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**REVIEW OF BROWN TREESNAKE PROBLEMS  
AND CONTROL PROGRAMS**

*Report of Observations and Recommendations*

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*At the Request of:*

U.S. Department of Interior, Office of Insular Affairs  
for the Brown Treesnake Control Committee

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# **REVIEW OF BROWN TREESNAKE PROBLEMS AND CONTROL PROGRAMS**

*Report of Observations and Recommendations*

## ***Prepared by:***

Bruce A. Colvin, Ph.D.  
Bechtel Corporation

Michael W. Fall, Ph.D.  
U.S. Department of Agriculture, Animal and Plant Health Inspection Service\Wildlife Services  
National Wildlife Research Center

Lee A. Fitzgerald, Ph.D.  
Texas A&M University, Department of Wildlife and Fisheries Biology, Faculty of  
Ecology and Evolutionary Biology

Lloyd L. Loope, Ph.D.  
U.S. Department of Interior, U.S. Geological Survey, Biological Resources Discipline

## TABLE OF CONTENTS

PREFACE.....	iii
ACKNOWLEDGEMENTS.....	v
EXECUTIVE SUMMARY.....	vi
FOREWORD: OVERARCHING GOALS AND THEMES.....	ix
INTRODUCTION.....	1
1.0 INTERDICTION ON GUAM.....	4
1.1 Regulatory Mechanism for Snake Interdiction .....	4
1.2 Integrated Pest Management.....	5
1.3 Current and Future Dog Programs.....	7
1.4 Military Programs for Snake Interdiction on Guam.....	8
1.5 Snake Capture Programs.....	10
1.6 Use of Barriers for Snake Interdiction on Guam.....	11
1.7 Data Management and Mapping.....	12
1.8 Snake Problems Involving Power Generation, Transmission, and Delivery.....	13
1.9 Transportation Industry Interdiction Programs and Coordination.....	14
1.10 Coordination with Program Components Located off Guam.....	15
2.0 INTERDICTION OFF GUAM.....	15
2.1 Regulatory and Enforcement Options.....	16
2.2 Integrated Pest Management.....	17
2.3 Barriers.....	17
2.4 Dog Programs.....	18
2.5 Rapid Response and Surveillance.....	19
2.6 Communications and Planning.....	20
2.7 New Invasive Species Introductions Could Increase Prey Base.....	21
3.0 BROWN TREESNAKE POPULATION CONTROL.....	22
3.1 Planning for Landscape-scale Snake Population Reduction.....	22
3.2 Eradication Strategy.....	24
4.0 SPECIES AND ECOSYSTEM RESTORATION ON GUAM AND OTHER PACIFIC BASIN AREAS.....	25
4.1 Restoration Planning.....	26
4.2 Restoration Strategy.....	27
5.0 RESEARCH.....	28
5.1 Coordination and Planning.....	30
5.2 Tools and Methods Development.....	31
5.3 Monitoring and Surveillance.....	32
5.4 Critical Ecological and Exploratory Research.....	32
5.5 Technology Transfer from Research to Operations.....	33

6.0	FUNDING.....	34
6.1	Overview.....	35
6.2	Office of Insular Affairs.....	36
6.3	Department of Defense.....	36
6.4	U.S. Department of Agriculture.....	37
6.5	U.S. Geological Survey.....	37
6.6	U.S. Fish and Wildlife Service.....	38
6.7	Island Governments.....	39
6.8	Transportation Industry.....	39
7.0	EDUCATION AND AWARENESS.....	39
7.1	Materials for Education and Awareness.....	40
7.2	Brown Treesnake Information Available on the Internet.....	41
7.3	Outreach to Achieve Public Support and Involvement in Early Detection.....	42
7.4	Building Local Capacity for Brown Treesnake Control.....	43
7.5	Training for Brown Treesnake Program Personnel.....	44
8.0	PROGRAM MANAGEMENT.....	44
8.1	Leadership and Planning.....	45
8.2	Coordination and Communication.....	47
8.3	Program Integration and Milestones.....	48
8.4	Human Resources.....	49
	Appendices	51
	Appendix A. Pacific Region Map .....	51
	Appendix B. Interview List of Public and Private Sectors .....	52
	Appendix C. Acronym List.....	53

## PREFACE

The brown treesnake (*Boiga irregularis*) was likely introduced to the island of Guam as a passive stowaway in a military cargo ship shortly after World War II. The snake's historic range includes portions of Indonesia, New Guinea, the Solomon Islands, and Australia. Upon arrival in Guam, the brown treesnake encountered an abundant prey base and an absence of natural predators and pathogens. Since its establishment, the brown treesnake has caused significant environmental and socioeconomic problems on Guam and has greatly raised the overall awareness of invasive species problems in the Pacific Basin.

The brown treesnake is responsible for the extinction or local extirpation of nine of the 12 native forest birds and two of 11 native lizards on Guam. The rapid nature of the decline of the birds was especially dramatic: in the early to middle 1980's, several common native bird species declined rapidly over a one to three year period. Native fruit bats also have experienced similar declines. The brown treesnake is the single greatest threat to terrestrial ecosystems in the Commonwealth of the Northern Mariana Islands (CNMI) and is certainly one of the greatest ecological threats to Hawaii.

Guam has suffered more than ecological consequences. The brown treesnake causes frequent power outages: more than 1,600 power outages took place in the 20-year period of 1978-1997 and recently nearly 200 outages occur each year. These localized and island-wide power failures have resulted in millions of dollars of losses from damaged power equipment, electrical repair costs, and lost productivity. A University of Hawaii economic study estimated that the introduction of the brown treesnake to Hawaii could cost the state's economy between \$28,515,800 and \$405,174,800 annually.

The brown treesnake also affects human health. It is a rear-fanged, mildly venomous snake that potentially poses a danger to infants and small children. Snakebite is the cause of approximately one in every 1,200 emergency room visits on Guam, with infants constituting a disproportionately high number of these cases. There are no known mortalities due to snakebite on Guam.

Great concern exists that the brown treesnake may further extend its range via incidental transport in air or sea cargo and cause similar ecological decimation and socioeconomic problems elsewhere. The high densities of brown treesnakes on Guam, coupled with Guam's importance as a shipping hub, make the spread of brown treesnakes from Guam a potential threat to other Pacific Islands. Considerable efforts have been expended by federal, state, and local agencies over many years on brown treesnake research, control methods development, and interdiction.

