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The Power of Partnerships: Eradicating Invasive Mice from Allen Cay, The Bahamas

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ABSTRACT: Developing countries often have urgent national commitments regarding protection of biodiversity, but can be experience- or resource-limited to undertake conservation action. The eradication of invasive alien vertebrates (IAV), requiring a specialized set of skills and experience and sometimes significant capital investments, is a case in point. Building international collaborations to eradicate IAVs from islands is a potential approach to enhance the conservation of threatened species within countries that do not have sufficient capacity or funding. Here, we present a case study, the successful removal of invasive house mice from Allen Cay, Exuma Islands, The Bahamas. The goal of the project was to protect Audubon's shearwaters and improve breeding habitat for the endemic Allen Cay rock iguana. The project was collaboratively planned and implemented by two previously unassociated organizations, the Bahamas National Trust (BNT) and Island Conservation (IC). Both organizations brought unique skillsets to the project: BNT provided compliance and local biological expertise, and IC provided eradication project management. Local capacity to implement future eradication projects was strengthened through BNT's ownership and management of the project, and a strong partnership now exists to increase the scale and efficacy of future Bahamian island eradication projects to protect threatened species. Efforts to expand and coordinate an international network of practitioners conducting IAV eradications will require an improved understanding of the threats posed by IAVs, access to technical support, exposure to best practices, and the empowerment of local agencies to invest in the protection of biodiversity on islands.

KEY WORDS: Allen Cay, Bahamas National Trust, capacity building, eradication, house mice, invasive species, Island Conservation, *Mus musculus*, restoration, rodent control

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INTRODUCTION

Although islands make up less than 5% of the earth's land area, 80% of all extinctions since the 1500s have occurred on islands. Of IUCN Critically Endangered species, 40% currently inhabit islands (Ricketts et al. 2005). Consequently, island nations often have competing and urgent national commitments to protect biodiversity, such as the Convention of Biological Diversity (CBD). Invasive Alien Vertebrates (IAV) are the primary cause for most of the extinctions that have occurred on islands; IAV also impact socioeconomic indicators and ecosystem goods and services (Clavero and Garcia-Berthou 2005, Reaser et al. 2007, Island Conservation 2012). Eradication or complete removal of IAV from islands is widely accepted as an effective method to reduce negative impacts on island species and ecosystems (Veitch and Clout 2002, Howald et al. 2007, Howald et al. 2010, Jones et al. 2011, Veitch et al. 2011). Decreased biodiversity and species extinctions linked to invasive species threaten the delivery and quality of many ecosystem services through economic, environmental, or social costs (Charles and Dukes 2007). However, many island nations and territories lack the scientific and technical information, infrastructure, and human and

financial resources necessary to adequately manage the negative impacts posed by IAVs (Donlan et al. 2003, Reaser et al. 2007). Successful IAV eradication projects require a solid foundation of operational, administrative, legal, communications, and other kinds of support (Morrison et al. 2011). International partnerships offer a way to transfer skills and experience, and to share resources to achieve these goals.

This paper presents an example of an effective partnership between a developing nation of islands and global experts on wildlife conservation and the eradication of IAVs. Of the more than 700 islands that make up The Bahamas, 52 still provide breeding habitat for 13 species and subspecies of reptiles, birds, and bats listed as Critically Endangered or Endangered on the IUCN Red List (IUCN 2013). Invasive mammals known to impact these threatened species are co-present on 37 of these islands (TIBP 2012). The Bahamas National Trust (BNT) is a non-government organization (NGO) with the mandate to manage the National Park System of The Bahamas (Bahamas National Trust Act 1959). BNT, in consultation with Island Conservation (IC) and researchers from Guilford College (Greensboro, NC) and Earlham College (Richmond, IN) developed a partnership that also

included a commercial enterprise and other research organizations to remove invasive house mice (*Mus musculus*) from Allen Cay in the Exuma Islands, The Bahamas. Here, we highlight the experience gained through the development of this successful partnership to protect nationally and globally significant biodiversity, and to create conditions for further restoration projects elsewhere in The Bahamas.

