DISTURBANCE MITIGATION PROJECT: AMELIORATING NESTING CONDITIONS AND MATING PAIR NUMBERS OF PIPING PLOVER IN AN ATLANTIC (LONG ISLAND, NY) POPULTAION

Daniel Firth, Mike Rhodes, Bradley Richardson, Andrew Smith

MANAGEMENT CONCERN

Economic development and land use manipulation projects of coastal resources has long threatened coastal ecosystems and their associated biological communities, both aquatic and terrestrial. Such ecosystem~~s~~ modifications are occurring with greater frequency, replacing natural habitats with sub-quality artificial characteristics indicative of human resource use. Whether through commercial and residential development or recreation and commerce, these commonplace actions continue to concentrate significant pressures on native wildlife and their habitats, producing numerous ecological concerns for researchers and managers throughout the Eastern seaboard. In lieu of such impacts, organizations and agencies have cooperated to relieve wildlife populations through projects such as habitat restoration, breeding propagation programs, and establishing habitat preservation areas. Management strategies and conservation projects for imperiled species demand that biologists and stakeholders develop informed, transparent, and effective efforts to treat at-risk populations and mitigate the impacts of economic development while sustaining revenues from industries. Such efforts are well-illustrated in the case of the Atlantic coast's population of piping plovers (*Charadrius melodus*), in particular, a breeding population on Long Island, New York.

The piping plover is a threatened shorebird species endemic to central and eastern North America which breeds discontinuously throughout its range, preferring sandy~~-~~ habitat (Cairns

1982, Elias et al. 2000) along ocean beaches, intertidal areas, river sandbars, and other marginal wetlands (Cohen et al. 2006). This preference in suitable sandy beach habitat consequently places the species in constant competition for space with humans, as well as increased exposure to predation risk from pets and gulls (*Larus spp*.); both of which are influenced by the frequency of human visits. Other hazards to Atlantic plover populations include habitat loss from coastal development, intertidal flooding (i.e., storm-surge), succession of vegetation (i.e., encroaching grasses and sedges on suitable nesting sites), as well as ATV and other motorized vehicle use along beach areas.

In response to human induced disturbances through intense recreational beach use, plovers are constantly forced to emigrate or locally disperse to select new habitat (Gandon and Michalakis 2001), potentially doubling their reproductive efforts both spatially and temporally each breeding season. Subsequently, this results in potential nest abandonment, an increase of re-nesting events, or ultimately – nesting failure. Flemming (1988) noted that recreational disturbance may lower piping plover reproductive success and may lead to complete abandonment of quality breeding sites. Furthermore, the high risk of egg or nestling loss to predation (whether natural or anthropogenic) may facilitate emigration (Weisser 2001), causing mating pairs and other individuals to separate from known breeding sites. Such diminishing effects from human activities have presented agencies with a unique set of challenges and require both the biological training of managers and researchers as well as the investment of the public's interests and willingness to adjust. To assist agencies and stakeholders in the management process, we employ a structured decision making approach to identify the objectives of both factions and formulate a model to monitor and evaluate management actions. Using this process, we aim to identify – and where possible - consolidate all potential objectives, outline any available alternatives, and measure the effectiveness of actions performed by the agency, while maintaining transparency in the process and delivering realistic information.

Spatial and Temporal Extent

The breadth of this project is restricted to the Long Island, New York barrier islands. Comprised of ~90 km of beach front, these islands constitute the only available and suitable nesting and brood-rearing habitat in the state (Cairns 1982), satisfying essential life-history requirements in both chicks and fledglings. Target populations occur on Westhampton Island, located off the south shore of Long Island, NY; West Hampton Dunes (WHD; 40°46’44”N, 72°42’57”W) located 3 km east of Moriches Inlet – bounded by Moriches Bay on the north and the Atlantic Ocean on the south, and contain approximately 2.8 km of ocean beach and 1.3 km of bay beach. Westhampton Beach (WHB; 40°47’50”N, 72°38’46”W) is adjacent to WHD to the east, and contain 3.2 km of ocean beach. WHB has no bay beach, but contains scattered small sandflats (< 1.5 ha total) on the bay side (Cohen et al. 2006). Additionally, Jones ~~i~~Island (25 km) and all 53 km of Fire Island, contain suitable beach habitat and have current plover populations. These barrier islands are characterized by large sand dunes, intertidal sandflats, mud flats, and ephemeral pools (Elias et al. 2000). Habitat available to plovers include ocean intertidal zones, backshore (dry sandy beach shoreward of the high tide line and seaward of the dune line), wrack (material deposited by waves and tide), open vegetation areas (mostly American beach grass, *Ammophila breviligulata*), and interdune areas (bare sand within open vegetation).