In 1990, the Nonindigenous Aquatic Nuisance Prevention and Control Act authorized a cooperative program aimed at control of the brown treesnake outside of its historic range. Shortly after, representatives from the Departments of Agriculture, Commerce, Defense, and the Interior; the CNMI; the Territory of Guam; and the State of Hawaii formed the Brown Treesnake Control Committee. This committee developed the Brown Treesnake Control Plan, which outlines research and control guidelines that are currently used.

The Aquatic and Nuisance Task Force approved the Brown Treesnake Control Plan in June 1996. Prior to the approval of the plan, between 1992-1996, a five-year Memorandum of Agreement (MOA) was developed and signed by the above parties to establish a policy framework and working relationship to facilitate the implementation of the plan and to amend or modify the plan as necessary. In 1999, the MOA was renewed with the addition of another agency, Department of Transportation.

Recognizing the need for periodic program reviews, the Department of Interior's Office of Insular Affairs convened an expert panel in January 2004 to assess research and control programs relating to the brown treesnake. The panel consisted of four individuals from the private and public sectors who have recognized international expertise in applied ecology and public policy, with specializations in environmental management, applied herpetology, invasive species biology, plant and animal quarantine, and vertebrate pest control.

The panel was charged with assessing progress and achieving objectives outlined in the 1996 Brown Treesnake Control Plan and developing recommendations to improve the effectiveness of Federal, State and local brown treesnake research and control programs. The panel's findings will assist the cooperating agencies in drafting an updated plan for brown treesnake research and control efforts in the Pacific Basin.

The panel's review included extensive review of published literature and agency reports, attendance at brown treesnake technical meeting and training, and site visits to Guam, Saipan, Hawaii, and research facilities in Fort Collins, Colorado. The panel conducted interviews with approximately 100 individuals from both the public and private sector who have been active in brown treesnake research and control efforts. This report contains a summary of the panel's findings and its recommendations to help improve the effectiveness of brown treesnake programs. The panel's findings have also been presented to informal meetings of federal, state, and local administrators, scientists, and management personnel in Guam and Washington D.C.

Leilani L. Takano  
Wildlife Biologist  
U.S. Fish and Wildlife Service  
Pacific Islands Office  
Honolulu, Hawaii

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# **Review of Brown Treesnake Problems and Control Programs**

## **EXECUTIVE SUMMARY**

Between March 2004 and February 2005, the Brown Treesnake (BTS) Review Panel performed independent review of activities and opinions related to brown treesnake control. A multi-agency effort is underway, with interdiction on Guam, Saipan, and in Hawaii, research based on Guam and at national centers in Colorado, and outreach and rapid response actions in the Pacific region.

BTS clearly poses a significant, immediate, and regional threat to natural resources and economics that should not be underestimated, and this risk is spreading through transportation routes. The risk is greatest for Saipan, but Hawaii and other islands in the Pacific Basin are also vulnerable. Repeated BTS sightings on Saipan indicate that an incipient population is now present there. Unlike Guam, where BTS has decimated avian populations, CNMI still harbors many native bird species.

The dedication and accomplishments of numerous individuals and organizations, under difficult conditions, are impressive. However, portions of the program are struggling or limited because of short-term planning and funding; much remains to be done. This is not a future need, it is an immediate priority given the significant threat to regional natural resources and economics that BTS pose.

Among invasive species, the BTS program is a success story ready to happen, but policy decisions need to be made at appropriate administrative levels and progress must be made on new technologies and control strategies. Five core topics for program enhancement are: (1) a legal basis for inspections and enforcement, (2) a greater and more stable funding base, (3) stronger senior leadership and ownership, (4) a comprehensive action plan with milestones, and (5) progress on research and program integration.

The interagency approach to planning (the BTS Control Committee) is effective and should be sustained and enhanced. However, program goals, objectives, and priorities should be better defined. The content of the new BTS Control Plan should be an integrated action plan that delineates essential tasks and milestones necessary to achieve program goals and that establishes critical paths and the sequence of actions. Overall, a more proactive and sustainable approach and a long-term, holistic vision are required. The overall program focus should be regionalized to place increasing emphasis on emerging or potential BTS problems outside of Guam.

Participating agencies should firmly establish their policies on invasive species and must elevate the BTS issue organizationally. More involvement and demonstrated ownership at senior levels is required. Foremost, with extensive land holding and increasing operations on Guam, the Department of Defense must improve its cooperation and support of the overall BTS effort. Although the Department of Defense has for many years dedicated a key senior position to coordinating the BTS-related activities of military agencies and has provided grant funding for



some of the most critical research, funding participation by the Department of Defense in the overall BTS program is not adequate. In contrast, the Department of Interior's Office of Insular Affairs has made funding decisions with decisive leadership and minimal layers of bureaucracy. Overall, the BTS program has been funded with short-term grants, often with funding delays. Program activities overall are underfunded, creating risks and restricting progress. BTS interdiction should be part of the cost of transportation systems and services in high risk areas for invasive species. Furthermore, limited and annual "soft" funding has hindered consistent staffing in a program requiring diverse skills and stable personnel resources; critical knowledge now exists among a very few individuals in positions that are subject to high turnover and job insecurity.

High quality research has been a hallmark of the BTS program. Ecological research by USGS and Colorado State University scientists in Fort Collins and methods development research by APHIS/Wildlife Services National Wildlife Research Center (NWRC) must be sustained. In particular, funding for research by NWRC must be greatly improved, with emphasis on control, eradication, and emergency response strategies, and particularly on development of effective baits, snake attractants, and practical delivery systems for control agents. Priority must also be maintained on ecological research on population dynamics and demographics and on surveillance and detection.

BTS interdiction programs exist on Guam, Saipan, and Hawaii. Efforts by Wildlife Services operations on Guam are excellent, but incomplete coverage of all program aspects exists because of insufficient funding and personnel. Interdiction actions in Hawaii by the Hawaii Department of Agriculture need improvement, including better coordination with the Guam programs. Legal and regulatory bases for cargo inspections and compliance are needed, along with broad monitoring and assessment of regional transportation networks. Integrated pest management (IPM) programs should be developed and tailored for affected ports and airports, with regular review.

Significant BTS population reduction or eradication is nearly feasible with the new and emerging technologies, particularly the toxicant, acetaminophen, which is now registered by the Environmental Protection Agency for use in BTS control. Alternatives for control and eradication actions range from buffer zones around high-risk ports to landscape-scale areas. Specific strategies for control and eradication methods and a logical sequence of actions need to be developed; the diverse habitats, access to privately-owned lands, and the detection and control of small snakes are issues to overcome. As part of control and interdiction, newly-designed barrier systems are important and should be incorporated into existing and planned infrastructure. BTS control should be incorporated into any new or expanding port or military facilities.