CASE STUDY

Project Site and Need

Allen Cay is located within the Allen Cays in the northern Exuma Islands in the Commonwealth of The Bahamas (24° 45' N, 76° 50.5' W). Allen Cay is a small, 6-ha uninhabited limestone island approximately 1 km in length with low coppice vegetation. Native species present on the cay, including the globally declining Audubon's shearwater (*Puffinus lherminieri lherminieri*) (Mackin 2007) and the endangered, endemic Allen Cays rock iguana (*Cyclura cychlura inornata*) (Iverson et. al 2004), were negatively impacted because invasive house mice attracted predatory barn owls (*Tyto alba*) to the cay. The presence of invasive mice also provided a food source that allowed barn owls to persist on Allen Cay throughout the year, increasing the predation rate on shearwaters (Mackin 2009).

The primary objectives of the project were: 1) to remove invasive mice from Allen Cay without harming native wildlife; 2) to monitor the current and future status of Audubon's shearwaters; 3) improve breeding habitat for the endemic Allen Cay rock iguana; and 4) to train BNT staff in techniques for eradicating invasive mammals to facilitate the restoration of other islands in The Bahamas.

1. Pre-Planning

Natural History Research Programs

The Bahamas has a small population of people and a limited budget for wildlife management, but organizations within The Bahamas including the BNT and the Bahamas Ministries for the Environment and Agriculture have continually worked with research scientists from The Bahamas, the United States, Canada, and elsewhere to help graduate students, scientists, and conservation organizations conduct conservation research. Mice were discovered because John Iverson, Sandra Buckner, and the BNT noticed large numbers of dead Audubon's shearwaters at Allen Cay and asked William Mackin to visit Allen Cay and explain the phenomenon. In 2003, Mackin observed a mouse along with hundreds of dead shearwaters and barn owl feathers at Allen Cay, and in 2007 he confirmed that the death rate of shearwaters was much higher on Allen Cay than on similar colonies.

Pre-partnership Networking

Professional connections had great value in joining the partners and recognizing common purpose. IC was endorsed by a scientific advisor to BNT and subsequently invited to assist with the project. Without the creation of that initial connection, the project was unlikely to have been implemented. Bringing leadership from the main

organizations (BNT and IC) together at the outset allowed joint visioning and planning. BNT's existing network of collaborators also helped the partnership to develop and function. Without resources and support from other partners such as Earlham College, the other participating research organization (Shedd Aquarium), and the commercial operator (Powerboat Adventures), the project would have required increased costs and time and far exceeded the funds available for the project.

Funding

Successful application for funds from the National Fish and Wildlife Foundation (NFWF) Recovered Oil Fund for Wildlife was made by BNT in consultation with Will Mackin and IC. BNT administered the grant funds and in-kind donations throughout the project. IC provided equipment, supplies, and supported additional personnel to support field activities. In-kind donations like transportation of personnel and supplies ensured that conditions for logistical success could be established a valuable support system for the project. BNT and IC committed to the project through shared financial investments, which ensured both organizations were accountable for the project's outcome. The project exceeded the costs initially anticipated during the pre-planning phase.

Clear Definition of Responsibilities

A Cooperative Agreement was developed with mutual consensus between BNT and IC which established a framework for partner engagement. The agreement defined the project purpose, funding information, the term of agreement, specific obligations for each organization, reporting requirements, invoicing, and agreement termination procedures. The agreement increased project efficiency because each organization had a concrete picture of their respective roles, responsibilities, and deliverables. It was critical that all project partners shared an understanding of the inherent risks and potential for project failure, and shared the expectation that the first project would serve as a training exercise for both organizations.

Communications

Prior to this project, BNT and IC had minimal interaction, but subsequently committed to learning about one another's core competencies and challenges. Regular information exchange and team-building via telephone meetings and training opportunities helped BNT and IC sustain enthusiasm, address uncertainties, and agree on details. Regular scheduled communications provided a platform for recognizing similarities and differences in organizational work style and constraints. Throughout the project, BNT folded IC into a long-standing collaborative history with various research institutes, tourism agencies, regulatory agencies, and environmental groups operating in The Bahamas. Communicating through this network provided the broad support base required to ensure acceptance and advancement of the project. Particularly strong bonds were formed between IC, Shedd Aquarium, and Earlham College, which supplemented and facilitated other partnerships.

2. Planning

Planning the removal of house mice from Allen Cay introduced both BNT and IC to the regulatory and logistical processes involved in removing IAV from islands in The Bahamas for conservation management.