Legal, Regulatory, and Institutional Constraints

The responsibility and management of natural resources within the state of New York lies with the New York Department of Environmental Conservation (NYDEC), specifically the Endangered Species Unit within the agency. Additionally, partnerships with the Nature

Conservancy, Audubon Society, and a vast network of concerned volunteers annually census the breeding colonies of Long Island. Cooperation with private and public landowners facilitates the use of signs and fencing to prohibit entry to critical areas. However, being a federally listed species, the overall protection, management, and jurisdiction of piping plover populations is delegated to the United States Fish and Wildlife Service (USFWS).

Life History and Ecology

Piping plovers are a small ground-nesting species of shorebird. Habitat preferences include open sandy beaches (preferably above the tidal line), alkali mudflats, dunes, river sandbars, and sandflats (Cohen et al. 2006). Typically nesting in such areas, they also utilize a range of small creeks and other marginal wetland habitat types where vegetation is sparse and low tides expose foraging grounds for invertebrates such as insects, spiders, and crustaceans (USFWS). Brood-rearing habitat is typically characterized by ephemeral pools and habitats similar to nesting sites where access to food (arthropod abundance) is reasonable (Elias et al. 2000). Nesting usually occurs on raised sandpits with little or no slope (Cairns 1982) and small stones and shell scattered around the territory from courtship displays during mating. Chicks are precocious with a typical clutch size of no more than 4 eggs (Cairns 1982) and mating pairs exhibit bi-parental care of young (USFWS). Foraging strategies are sight dependent, classifying plovers as “active-foragers” using visual cues such as movement to search for prey.

Piping plovers are seasonal migrants, breeding in spring and summer in the northern United States and Canada (USFWS). There are three distinct nesting locations for plovers: (1) Atlantic Coast, (2) Great Lakes, and (3) Great Plains. In the fall, plovers migrate south to winter along the coast of the Gulf of Mexico or other southern locations, however, the wintering range is poorly understood for most of the population (Cairns 1982, Cairns et al. 2000, USFWS).

In addition to the aforementioned threats (i.e., nest disturbance via human activity and habitat destruction), predation occurring from dogs, cats, red foxes (*Vulpes vulpes*), gulls, as well as common and fish crows (*Corvus brachyrhynchos and C. ossifragus*) may contribute to high mortality in both adults and young (Elias et al. 2000). Of particular concern is the attraction of gulls due to trash materials left over from human occupation, which may also contribute to an increase in chick mortality.

STAKEHOLDERS

The two stakeholders with decision making power are the USFWS and NYDEC. Additional stakeholders are Audubon, the Nature Conservancy, local businesses, and the general beach using public.

OBJECTIVES

Stakeholders empowered a task force to develop a recovery plan for New York State's Atlantic Piping plover population which can meet the objectives of the USFWS Piping Plover Recovery Plan without placing burdensome restrictions on community beach use. To this end the task force developed a means network (~~f~~Figure 1) and established socioeconomic value as the fundamental objective. This objective can be broken down into three fundamental parts: 1) contribute to the delisting of the species by increasing the regional population; 2) maximizing public beach community availability and utility, and 3) meeting these objectives with minimal use of scarce stakeholder resources.

DECISION ALTERNATIVES

Decision alternatives were proposed which could control variables relevant to Piping plover population and reproduction on New York's Long Island beaches and be implemented by

NYDEC in collaboration with partner organizations and agencies. Decision alternatives include restricted beach access during breeding season, beach dune and vegetation management, public outreach and education, and construction of nest exclosures. These management options are all within the purview of state regulatory agencies. These decisions and their impact on model parameters are designed to assess the relative value produced by available policy options, rather than comprehensive management plans.

VALUATION OF OUTCOMES

The model values outcomes based on an abstracted unit of socio~~-~~economic value which integrates the value of public use of Plover beach areas and probable future Plover breeding pair abundance. Outcomes were created using additive value assessment and assigned a value from 2, the worst, to 7, the most desirable.

DECISIONS MODEL OVERVIEW

A stochastic decision model was used to determine the optimal decision for managing coastal Piping plover. The model includes various factors determining future population and the predicted impact of different management interventions on those factors, as well as changes in human beach use. Factors which ~~effect~~affect future Piping plover breeding pair abundance include nest success, chick survival, and adult survival. The socio~~-~~economic impact of a given management intervention is valued based on an abstract unit representing the social gain of continued Piping plover recovery and community use of beach areas. Decision alternatives represent theoretical impacts of single policies rather than singular and mutually exclusive management plans with values representing the relative emphasis that ought to be placed on a given intervention in a comprehensive recovery strategy.