The public outreach program on Saipan is a model, particularly the partnership with private industry. Additionally, the regional focus on rapid response is excellent and should continue to grow and be supported, including evaluation of dogs for field detection of BTS. The rapid response teams are conducting public outreach; this should be recognized as a major component of their mission to help assure public awareness of and participation in BTS monitoring.

Regionally, increased involvement of policy makers, regional organizations, and private industry should be sought. Local capacity-building is needed to support research, operations and program management, and to improve local recruitment pools. Efforts could include cooperative university and government programs.

Restoration of avian populations on Guam is important but should not dilute the focus on preventing BTS spread. Restoration should be planned and timed according to control and eradication technology and schedules. Overall, restoration goals need to be better defined, and more biological information is needed to support restoration planning. BTS is not the sole issue pertaining to restoration; habitat loss and other vertebrate pests, particularly rats, feral cats, and ungulates, may impede establishment of self-sustaining avian populations.

A full-time BTS program coordinator should be established to work with the BTS Control Committee, and replace the current reliance on the voluntary assistance of a biologist with many other duties. Such a position would logically remain within the USFWS, which now performs these functions informally. Program management should become more formalized and structured. As the BTS program moves forward, project management methods and skills will become increasingly important, including program integration, strategic and decisive actions, and periodic review of milestones and progress. Processes should be documented and institutionalized, and teamwork set with discipline-specific working groups.

The BTS program is interdisciplinary, requiring diverse skills and integration at all levels. Such an invasive species program requires leadership, cooperation, coordination, political support, and stable funding. The program must be managed with the immediacy it requires. Significant opportunities for control and long-term eradication are emerging now.

## **FOREWORD: OVERARCHING GOALS AND THEMES**

Summarized below are two overarching goals and ten overarching themes associated with this BTS programmatic review. Following that information is the report introduction and eight sections, each with subject-specific observations and recommendations.

### **TWO OVERARCHING GOALS**

1. Prevention of BTS dispersal to other islands, thereby preventing additional and widespread regional impacts and damage.
2. Control and eradication of BTS island-wide or on significant portions of Guam, thereby reducing or eliminating impacts and damage there.

### **TEN OVERARCHING THEMES**

#### **1. Leadership**

Considerable leadership and potential for leadership exist at the implementation level, among field and research staff. However, stronger leadership and involvement at the policy and senior management levels are essential to ensure long-term sustainability of BTS control efforts; this should be a priority. Many program elements seem to be managed from the bottom up, based on the personal dedication of a few individuals. An effective program requires strong, diverse, and committed leadership at all levels of the organizations involved, from government to private industry. Immediate action is required; there is too much at risk from both an economic and scientific perspective. Although the interagency committee approach to planning is important and valuable, this committee does not represent senior-level decision-makers or funders. Ultimately clear commitment to the problem and accountability must be established at the senior level among the agencies involved.

#### **2. Goal Setting and Planning**

Long-term vision defined objectives and goals, and the establishment of milestones (interim goals and objectives) that are scheduled and tracked should replace cyclic, short-term planning. Planning must be integrated among agencies to maximize the accomplishment of shared (defined) objectives and to assure understanding and recognition of critical-path tasks (i.e., essential actions and priorities for moving forward). The BTS Control Committee has been established for the purpose of integrative planning and appears to have made much progress on inter-agency cooperation in recent years. Planning must be realistic, practical, and flexible for the magnitude of the spreading problem. Planning should include risk and alternatives assessment and a process for continuous improvement and periodic review. Appropriate input should be sought from a wide range of stakeholders.

### **3. Communication and Coordination**

Communication is occurring vertically and laterally within the organizations involved in BTS research and control. Some communication paths are working well and others can and must be enhanced. Success ultimately is predicated upon open communication and, most importantly, cooperation among numerous entities. Communication includes various government agencies, but also must include the general public and private industry (e.g., transportation, construction). Impressively, the BTS Control Committee has helped pull agencies together for planning and information sharing. Whether for BTS or other invasive species, the public and policy makers must be made aware of the risks and impacts. Education of stakeholders should be accomplished through diverse methods and broad participation; the public is an important part of front-line monitoring and reporting. Establishment of a permanent outreach and coordinator position for the committee may be valuable and should be considered.

### **4. Funding and Resource Allocation**

Funding is distinctly inadequate relative to the magnitude of the existing problem, and to the emerging problems and associated risks for other islands. Short-term funding cycles are hampering necessary research and interdiction activities and are restricting the forward momentum needed for an effective program to control invasive species. Because BTS efforts are underfunded, the risk of much higher costs looms in the future to resolve expanding threats not addressed now. The cost-sharing among agencies and the transportation industry needs to be improved. OIA is carrying much of the funding responsibility at present, and, inappropriately, the perceived ownership of the problem. Greater and sustainable investment by the military agencies is warranted as part of their doing business in high-risk areas for invasive species dispersal and their overall stewardship of natural resources on their lands.

### **5. Interdisciplinary Activities**

The BTS program must be recognized as interdisciplinary, requiring practical and flexible integration of multiple program elements and skills. Research is a central theme in BTS control, and especially important are the closed population studies and bait and delivery system development. Regional issues, coordination, capacity building, rapid response, outreach, and interdiction are all inter-related and, as such, must be appropriately funded and closely integrated for a holistic approach to control/eradication and ultimately restoration. A shared work plan with commonly accepted milestones is the best way to assure integration and cooperation among participants. The interagency approach used now for the BTS program serves as a model for invasive species management and control.

### **6. Research**

Excellent research has been conducted on many aspects of BTS biology and control measures. Additional ecological research is needed to facilitate control and interdiction, including studies of population dynamics and reproductive biology. Research and development of control measures need much greater support, particularly in the area of baits and attractants, practical methods for delivery, application of control agents, and logistics associated with control and interdiction. Pursuing these critical research topics is central to the resolution of BTS issues.

Further exploratory research may be needed as proven technology for vertebrate control continues to evolve. Research by all parties should be closely coordinated and integrated to maximize efficient use of funds and execution in the field.

## **7. Program Execution**

The program accomplishments to date are impressive. However, a general shift from a reactive effort to a proactive, sustainable program is needed. For example, this shift might include tailoring local integrated pest management (IPM) programs to incorporate BTS interdiction. However, a critical shift is needed away from interdiction focused on BTS capture (under the 1996 BTS Control Plan) with short-term funding. A plan for program execution is needed that defines the process for implementing long-term priorities (e.g., improved control measures and emergency response capabilities, attempts at full-scale eradication), defining milestones, and monitoring results. Such a plan also should articulate the policy, funding, research, and regulatory support necessary to accomplish its stated goals and objectives.

