

Science-Based Conservation Management  
on the Virginia Barrier Islands:  
Avian Habitat Restoration Through Predation Management

2006 Project Report to the:  
Virginia Coastal Zone Management Program

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**Virginia Coastal Zone**  
M A N A G E M E N T P R O G R A M



## I) *Project Summary 2006*

Our 2006 pilot field trial tested the effectiveness of an estrogen-induced food aversion in reducing raccoon depredation on the eggs of ground-nesting shorebirds and colonial waterbirds. We used artificial nest “colonies,” automatic cameras and radio-telemetry to determine the rate of encounter between tagged raccoons and nests, variability among individuals in their propensity for egg consumption, consumption rates of both treated and non-treated eggs, and the likelihood of effective dosing in a single foraging bout. Results of this trial indicate that the estrogen-induced food aversion was real, it influenced the foraging activity of individual raccoons, and it lasted long enough to encompass the avian egg-laying period. We conclude that aversive conditioning holds substantial promise for reducing depredation by raccoons on any Virginia barrier island having low numbers of predators.

## II) *Background*

The recent spread of the raccoon (*Procyon lotor*) and red fox (*Vulpes vulpes*) on the Virginia barrier islands has greatly reduced habitat suitability for beach-nesting and colonial waterbirds on the islands (Erwin et al. 2001). We have been working to develop, test and refine a plan for predation management on the islands. Trapping-and-removal has proven very effective in reducing raccoon and red fox numbers on several islands. Once mammalian predator numbers are reduced on an island, low numbers generally can be maintained with annual short-term trapping. It is practically impossible, however, to keep many of the islands predator-free, particularly Assawoman, Metompkin and North Cedar. At the same time, these islands are tremendously important to the birds.

In a year in which other factors are favorable on smaller islands, the birds appear to be able to tolerate the presence of a raccoon, but never a fox. Therefore, we have explored methods of predation management to supplement the annual predator removal program on the islands. Ideally, this method would reduce the potential impact of one or even a few raccoons. Deception-based food aversion appears to be a promising non-lethal management option.

In a review of behavioral principles governing conditioned food aversion based on deception, Conover (1997) outlined the conditions in which a conditioned aversion would have the greatest chance of being effective. The Virginia barrier islands appear to offer almost optimal conditions for the application of this technology: highly seasonal egg availability, nutritious models (eggs of beach-nesting and colonial waterbirds) that are easily mimicked (treated quail and/or bantam chicken or duck eggs), nest models (scrapes on barrier beaches) that are easily mimicked (with artificial scrapes), a depauperate mammalian predator community dominated by a single, solitary-foraging predator (raccoons), abundant alternative food resources, and limited public access.

After a critical review and assessment of the potential for using chemically treated eggs to induce an aversive response by raccoons to the consumption of eggs, we concluded that oral estrogen is the most promising aversive agent currently recognized for raccoons. In 2005 we conducted a pen trial and pilot field trial using eggs injected with oral estrogen. Although we observed substantial variability in the aversive response of raccoons to the ingestion of estrogen-injected eggs, the results of both our pen trial and a pilot field study of aversive conditioning were very encouraging.

Our experience and observations in 2005 were indispensable to our design of a more extensive field trial in 2006. We know the technology can work with Coastal Plain raccoons. In 2005, most of the animals on Skidmore Island apparently developed an aversion to eggs after only one-to-a few exposures to estrogen-injected eggs. In 2005, we observed a rapid drop-off in egg depredation rates during the first 12 days of a 16-day field trial, with an increase in depredation in the last 4 days. Although we deployed 8 automatic cameras to record depredation events, we accumulated only 40 photographs of individually identifiable raccoons (and hundreds of photos of unidentifiable raccoons). We could not, therefore, determine whether the decline in depredation was temporary because (1) the aversion was temporary in individual raccoons, (2) because of the continued presence of untreated (i.e., non-averse) raccoons in the field population, or (3) because the raccoons could detect the difference in the untreated eggs that were deployed on day 12. The extraordinary density of raccoons on Skidmore Island in 2005 (~1 raccoon per 2 ha of upland) confounded our ability to interpret the field results, but we strongly suspected that untreated raccoons were involved in the apparent transience of the aversion.

### III) *Study Plan 2006*

The Virginia Museum of Natural History (Nancy Moncrief) and Utah State University (Ray Dueser and Joel Martin) continued to collaborate on this project in 2006 with the U.S. Fish and Wildlife Service Eastern Shore of Virginia National Wildlife Refuge (Sue Rice and Pam Denmon), and the Long-Term Ecological Research Program (Arthur Schwarzschild) of the University of Virginia. This project would not have been possible without the collaboration of these organizations.

We undertook two tasks in 2006: (1) conducting a field test of the estrogen-based repellent technology to induce in raccoons a deception-based food aversion to egg consumption and (2) describing our plans for implementing a field-scale management trial in 2007.

#### IV) *Study System*

Skidmore Island is located near the southern tip of the Delmarva Peninsula, and is part of the Eastern Shore of Virginia National Wildlife Refuge. Measuring ~44 ha in area, Skidmore is one of the smaller of the Virginia coastal islands. The island is actually located in the estuary behind the ocean-facing barrier islands, but a narrow sand beach circles ~75% of the way around the island, on the north, west and south sides. The upland portion of the island (above mean high tide) measures ~16 ha. Skidmore supports several hectares of mature pine forest, an extensive tall shrub thicket, extensive grassland, and a broad expanse of tidal marsh. Refuge Manager Susan Rice granted permission for us to conduct the 2006 field trial on Skidmore.