Figure 2 contains the decision model created with the Netica software. Bubbles contain factors describing model states and have probabilistic conditional relationships with other factors, with relationships indicated via arrows. Following below are descriptions of the model states.

Current Adult Abundance

This probability is unconditional, i.e. it is not dependent on other model states. It reflects the best estimate of current adult abundance representing the probable~~y~~ range of abundances estimated via USFWS and affiliate surveys.

States: 700 summer adults within the New York Atlantic region.
800 summer adults within the New York Atlantic region.
900 summer adults within the New York Atlantic region.
1000 summer adults within the New York Atlantic region.

Clutch Size

Clutch size represents the number of eggs expected per breeding pair and ranges from one to four, with four being the most probable. Parameters are unconditional and came from expert opinion.

States: one-four eggs

Eggs Laid

Eggs laid represent the number of eggs produced in a season within the region. It is conditional on adult abundance and the number of eggs produced per clutch. Parameters come from the expected nests produced per adult and the expected number of eggs per nest, and is derived from expert opinion.

States: Range from a minimum of one egg per adult pair to a maximum of four per adult pairs

Egg Survival

Egg survival is driven by human beach use and management decisions. The effect of human use of beach area and the impact of management practices was parameterized using expert opinion and discretized into bins.

States: 0-25% survival.
25-50% survival
50-75% survival
75-100% survival

Eggs Hatched

Hatched eggs describe chicks successfully born and are conditional on egg survival and total eggs laid.

States: 0-800 eggs
800-1600 eggs
1600-2400 eggs
2400-3200 eggs
3200-4000 eggs

Adult Survival

Adult survival is an unconditional probability primarily determined by overwinter survival with a small contribution by local mortality during the summer breeding, and was calculated from expert opinion.

States: Low survival
Medium survival
High Survival

Juvenile Survival

Juvenile survival is an unconditional probably determined for model purposes by natural outside conditions. Survival proportion has been discretized.

States: Low survival
Medium survival
High Survival

Future Adult Abundance

Future adult abundance is a conditional node determined by current adult abundance, adult survival, juvenile survival, and eggs hatched.

Stages: future abundance is divided into probable bins of 150 ranging from 700-1600+

Human Beach Use

Human beach use is a conditional variable with values determined by the decision node and probabilities reflecting the different impacts of management decisions.

Stages: Low use of beaches: reflects tight restrictions on beachside development, completely restricted beach access during breeding season and no or minimal beach nourishment

Medium beach use: reflects moderate restrictions, limited access during nesting season, public outreach and education regarding bird safety and limited development within areas of high use by Piping plovers

High: Reflects purely symbolic restrictions on beach use during nesting season, widespread modification of beach and near shore environment including beach nourishment and construction and dune stabilization.

Future Breeding Pair Abundance

Future breeding pair abundance is the proportion of the adult Piping plover population that is expected to form a breeding pair in the next season.

Stages: Future pair abundance is discretized into six equal bins from less than 100 to 600 and one more covering all outcomes above 600, reflecting expected outcomes.

Mating Rate

The mating rate is an unconditional variable which predicts the expected proportion of future adults which will form breeding pairs.

Stages: < 40% of adults forming a breeding pair

40%-50% forming breeding pairs

>50% forming breeding pairs

DISCUSSION

Model utility results are depicted in Figure 3. The highest expected socio~~-~~economic return from an intervention was 5.49 from Nest ~~e~~Exclosures, followed closely by Public Outreach (5.47), then Vegetation Management (5.27), and Restricted beach access producing the lowest return (4.56). Continued population recovery is expected following implementation of all management options, with an expected next season increase in breeding pairs to a mean of 387 using exclosures followed by restricted beach use at 383, with vegetation management producing the smallest increase in total breeding pairs at 360.

Maximum utility was found to be state dependant, with public outreach producing more utility than nest exclosures when the mating rate is low (figure 3). Sensitivity analysis found the model differences in future mated pair abundance produced the largest changes in expected utility (figure 4). The most sensitive unconditional parameter was present adult abundance.