## **8. Restoration**

The goals of BTS control can be described as (1) restoration of extirpated species on Guam and (2) protecting fauna and other resources in the region from extirpation or damage by BTS. Restoration activities and planning need to be coordinated with the development and implementation of BTS control technology. Restoration projects must consider the multiple invasive species present (in addition to BTS) that may impede reintroduction efforts and the development of self-sustaining populations. Habitat loss appears to be a significant issue that also must be addressed as part of restoration planning. Restoration could be coordinated with a control/eradication project, with distinct planning linkages between them. Separate funding mechanisms for restoration efforts are required.

## **9. Regional Perspective**

BTS is not just a Guam problem; it is a growing regional issue, and a serious risk in terms of potential economic and natural resource losses. The threat to islands other than Guam, particularly Saipan, is a serious concern requiring immediate attention. A synergistic, regional perspective is required when developing strategies, mobilizing resources, and executing a management and control program. The efforts underway on BTS control and interdiction provide an excellent model for management of any invasive species using a regional, cooperative, and holistic perspective. Various regional organizations, policy makers, and government officials need to be actively tracking and supporting BTS efforts.

## **10. Management and Accountability**

The efforts of numerous people involved with BTS have been admirable, especially given the many organizations involved and limited funding available. However, it now is essential to move forward to the next level of program implementation with clear priorities, accountability, institutionalized procedures and processes to achieve necessary goals. A diversity of skills and personnel resources are needed to assure sustainability and efficient program execution. Skills in

biological sciences must be complemented with skills in project management, scheduling, budgeting, policy development, and stakeholder outreach. The critical nature of the BTS problem and the associated risks warrant dedicated resources for program management and coordination. However, achieving program goals and dedicating resources will require agencies to affirm their policies and priorities, and to assume greater responsibility for the problem.

# **Review of Brown Treesnake Problems and Control Programs**

## **INTRODUCTION**

Preventing spread of the brown treesnake (BTS) from Guam and mitigating its impacts on Guam are national responsibilities for the United States. BTS very likely arrived at Guam's major harbor shortly after World War II with salvaged war materials returned from strategically crucial military operations in 1942-45 on islands near New Guinea, where BTS is native. Though this scenario is not 100% confirmed, it is rare to find a biological invasion for which there is such strong evidence of the source, pathway, and timing.

BTS invaded the whole of Guam over several decades. In conjunction with research into the rapid loss of Guam's native birds, the discovery was made that BTS occurs on the island at remarkably high population densities (up to 40/acre versus less than 1/acre in their native range). The treesnake invades Guam airports and harbors in search of prey and occupies a variety of habitats. The nocturnal BTS hides during the day in crates, vehicles, and other materials that are commonly moved by air and sea to other islands. It can survive for months without food. Guam is a transportation hub for civilian and military traffic in the western Pacific. Individual snakes have traveled as far as Japan, Okinawa, Wake Island, Hawaii (Oahu), Alaska, Texas, Spain, and Diego Garcia. The species may already be established on Guam's neighbor island, Saipan, and individual snakes have been found on nearby Tinian and Rota.

Consequences of BTS invasion have been devastating to the biological diversity and human infrastructure of Guam (an area of 209 square miles with a population of 135,000). BTS would clearly precipitate a biodiversity and economic crisis through establishment and population expansion on any other tropical or warm-temperate island in the world outside its native range. There is no question about the magnitude of the risk involved; the snake has the potential to damage infrastructure and eliminate not just endangered birds but virtually all island bird populations wherever it establishes.

BTS could wreak havoc on the biodiversity and electric utilities of Hawaii (with about 4,000 square miles of land area potentially habitable by BTS, and a population of 1.2 million). Hawaii's Honolulu International Airport is the world's 17<sup>th</sup> busiest airport and the major transportation hub for the central Pacific Region. Although island ecosystems are most vulnerable, BTS could likely have similar impacts under certain circumstances on continents. From an international perspective, it appears that the United States has a huge responsibility to protect at minimum the roughly 20 island nations in the Pacific Ocean that are most vulnerable to BTS introduction from Guam.

The invasion of BTS in Guam caught the scientific and conservation community completely by surprise when it was discovered in the early 1980s. Although BTS is now a textbook example of the danger of moving species into ecosystems in which they did not evolve, 25 years ago no one had realized that predation by an introduced snake could devastate bird populations, much less extinguish entire species.

Once the impacts of BTS were acknowledged, the history of response to this invader provides in many ways a stellar model of how to address a completely new and unimagined environmental and societal issue through human ingenuity (a blend of research and timely action). The BTS program also may provide an attractive model for coordination among diverse agencies for addressing other high priority invasive species concerns. Our impression is that similar levels of coordination are non-existent or at least very rare for other invasive species issues in the United States.

A combination of science-based techniques -- erection of barriers, trapping and use of detector dogs -- currently provide tools for substantially reducing but not eliminating opportunities for transport of BTS from Guam's airports and harbors. Although the current interdiction strategy makes use of the best available techniques, sustained support for research toward better long-term solutions is essential. Registration of the environmentally safe toxicant acetaminophen in 2003 represented a key step toward major breakthroughs in reducing snake populations in the vicinity of ports and island-wide. This toxicant can be used to reduce and perhaps locally eradicate BTS as soon as efficient means of bait delivery are developed.

The nearly intractable problems of estimating the size of the extant BTS population on Guam and detecting new ones on other islands are being attacked using cutting-edge science. Large-scale eradication is not out of the question. Huge strides have been made on Saipan to involve the public in detection and timely reporting of snake sightings. Developing and refining detection by dogs trained to find snakes following reports is a very promising next step. We regard the BTS program as "a success waiting to happen."

A major problem faced by the BTS program is that although addressing BTS is clearly a national responsibility, no agency in the federal government -- with the exception of the Department of Interior's Office of Insular Affairs -- has taken responsibility for funding BTS interdiction, control, or research in a sustained and meaningful way. The success of the BTS program involves a cast of many dozens of dedicated individuals at any one time, but personnel turnover is high. In fact, the sustenance and excellence of the BTS program has depended primarily on leadership of a very few immensely skilled and dedicated individuals, more often than not acting outside their job descriptions. Under such a regime, loss of a single key individual could be devastating for this diverse program.

Management of invasive species in general cannot be successful if a program's sustainability is based on the actions of a heroic few and long-term agency commitment is lacking. To date, no legal instrument exists to require preventative action by individuals or federal agencies to avoid the dispersal of BTS from Guam. An effective legal fix (probably at the state/commonwealth/territory level) is also urgently needed to provide for mandatory, rather than voluntary, inspection and clearance of goods leaving Guam.