Based on Conover's (1997) review of the environmental conditions favorable for the application of aversive conditioning, Skidmore represents an ideal venue for a field trial: (1) the island is surrounded by open water for at least 0.5 km in every direction, and thus represents a relatively isolated experimental system; (2) there is an abundance of sparsely-vegetated sand surface suitable both for establishing artificial nest scrapes and for definitive track identification; (3) there currently are no known ground-nesting birds, and no nesting colonies, that might be disrupted by our activity on the island; (4) the resident raccoon population appears to be of sufficient size to facilitate an effective field trial, being neither too small to provide a credible test nor too large to prevent effective implementation of the estrogen treatment; (5) raccoons appear to be the only mammalian predator species resident on the island; (6) alternative predator food supplies are abundant in the marsh; and (7) the island is uninhabited and public access is restricted. Finally, working on a National Wildlife Refuge will ensure communication of our results directly into the wildlife management community

#### V) *Methods*

The 2006 field trial consisted of three phases: pre-treatment, treatment, and challenge. During the pre-treatment period, we live-trapped raccoons on Skidmore Island, using wire cage traps. We fitted eleven mixed-age adult raccoons with both flexible, numbered, color-coded, Y-TeX polyurethane ear tags to allow photographic identification and a radio-collar to allow periodic checking for the persistence of the animals on the island.

We established a series of six artificial nest colonies on Skidmore, each consisting of 18 shallow scrapes (nests) in the sand >1m apart. Each colony was shaped to fit within its trackable location or clearing. We monitored depredation events with two automatic 35 mm still cameras (TrailMaster, Inc.) per colony.

During a 13-day treatment period, each of the artificial scrapes was stocked with two medium chicken eggs injected with estrogen. During a subsequent 13-day

challenge period, non-treated eggs were deployed in the scrapes. We discontinued trapping and marking raccoons when the treated eggs were deployed.

Treated eggs were checked and replenished daily for 13 days, recording the numbers and locations of eggs eaten and/or damaged and the cause of any egg loss (i.e., raccoon, crow, or gull). The 13-day challenge phase tested for persistence of the aversion. We radio-monitored animal locations periodically from July 1 through August 9 to obtain information on raccoon presence and den sites. Six hundred dozen treated and untreated medium chicken eggs were deployed in the colonies over a 35-day period.

## VI) *Results*

We accumulated over 2,000 photographs of individually recognizable raccoons, as well as 19 daytime locations of radio-collared animals over a 40-day period. Analyses of these data yielded the following results:

- (1) All 10 raccoons became averted to egg consumption within 2-4 days.
- (2) This aversion was persistent for a period of at least 26 days.
- (3) The treatment effect was significant for all six colonies: the mean number of treated eggs damaged per day during the treatment phase (5.7) was greater than the mean number of non-treated eggs damaged per day during the challenge phase (1.0) ( $F_{1,5} = 48.52, P = 0.0009$ ).
- (4) Raccoons could not distinguish between treated and non-treated eggs: during the challenge phase the mean number of non-treated eggs damaged per day for all colonies combined (1.0) was not different from the mean number of treated eggs damaged per day for all colonies (1.9) ( $F_{1,11} = 0.78, P = 0.40$ ).
- (5) Averted raccoons altered their foraging behavior to visit colony areas less frequently and to visit fewer colonies.
- (6) All 10 raccoons remained on Skidmore throughout the experiment.

## VII) *Conclusions*

The estrogen aversion was real, it influenced the foraging activity of individual raccoons, and it lasted long enough to bridge the period of avian egg-laying and incubation. Predation management remains a useful method to enhance and restore avian nesting habitat on the Virginia barrier islands. Trapping-and-

removal has proven effective in reducing raccoon and red fox numbers on several islands. In reality, however, removals are seldom complete; it is common for 1-3 raccoons to remain on an island (or to re-colonize an island very quickly) even after a productive removal program. Aversive conditioning appears to hold substantial promise for reducing depredation by predators on any island having low numbers of predators, either naturally or following a trapping campaign. Predation management is both more feasible and more effective as a conservation strategy on the Virginia barrier islands than has been reported from several studies conducted on extensive mainland areas elsewhere in North America.

*Draft description of the field-scale application of this management in 2007*

Aversive conditioning as a means of nest protection is most likely to be effective in a situation in which there is a low probability of turnover in the predator population during the season of treatment. A continuing high frequency of naïve (i.e., non-treated) individuals on a densely-populated island would render the treatment ineffective. Therefore, this treatment would be most likely to work (and easiest to implement) on islands having low densities of raccoons and subject to low rates of immigration.

Early field-scale applications of this technology will be relatively labor intensive, as appropriate and effective methods are tested and evaluated and standard methods are developed. These early applications will include several integrated components: 1) pre-season predator removals, 2) pre-baiting, and) aversive conditioning, initially using methods that were effective in the 2006 field test on Skidmore.

VIII. *Literature Cited*

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