Value of the SDM Process

Following the structured decision making process allows decision makers to demonstrate due diligence and justify potentially contentious policy decisions in the context of conservation policies with major social costs. Creating an integrated model of population abundance and the expected probabilities for each outcome given the application of a specific intervention allows researchers to clearly and effectively evaluate and justify the impact of management decisions in a way that can be iterated over time as additional research data accumulates. By identifying a state dependent change in the optimal decision the model indicates monitoring efforts should be concentrated on accurately determining present abundance. It also identified areas of serious import to population persistence outside the control of New York’s regional stakeholders, particularly winter adult survival, where cooperation with outside actors is necessary to insure successful species recovery. In this project interventions have been ranked by their expected return allowing managers to set management priorities.

Future Steps

This model indicates that continued recovery is likely following the continued application of management action, as is consistent with past trends in species recovery. Monitoring efforts should be focused on accurately determining the present population. In order to build on this project, management teams could expand the Bayes net constructed herein to develop a more nuanced model including gradiations in management decisions and describing expected outcomes for complex management plans integrating multiple intervention strategies in a way directly actionable for decision makers.

Commented [BR1]: ??

LITERATURE CITED

Cairns, W.E., 1982. Biology and behavior of breeding Piping Plovers. *The Wilson Bulletin*, pp.531-545.

Cohen, J.B., Fraser, J.D. and Catlin, D.H., 2006. Survival and site fidelity of piping plovers on Long Island, New York. Journal of Field Ornithology, 77(4), pp.409-417.

Elias, S.P., Fraser, J.D. and Buckley, P.A., 2000. Piping plover brood foraging ecology on New York barrier islands. *The Journal of wildlife management*, pp.346-354.

Flemming, S.P., Chiasson, R.D., Smith, P.C., Austin-Smith, P.J. and Bancroft, R.P., 1988. Piping Plover Status in Nova Scotia Related to Its Reproductive and Behavioral Responses to Human Disturbance. Journal of Field Ornithology, pp.321-330.

Gandon, Sylvain, and Yannis Michalakis. "Multiple causes of the evolution of dispersal." Dispersal. Oxford University Press, Oxford (2001): 155-167.

USFWS. "Northeast Region, U.S. Fish And Wildlife Service". Fws.gov. N.p., 2017. Web. 26 May 2017.

Weisser, W.W., 2001. The effects of predation on dispersal. Dispersal. Oxford University Press, Oxford, UK, pp.180-188.

FIGURES

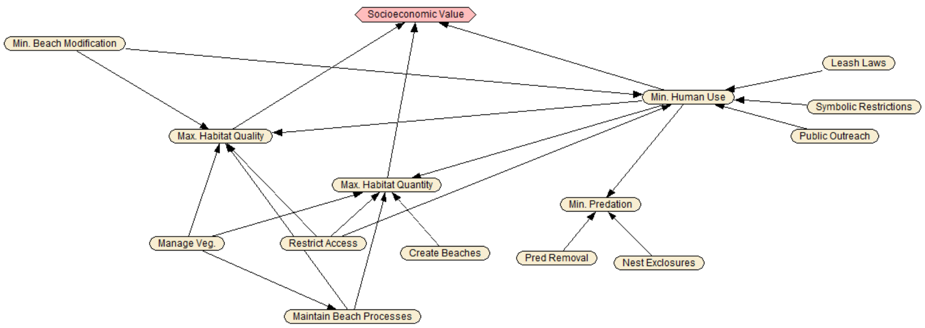

Figure 1: Means objective diagram illustrating management priorities for Piping Plover, Long Island New York.