Passage of the Brown Tree Snake Act of 2004 unfortunately does not include stringent requirements for BTS prevention and control by federal agencies. When our panel started its work in 2004, the working draft of the bill had an excellent section (4) that mandated items requiring specific compliance from all federal agencies involved in actions that might cause accidental introduction of BTS to uninfested areas. The excision of that language before the bill



was passed was an egregious setback for addressing the national responsibility for BTS interdiction and control.

Most notably, the U.S. Navy and U.S. Air Force, dominant players in transport of goods from Guam to other locations (including Hawaii, Saipan, Rota, and Tinian), and currently burgeoning on Guam because of national security needs, are exempt from any obligatory requirement for compliance or even cooperation with BTS interdiction and control efforts. Hence compliance and cooperation depend only on the good will of local military commanders, who undergo a steep learning curve for many issues and rapid turnover (typically every two to three years). National security is their primary mission, but there are also many Federal environmental regulations with which they are required to comply. Officials explained to us that the Navy's environmental program has a \$1.2 billion annual budget for compliance with environmental laws and regulations, but it cannot justify funds for BTS because there is no requirement for compliance. Compliance with BTS control efforts by military agencies should be mandatory, not optional.

Although year-to-year funding by Congress has so far allowed development of fairly effective and well-coordinated (though periodically stressed) interdiction, control, and research programs, an urgent need exists for increased and sustained funding in the budgets of individual responsible agencies. This funding will not happen without strong support at the highest levels within the agencies/departments.

### **Brown Treesnake as a Model for Addressing Invasive Species Issues**

The BTS program has made significant progress to date and in many ways it already is a model program for addressing invasive species issues nationally and internationally. This is especially apparent when compared with the lack of national response or coordinated effort to prevent spread of the red imported fire ant (*Solenopsis invicta*) to Hawaii and Pacific Islands. Many similar examples exist. The ingredients of the BTS program's successes are: (1) timely initiation of the program prior to massive spread of the BTS to other localities; (2) reasonably adequate funding to meet the primary goal of keeping the snake out of the transportation network; (3) generally excellent communication and coordination among the far-flung components of the program; (4) a philosophy of concern for protecting all vulnerable locations, not just those in the United States; and (5) a reasonable balance between research and operational aspects of the program.

The BTS program can be made more effective and a better model for others by: (1) obtaining more stable and sustained funding; (2) promoting legislation that requires action to prevent spread of BTS, including mandatory inspections; (3) clarification of leadership responsibilities and program responsibilities; (4) development and implementation of a comprehensive plan with long-term goals, enhanced integration of tasks, and clearly defined milestones; and (5) further refinement of communication/coordination, program processes, and quality assurance.

## **1.0 INTERDICTION ON GUAM**

1.01 Interdiction of accidental transport of snakes from Guam to other Pacific Basin islands is an over-riding concern and has been a focus of BTS program efforts since funding first became available in 1993. The panel reviewed literature and program documents; visited port, airport, and military facilities; interviewed managers and personnel concerned with interdiction programs and methods development and evaluation; and observed demonstrations of trapping and capture procedures, dog inspection procedures, and barrier models; and examined in some detail the environmental features of areas near facilities at high risk for accidental snake infestation. Overall, we found an excellent, multi-faceted program that should be stabilized with permanent, predictable funding; improved coordination among the cooperating organizations; and through mechanisms for assured compliance with inspections and other control actions, including vegetation and harborage control around high-risk areas.

1.02 The current impediments to complete BTS inspections of all cargo can be summarized in terms of the limited availability of trained personnel (dog handlers, snake trappers, and supervisors), lack of mandatory compliance, labor-intensive trap maintenance and snake harborage reduction, and lack of funding mechanisms to ensure adequate personnel and logistic support for maintaining buffer-zones and conducting dog inspections. The panel recognized the difficulties of voluntary interagency cooperation across both public and private sectors.

### **1.1 Regulatory Mechanisms for Snake Interdiction**

#### **Observations**

1.1.1 Inspection programs for both government agency shipments and private shipments are currently operating on a voluntary basis. Although these programs have had sustained success over the past several years in that snake exports are apparently not occurring, there are no legal instruments in place that require preventive action by any individual or agency to avoid dispersal of BTS. The broad base of stakeholders in regulatory issues, including the transportation industry and military organizations, recognizes the difficulties in maintaining voluntary clearance procedures. Small, casual shipments in fishing boats and other private craft remain a concern.

1.1.2 Considerable effort is required on the part of Wildlife Services operations on Guam to alert stakeholders of the need for inspections and rigorous notification of expected shipments. Cooperation on manifest documentation and inspections appears to be growing as a result of personal efforts between Wildlife Services personnel and the transportation industry.

1.1.3 Voluntary cargo inspection at military bases is not complete and is largely dependent upon individual cooperation at various command levels. Base commanders frequently change, sometimes resulting in loss of previous cooperation achieved. Commanders reportedly may be hesitant to prioritize resources for cargo inspections and other BTS control measures because of the lack of legal requirements.

1.1.4 Cargo storage warehouses (and other areas where snakes could easily move into the transport system) are not required to have buffer areas clear of debris and vegetation that could provide snake harborage or to conduct inspections to assure populations of rodents and other pests providing an attractive food source for snakes are not established.

1.1.5 The Brown Tree Snake Act of 2004 authorizes use of federal funding for enforcement of pre-departure quarantine protocols enacted by states and territories to provide protection from BTS. Also, United States shipping regulations now require a detailed electronic manifest for all containers at least 24 hours before aircraft/ships arrive at a United States port from outside the country. These developments may aid in establishing both appropriate legal mechanisms and appropriate funding to make them functional in preventing snake export.

## **Recommendations**

1.1.6 The interagency BTS Control Committee should support the consideration of legislation, both on Guam and elsewhere, to assure the effectiveness and enforceability of regulations put forward. This would require gaining full participation by the transportation industry and military.

1.1.7 Since civilian enforcement of military compliance with shipments not entering the civilian traffic system is not feasible, the Department of Defense (DOD) should continue to consider separate, rigorous mechanisms to assure all material of military origin leaving Guam is inspected, possibly including procedures that note or penalize non-compliance by responsible personnel. Periodic summaries of procedures for the other cooperating agencies comprising the BTS Control Committee could help overcome the perception that most departing material and equipment is not inspected.