Planning Documents

Production of planning documents at various phases of the project helped to maintain engagement of partners through the project cycle. Joint preparation of a feasibility assessment and operational and biosecurity plans required familiarity and consistency with eradication principles and required clarification of concerns or issues. Assembling plans also enhanced the credibility of the project initiative (proof of competence) to project participants and project stakeholders including government, donor, and project supporters.

Permitting

IC compiled the necessary technical information to fully assess potential environmental risks of the proposed rodenticide application, and together with Earlham College designed the mitigation necessary to protect non-target native species. BNT expedited approval for permits to conduct scientific research and export specimens from the Bahamas Environment, Science and Technology Commission (BEST) in the Ministry of the Environment, and ensured that local laws and guidelines were upheld for all aspects of the project.

Training and Skill Sharing

BNT widely distributed participation opportunities throughout its regional offices and National Park System. Personnel at different levels and departments within BNT were involved in project scoping, feasibility assessment, operational planning, and implementation. Participants gained hands-on exposure to eradication theory and practice with the goal of strengthening BNT's capacity to participate in and eventually lead the removal of IAV from islands in the future. BNT staff from New Providence, Abaco, Eleuthera, and Grand Bahama formed the core of the operational team with technical advice and support provided by IC. Prior to this project BNT staff had limited experience in planning and executing a rodent eradication, and some of the staff involved had not undertaken a multi-day expedition to a remote island. To develop necessary technical skills, fieldwork was conducted in small teams supervised by IC staff to ensure proficiency before staff worked independently. The feasibility assessment included baseline monitoring of the target and non-target species, bait persistence and degradation, collection of samples for genetic analysis, and a population assessment of the cay's Audubon's shearwater population.

During the feasibility assessment, personnel were introduced to novel skills like rodent detection, live-trapping, GPS plot monitoring, and safe handling of rodenticide pellets. The operational team varied in experience with specific skills (i.e., using a GPS) that ranged from novice to expert. Fieldwork provided an opportunity for "refreshment training" to ensure that the fundamentals were consistent among all participants. The

logistics of running a field camp at Allen Cay was a learning experience for all. Minor issues with transportation of personnel and supplies or preparation of essential equipment required the team to draw upon the experience and strengths of both organizations in order to continue with the fieldwork.

Training with BNT in the field also provided IC staff the opportunity to learn from expert naturalists that manage the National Parks and Protected areas in The Bahamas. IC's ability to understand and predict species interactions and ecosystem impacts in The Bahamas improved as staff learned to identify local flora and fauna working alongside BNT naturalists. Together, the operational team developed a detailed understanding of local threats posed by IAV in The Bahamas.

3. Implementation

Operation

The implementation, conducted in May 2012, was also regarded as an opportunity for capacity development. The operational team consisted of staff that had participated during the feasibility assessment but also staff new to the project. Participants from the feasibility study took on a leadership role by mentoring new staff. The operation was achieved by distributing rodent bait containing the second-generation anticoagulant brodifacoum (Brodifacoum-25D Conservation, Bell Laboratories, Inc., Madison, WI) in two applications. Allen Cay's flat terrain, small size, and accessibility allowed rodent bait to be applied by hand. The field team monitored bait availability and observed mice that succumbed to the effects of brodifacoum during direct and opportunistic carcass surveys.

Non-target Management

Measures to minimize adverse effects on non-target species were undertaken to protect native wildlife at Allen Cay. Prior to the implementation, John Iverson and team captured 18 of the 21 known iguanas at Allen Cay and relocated them to a nearby cay to prevent exposure to rodenticide and potential disturbance during the operation (Iverson 2012). Laughing gulls (*Leucophaeus atricilla*) were hazed from landing and nesting at the cay during the period when exposure to rodenticide was possible.

4. Post-Implementation

Confirmation Monitoring

Monitoring to confirm the presence or absence of the target species post-eradication is crucial to determining the success of an eradication project. One year after the Allen Cay mouse eradication, no signs of mice were found using live traps, tracking tunnels, and camera traps deployed at Allen Cay, including 150 trap nights, 150 tracking tunnel nights, and over 200 person-hours of observation (Bahamas National Trust and Island Conservation 2013).