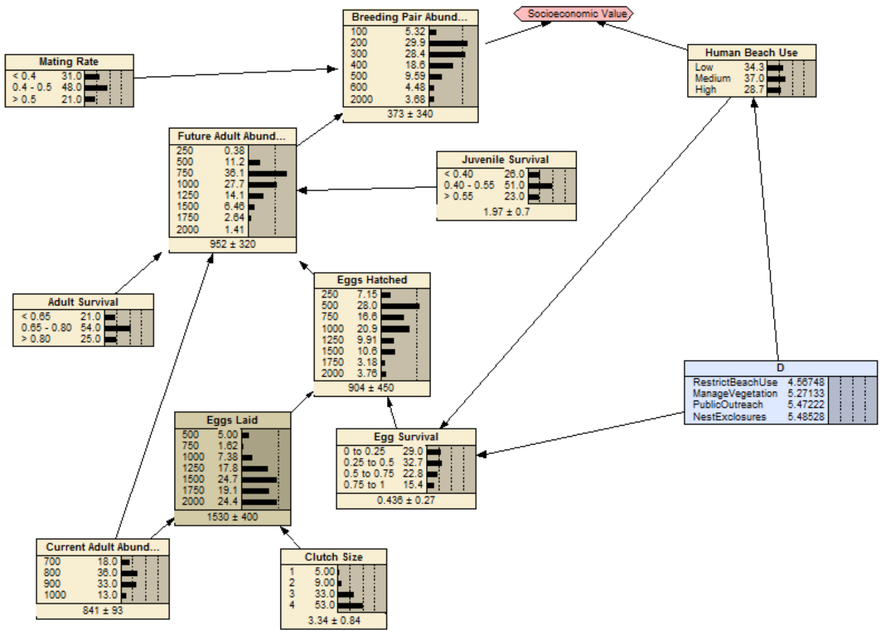

Figure 2: Influence diagram for creating comparative evaluations of different management options for Piping plover in Long Island, New York.

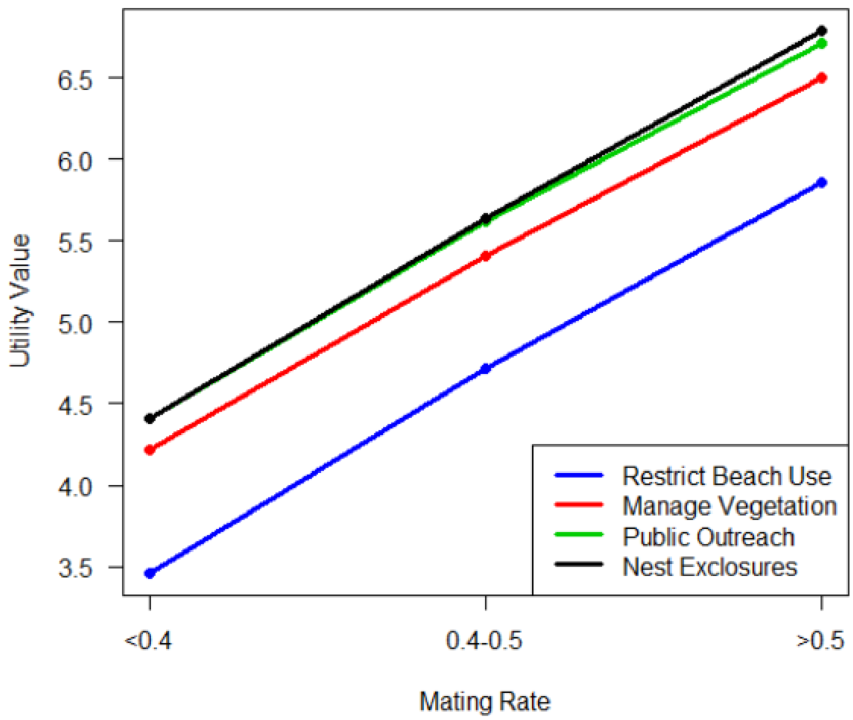

Figure 3: Decision utility plotted against mating rate, demonstrating the state dependence of the optimal decision.

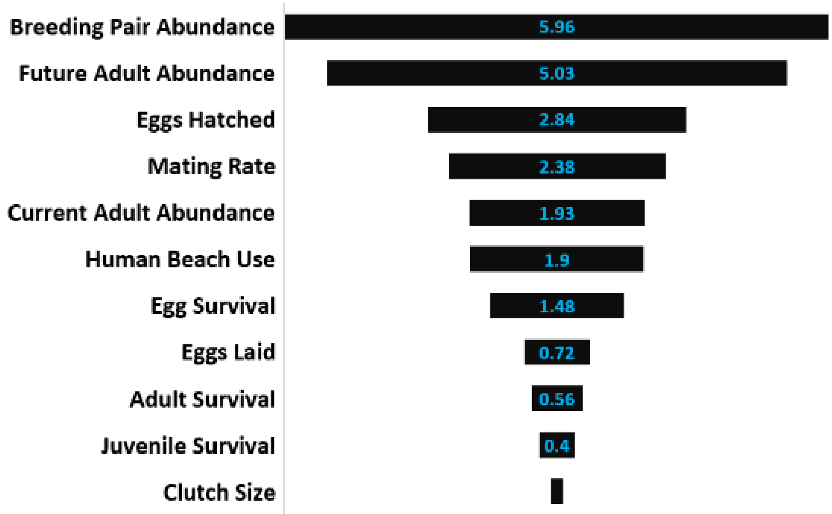

Figure 4: Tornado diagram indicating model sensitivity.