1.1.8 The Government of Guam should consider whether establishment and enforcement of sanitation codes are a practical means to minimize snake habitat and food sources at cargo warehouses, airports, ports, and storage areas. Likewise, Government of Guam should consider whether a regulatory basis for pre-clearance of cargo could be established and enforced. Clearly, stable, long-term funding for enforcement would be an over-riding consideration in such an approach.

## **1.2 Integrated Pest Management**

### **Observations**

1.2.1 Integrated pest management (IPM) has been defined as “an ecological approach to pest control,” and use of the approach by federal agencies has been mandated by Congress. The U.S. Department of Agriculture (USDA) has defined IPM as “[t]he process of integrating and applying practical methods of prevention and control to keep pest situations from reaching damaging levels while minimizing potentially harmful effects of pest control measures on humans, non-target species, and the environment.” IPM is sometimes misconstrued as simply

using more than one pest control tactic or as a technique that eliminates the use of chemical controls; neither is correct. The key to effective IPM use is careful coordination of pest control tactics tailored to local situations and monitoring of results in relation to specific management objectives. Site-specific IPM planning documents could be useful to the agencies comprising the BTS Control Committee for guiding the appropriate application of management tools and for compliance monitoring.

1.2.2 Elements of integrated pest management exist in all of the BTS interdiction programs, and the BTS Control Committee produced an overview document amending the 1996 BTS Control Plan (Integrated Pest Management Approaches to Preventing the Dispersal of the Brown Tree Snake and Controlling Snakes in Other Situations, Department of Interior, Office of Insular Affairs, September 1999). This very useful resource focuses principally on individual control methods. However, because no resources have been available to the cooperating civilian agencies for implementing comprehensive IPM programs, none of the agencies has written a plan or established a comprehensive IPM program.

1.2.3 Military bases have IPM programs and Environmental, Safety and Health (ES&H) Plans and Integrated Natural Resource Management Plans (INRMP), but the formal incorporation of BTS control into these plans was difficult to determine. Specific snake control and interdiction activities on military bases have largely been conducted by Wildlife Services with military oversight; this approach fosters idiosyncratic, site-specific tactics rather than a comprehensive approach.

1.2.4 Consideration of BTS control as part of the engineering and construction at ports, airports, and military bases has been inconsistent; the extensive available information is not being fully utilized or may be unfamiliar to engineering personnel or contractors.

## **Recommendations**

1.2.5 Site-specific IPM plans should be developed and maintained for all areas presenting high-risk for snake export. The IPM approach, incorporating the standard elements of objectives, site description, control actions, timing, monitoring, and review can be used to incorporate developing technologies into snake control programs. Each land management agency needs to prepare such a plan and identify sufficient funds to carry out critical routine functions so that deviations from the norm (for example, periodic typhoons or military exercises) can be accommodated without putting personnel into a crisis mode.

1.2.6 Encourage use of IPM by the cargo industry through training, outreach programs, and regulatory mechanisms where appropriate, recognizing that the costs for funding such programs are a primary issue.

1.2.7 Incorporate BTS control efforts prominently in base IPM and ES&H programs and INRMPS, and review those existing programs/plans to ensure a holistic approach and up-to-date administrative and control measures. Control efforts must include the base housing areas as well as airfields, warehouses, and other operational facilities. Long range plans for military infrastructure development on Guam should be examined periodically as part of the planning

process, to assure that appropriate site-specific BTS control measures are applied in the context of long-term land use.

1.2.8 Prioritize the incorporation of engineering and construction methods that help control and mitigate BTS risk, especially for all new construction and facility expansions. BTS management should be addressed in all environmental assessments and evaluations. Infrastructure investments, though costly initially, should help reduce costs of other program elements over time. This should result in more effective risk management overall and, eventually, surplus resources that might be re-directed to other program elements.

### **1.3 Current and Future Dog Programs**

#### **Observations**

1.3.1 Wildlife Services conducts dog inspections at commercial shipping facilities, at the commercial port and airport, and at military facilities. The dog housing facility is provided at no cost by Andersen Air Force Base. The dog program is arguably the most important effort for snake interdiction on Guam. However, because personnel and cooperating agencies recognize that dog inspections cannot achieve 100% snake interdiction because of the nature of cargo and airplane configuration, the program is planned and operated as one component of an IPM program. This component of the program is well-organized and incorporates training for dog/handler teams, evaluation, and quality assurance.

1.3.2 Currently Wildlife Services is not able to operate dog inspection teams continuously, 24 hours a day, 7 days a week – meaning that some shipments and flights are not inspected. The problem is complex, involving the voluntary nature of inspections, limited personnel and funding for 24 hour work schedules, limited funding for dogs and training, and the uncertain availability of dog housing facilities from year to year. Through the dedicated efforts of program personnel, most of the periodic program gaps have been filled; however, the entire dog program is funded - by DOD and has not increased in 10 years. Considering the imminent expansion of military bases and activities on Guam, it will be impossible for Wildlife Services to keep up without a significant improvement in the funding base and annual adjustments.

1.3.3 Coordination and communication among dog programs in the Pacific areas is not consistent in validating training procedures and assuring notification of shipments that escape inspection when leaving Guam. New efforts undertaken by U.S. Geological Survey (USGS) contractors to develop dog-assisted search techniques in forested areas will add complexity to the dog program on Guam.

#### **Recommendations**

1.3.4 In light of the overriding importance of the dog program to the overall BTS interdiction effort, all of the cooperating agencies should focus on stabilizing funding, personnel support, and facilities to ensure that dog inspections will be continued for the foreseeable future. The cooperating agencies comprising the BTS Control Committee should consider mechanisms,

including legislation, to assure that all shipments are inspected. Because funding for dog inspections continues to be problematic, and because military personnel have advised the panel of the expectation that military funding might be restricted to on-base activities, it is critical that direct appropriations be a part of future efforts to stabilize the program.

1.3.5 A well-coordinated communication network needs to be maintained among all of the dog programs operating in different Pacific Basin areas. The communication network should assure that recipient sites are quickly informed of un-inspected flights or cargo. Frequent quality checks by supervisory personnel should assure that this communication network, however it is organized, operates at a high level of efficiency. USGS research leaders overseeing dog research should assure frequent interaction with the dog inspection program on the assumption that research will be successful and dog-assisted BTS searches in forested areas will be incorporated into operational programs.

1.3.6 Establish clear communication paths and periodic exchanges or shared training among dog programs. Quality assurance on Guam by Wildlife Services must be complemented by quality assurance in Hawaii. Results on both ends of the transportation pathway should be shared. All dog programs should function as part of a regional network for snake interdiction, rather than discrete, isolated units.

