of Michigan Biological Station, Pellston, MI. We record the number of viable eggs collected, hatched, and successfully reared to release age (circa 27 – 35 days) and associated dates. For wild-nesting birds we record the number of nests, eggs laid, eggs hatched, chicks fledged per pair and associated dates including date of disappearance. During the nonbreeding season, piping plover surveys and data collection were conducted by volunteers.

Survival Analyses – I am using band resighting data collected 1993-2008 to conduct Cormack-Jolly-Seber mark-recapture analyses in program MARK[9] and estimate survival of Great Lakes piping plovers. Below I detail how I am using these methods to address questions 1-2 & 4-5 presented above:

1. I am using dates of first detection (2000-2008) to identify plovers observed in the first or second half of the breeding and non-breeding seasons. I am using this structure to estimate survival of plovers during stationary periods (time spent on the breeding or nonbreeding range) and migratory periods (movement between ranges).
2. I used data collected on nest abandonment since 1993 to identify uniquely banded nesting plovers recorded as having disappeared during incubation. I then used 'disappearance' during incubation as a covariate in survival analyses to determine whether these individuals were less likely to be detected again following disappearance.

3. I am using banding data to construct a Great Lakes pedigree from which I then generate inbreeding coefficients[(10)]. I am using these inbreeding coefficients as individual covariates in a survival analysis aimed at determining the influence of these inbreeding coefficients on survival on chicks both 25 days and from 25 days to 1-year-old.
4. I sorted plovers into two groups based on rearing type (captive vs. wild). I used the age (days) at which bands were received as a covariate (i.e variable of predictive importance) so I could adjust model estimates to compare first year survival for both groups at a common age. I found that captive-reared individuals did not survive as well as wild-reared individuals.

Genetic Analyses – I conducted all DNA extraction of collected feather samples at the University of Minnesota and developed species-specific microsatellite primers in collaboration with the Pritzker Lab (Field Museum of Natural History, Chicago). I am screening potential genetic marker primers (microsatellites) at the University of Minnesota. I will use 10 microsatellite markers and the model clustering tool STRUCTURE[(11)] to assign the genotypes of unbanded adults to a Great Lakes or non-Great Lakes origin. If the genotypes of unbanded adults do not sort with current Great Lakes genotypes this will be evidence of contemporary gene flow due to immigration. If I can match these individuals to either Great Plains or Atlantic Coast genotypes, I will be able to identify the source of immigrants.

Potential Significance – Existing knowledge of population range and individual dispersal within the Great Lakes offers a unique opportunity to explore questions of small population dynamics. The questions posed in my dissertation are ones commonly asked by professionals responsible for the conservation of piping plovers. The answers to these questions are intellectually interesting, but far greater value comes from the fact that they are relevant to on-the-ground conservation efforts. For example, the results for my survival analyses of captive-reared plovers and abandoning nesting plovers have already resulted in federally directed changes in management. Implementing informed conservation strategies will not only support population growth in the Great Lakes, it also exemplifies policy that is widely applicable to shorebird species throughout North America.

Progress to date and schedule for completion – I have completed and submitted objectives 1 and 3, the former of which was published in 2008 in *Biological Conservation* and the latter submitted to *The Auk*. Data collection is complete for objectives 2 and 4 and I am currently in the middle of my first round of analyses. By April 2009 I will complete and submit a manuscript for objective 3. I will complete my analyses for objective 4 by April 2009 and submit my results as a manuscript in September 2009. I am in the process of screening microsatellite primers for polymorphisms and will complete analysis of genetic data necessary to address objective 5 in the fall of 2010. I will defend my dissertation by May 2010.

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