Media

The Allen Cay partnership attempted to increase awareness of the threats posed by IAVs in The Bahamas through local and international media outlets. The removal of mice from Allen Cay attracted global and

local media attention and was promoted 23 times, including distribution from sources such as BirdLife International, Ornithology Exchange, Europe Overseas Forum of IUCN, Bird Conservation Nepal, Bahamas Weekly, Bahamas Islands Info, Bahamas Local, and more. Widespread recognition of the project success enhanced the reputation of the organizations involved in the project and further solidified the strong relationship as partners.

DISCUSSION

The word 'partnership' is applied to a wide range of working relationships within and between the public, private, and NGO sectors leaving plenty of scope for the term's interpretation (Caplan 2003). FFI (2009) suggests that engagements should be articulated to ensure the context, needs, and objectives of the organizations involved are aligned. In this context, the Allen Cay partnership was defined as key people and organizations that combined their resources and efforts to achieve the shared goals of removing mice from Allen Cay, for mutual purpose and benefit within wider environmental goals of improving habitat and protecting threatened populations of native species. A partnership was necessary because no one individual or organization had all of the attributes necessary to advance the project (e.g., logistical or financial resources, historical data, technical expertise, island access). Focusing on mutual interests, the partnership sought to complete the project in a timely, cost-effective manner that ultimately met the objectives of each partner. As a result, the partnership achieved more by working together than each individual or organization could have achieved by working on its own.

Land managers in developing nations such as the BNT are typically well-placed to protect native species in their region, but they likely require collaboration with other organizations to gain the technical skills, funds, or resources in order to undertake complex eradication projects. Allen Cay, the first collaborative project between BNT and IC, had a higher cost than expected because both partners took the time to get to know each other through an extensive planning process and engaged in shoulder-to-shoulder training while executing the project phases. However, the investments made in this partnership were considered cost-effective because it was anticipated that the implementation of future projects would be more efficient as a consequence. This projection has already been borne out with the progression of another eradication project by BNT and IC on Booby Cay, off Mayaguana Island in the southern Bahamas.

Biosecurity is critical to eradication project success. Nature-based tourism and other boating also present a risk of IAV reinvasion to islands like Allen Cay because of the ease of access. The Allen Cays are uninhabited but visited frequently by tourism operators, researchers, and private vessels. Tourism accounts for 60% of The Bahamas economy (CIA 2014), and the natural beauty, biodiversity, and ecological health of the islands are critical components for attracting tourism to the country. Elsewhere in The Bahamas, stakeholder and constituency groups are different for each island, and the specific

threats to biosecurity vary geographically. The larger issue of biosecurity in The Bahamas requires improved public awareness and an enhanced biosecurity management plan. Coordinated outreach (Gap analyses of risk, increased local media, focused education programs to specific user groups) regarding the threats of IAVs, the benefit of IAV removal, and increased political support should continue to develop with a goal of national prioritization of IAV eradications in The Bahamas.

Developing countries not having eradication experience require access to resources to streamline planning and ensure that environmentally safe and efficient methods are put into practice. The resource kit developed by Pacific Invasive Initiative (PII 2011) is an example of a globally-accessible guide that helps project managers plan and implement rodent and feral cat eradications. The resource kit describes the phases of typical IAV management planning, implementation, and evaluation processes, and offers guidelines that generalize best practice options and allow managers to select the best approach for their particular environment. In this case study, PII's resources were extremely valuable for orienting and training conservation professionals new to IAV management and drafting management plans relevant for The Bahamas.

Funding will be a fundamental component to successful conservation partnerships within developing countries. International partnerships can increase the potential for securing funds by providing technical grant-writing support to access multilateral funds such as the Global Environment Facility, and expanding philanthropic networks. Strategic multi-project proposals are likely to fit the funding model required by such agencies. Proposals will also need to address broader conservation issues, and not just eradication projects alone, to support the competing commitments that land managers in developing countries also need to address.

International partnerships to advance conservation goals require a healthy understanding of a partner organization's history, ambitions, and restrictions. Recognition and understanding of the individual strengths and weaknesses of partner organizations was instrumental to the success of the project.

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DISCLAIMER

The views and conclusions contained in this document are those of the authors and should not be interpreted as representing the opinions or policies of the U.S. Government or the National Fish and Wildlife Foundation. Mention of trade names or commercial products does not constitute their endorsement by the U.S. Government or the National Fish and Wildlife Foundation.

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