1.3.7 Facilities for dog housing and costs for dog care and maintenance are a particular concern; dogs must be healthy and fully able to perform at all times. DOD should construct and sustain a permanent dog facility at Andersen Air Force Base as a cost of base operations, with complementary support for dog trainers and handlers for civilian programs to be provided by other sources. Such a facility should have adequate space to anticipate the growth in military facilities and programs and the increased number of dogs likely to occur when techniques for searching forested areas with dogs in rapid response programs become operational.

## **1.4 Military Programs for Snake Interdiction on Guam**

### **Observations**

1.4.1 Operations budgets of military facilities could include line items for BTS interdiction to assure that these efforts are coordinated with the BTS Control Committee, that they are consistent with other Guam-based snake interdiction efforts, and that essential funds are available year by year. Institutionalizing comprehensive interdiction programs on military facilities in spite of frequent changes in command and military priorities will be difficult to achieve unless the need for continuing snake interdiction is articulated in these annual budgets.

1.4.2 Although military agencies have generally been extremely cooperative in organizing, funding, and conducting dog inspections of flights and shipments of cargo and materiel, there is a continuing need to assure compliance with required dog inspections. Historically, base commanders have been inconsistent in their view of the dog program. Some have provided enthusiastic support, others have viewed inspections as a nuisance to be avoided if possible. Several interviewees within and outside of the military recounted instances where BTS

inspections were aborted because military operations could not be delayed. Similar interruptions of BTS inspections may become more frequent if military operations increase in both frequency and urgency.

1.4.3 Wildlife Services on Guam has been appropriately used by military agencies as their agent for conducting most snake interdiction activities on military bases. These activities are supported both by direct funding and by provision of in-kind facilities and services. However, frequent changes in military planning and requirements make it difficult to maintain a well-coordinated program, particularly since specialized personnel are needed for some activities, especially dog inspections. Facilities and materials provided by bases are particularly subject to unpredictable changes or elimination without warning and military agencies must appreciate the difficulties such changes can cause in service delivery. Despite multiple inquiries, the panel had difficulty identifying points of contact for BTS issues at individual military bases on Guam.

## **Recommendations**

1.4.4 As major landholders on Guam, military agencies have management responsibilities to help assure snakes are not exported. To some degree, these responsibilities are incorporated into the National Environmental Policy Act (NEPA), the Endangered Species Act (ESA) and legislation related to the interdiction of invasive species. The agencies have recognized these responsibilities and have generally met them effectively, often through cooperation and coordination with resource management agencies working on other aspects of the BTS problem. However, BTS control activities are obviously not high on the military list of priorities, and the military agencies individually, and collectively through DOD, need to take the budgetary and planning actions necessary to assure that funding and support for snake control are stable and predictable from year to year and that military responsibility and commitment are not subject annually to interpretation and revision below the command level.

1.4.5 INRMPs should designate snake interdiction as an important issue, in accordance with the Sikes Act, and essential interdiction activities should be funded accordingly. Snake interdiction activities conducted by the military, as well as those conducted by other agencies, should be monitored and periodically reviewed by the interagency BTS Control Committee.

1.4.6 Dog inspection of all military flights and shipments should be recognized and institutionalized as an essential part of base operations at each facility. Inspection and compliance procedures should be stated in the environmental policies for each military facility on Guam. Each new base commander should be briefed on inspection requirements and should re-affirm compliance policy for the base to the appropriate office of the U.S. Fish and Wildlife Service (USFWS), consistent with the Sikes Act.

1.4.7 The panel's view, based on national invasive species policy and related legislation, is that risk of BTS invasions is part of the complex of national security issues. There is ample precedent for this view based on regulations related to agricultural pest inspections conducted by military agencies at considerable financial and logistic costs (e.g., washing vehicles to remove seeds, mud, and vegetation). Inspections for BTS, (and probably for other invasive species, need

to be incorporated into regular cargo shipping protocols used by the military as an essential part of base operations.

1.4.8 The panel noted that mandatory environmental management mechanisms, such as INRMPs, may be used to provide justification for committing funds to BTS inspections and for overcoming some of the bureaucratic difficulties we observed. Responsible personnel at both local and regional levels should be identified and assigned to monitor base compliance and to provide effective liaison with the cooperating agencies of the BTS Control Committee. Agencies must recognize that lapses in snake interdiction efforts are not acceptable and they must take the necessary steps to assure continuity and quality of all snake control and interdiction efforts on bases and on off-base military shipments.

## **1.5 Snake Capture Programs**

### **Observations**

1.5.1 These interdiction programs are highly labor-intensive and snake captures in the maintenance mode for interdiction are infrequent; however, snake trapping is at present the primary tool available for population suppression. The trapping teams on Guam understand their objective is to reduce the chances for dispersal of BTS into high-risk cargo areas by maintaining trapping buffer zones around perimeters of bases, airports, and seaports. This objective is clear, and not confused with the notion of affecting BTS populations. Buffer zones are maintained by an impressive and well-organized system of trapping and capture teams that work seven days each week. A total of 4,300 traps are currently maintained, each of which contains a live mouse cared for according to strict animal use protocols and a hand-made bait block and potato (as food and water sources for the mouse).

1.5.2 Many miles of chain-link fence are checked several nights weekly to remove snakes from military housing areas. The fence-line searches serve the purposes of reducing the number of human-snake encounters in the base housing areas and educating base occupants about BTS control, in addition to reducing the incidence of snakes entering household goods.

1.5.3 The snake capture programs are highly responsive to technological improvements in baits and traps, and considerable research has been conducted and published to document these improvements. At present, Konjac-based blocks (a starch gel food product) are currently being tested on a small scale and show promise as an efficient food and water source for mice. In addition, much work was done to improve and test trapping efficiency and to make traps more practical to check and service; Wildlife Services personnel are generally satisfied with the double-funnel traps. Further technological developments to reduce the labor and costs of trapping are impeded by a lack of funds; development of snake attractants in particular is viewed in all quarters as a critical research need.



## **Recommendations**

1.5.4 Continuation of the trapping and fence search programs are of critical importance to the overall interdiction efforts. It is especially important that these programs not be interrupted once a maintenance mode is achieved in a locale, since re-invasion and re-establishment of snakes can occur quickly in small areas that provide suitable habitat and food resources. Periodic reassessment is also important, however, because ecological factors may influence population changes or snake activity. Such assessments currently are (and should remain) a routine part of the interdiction programs.

1.5.5 Like most other research and management actions related to BTS control efforts, stable, predictable funding (appropriately adjusted to increases in personnel and material costs) is the key to maintaining the capture programs conducted by Wildlife Services and to gradually expand the areas of coverage. The agencies comprising the BTS Control Committee, individually and collectively, need to take the necessary actions to assure that funding for capture programs is maintained.

1.5.6 Labor-intensive snake capture programs should not be viewed as a permanent solution to snake interdiction and surveillance. Investments in new technology and research by the cooperating agencies are needed to ultimately reduce the labor costs associated with maintenance of BTS buffer zones. The cooperating agencies need to organize funding for research on snake attractants and other promising technologies that could enhance and expand population suppression or snake eradication efforts. New technology should be implemented as quickly as practical and funding projections should anticipate successful technology development and deployment.

1.5.7 Interdiction efforts should be planned, executed, and reviewed as dynamic efforts, not static programs, even though dynamic efforts will be much more difficult to manage. As new technologies, particularly toxicants and chemical sterilants become available, and as eradication strategies are engaged, applications should initially focus at and around high-risk sites, and then expand gradually. Trapping programs will be essential for assessing the effectiveness of these technologies as well as for continuing surveillance of areas where snake populations have been eradicated.

## **1.6 Use of Barriers for Snake Interdiction on Guam**

### **Observations**

1.6.1 Barriers to exclude snakes from areas have been researched carefully over many years and technology is available to construct both temporary and permanent snake-proof barriers. Barriers have use in isolating shipping and cargo areas and areas designated for wildlife restoration, containing un-inspected shipments, and ultimately in ensuring that an area cleared of snakes remains snake-free. Full implementation of existing barrier technologies would drastically reduce (not eliminate) the trapping and fence capture components of BTS-buffer zone maintenance. Barriers will be an important part of any systematic, landscape-level snake eradication strategy.

1.6.2 Although initial barrier construction costs are high, and there are maintenance and monitoring costs associated with barriers (weeding, repair, cleaning), the long-term benefits and cost reduction through time outweigh costs of maintaining leaky buffer zones using labor-intensive snake capture. There are, however, serious impediments to full implementation of barrier technology, including high initial cost, unique design features, high and essential maintenance needs, esthetics, resistance to typhoons, and changing land use patterns over time.

## **Recommendations**

1.6.3 The technology of BTS-proof barriers is well understood by the BTS Control Committee. The committee should consider how best to assist land management agencies, ports, airports, and shipping facilities to build snake barriers for interdiction. When fence construction is anticipated for other purposes (such as privacy or security), consideration should be given to the possibility that the additional cost of snake-proof construction may be warranted. Agencies planning barrier construction should consult experts for specifications on proven snake proof designs and use only those designs.

1.6.4 Barrier maintenance is especially critical in tropical areas because of year-round, rapid vegetation growth. While some opportunities exist to reduce the labor of barrier maintenance, agencies contemplating barrier installation should plan and budget for the continuing maintenance function.

1.6.5 Temporary barriers should not be used for more than a few weeks and should be removed upon task completion.

1.6.6 Continuing research efforts on barriers (and related snake behavior) should focus on improving barrier efficiency, lowering construction and implementation costs, and investigating the practicability of movable barriers for use during large-scale eradication efforts. Until recently, the high cost of prototype barrier construction has impeded research on this important snake-control tool, but because of its continuing importance, the cooperating agencies have identified funding sufficient for additional exploratory work.

1.6.7 The interagency BTS Control Committee should consider economic studies to model the relationship between costs of permanent barriers (amortized over extended periods) and labor-intensive interdiction programs conducted in perpetuity, recognizing that elements of both approaches may be needed in effective IPM programs.

## **1.7 Data Management and Mapping**

### **Observations**

1.7.1 The operational and research programs run by various agencies currently have limited capacity for technical planning, documentation of deliverables, and monitoring of landscape-scale control activities. Current BTS control activities are barely tracked and are maintained principally through off-time efforts of supervisory personnel. Military agencies, in particular,

are critical of the reporting efforts of the other cooperating agencies (although their own reports are also difficult to obtain).

## **Recommendations**

1.7.2 For snake management programs, Geographic Information System (GIS) and advanced data management systems may be applied to improve efficient tracking of current management efforts and as a valuable planning tool for snake eradication. Research personnel at the cooperating agency research institutions (USGS and the National Wildlife Research Center (NWRC)) could design and assess GIS and other data management systems in cooperation with operations personnel if funding were available. Such systems require oversight by information technology personnel and may entail substantial upfront costs as well as continuing costs for data input and for periodic software and system upgrades.

1.7.3 The interagency BTS Control Committee should consider how to put resources in place quickly to develop data management systems for current and future application, recognizing and planning for substantial development, support, and maintenance costs.

1.7.4 Although overall program coordination is discussed elsewhere, how data, results, and progress are reported among the cooperating agencies is critical. It is clearly inappropriate for managers to cross-question each others' integrity when the issue is really communication of information in a form that fits the expectations of different agencies. Establishment of a coordinator position for the BTS Control Committee could assist in providing easily interpreted data and information to the cooperating agencies and in resolving issues related to miscommunication.

## **1.8 Snake Problems Involving Power Generation, Transmission, and Delivery**

### **Observations**

1.8.1 Snake interference with power generation, transmission facilities, and infrastructure, evident since 1978, was a significant economic problem that cost millions of dollars in lost time, damaged equipment, and repairs. Along with the disappearance of birds, island-wide power outages were the original signals of the snake infestation on Guam. A variety of snake guards on power poles are visible in many areas. Although island-wide outages are less common today, snake-caused power outages take place roughly 200 times each year. According to power industry personnel, the long range plan of establishing underground transmission lines would greatly diminish the problem.

### **Recommendations**

1.8.2 The power industry has a substantial economic stake in addressing problems with its equipment caused by snakes or other factors. Since snake control methods and effective barrier systems are now available, the industry's principal short-term need is for continuing efforts to keep its personnel alert for snakes and snake-caused problems. Industry personnel were

enthusiastic about training personnel to be alert for snakes and coordinate with the Rapid Response Team efforts on Guam. The BTS Control Committee should certainly encourage such coordination and use the Guam program as a model for snake monitoring and coordination in other appropriate areas.

## **1.9 Transportation Industry Interdiction Programs and Coordination**

### **Observations**

1.9.1 Industry and agency personnel have cooperated successfully to streamline the process for voluntary inspections of flights and cargo, and industry support for the snake inspection programs appears to be excellent. However, there is continuing need for effective communication and assured compliance for inspections. Most of the managers we spoke with recognize that the system in place cannot be 100% effective, even with everyone's best efforts because of technology limitations and the fact that some shipments inadvertently leave Guam uninspected. The need for mandatory inspections to prevent snakes being exported from Guam seemed to be widely recognized by industry and port personnel.

1.9.2 Trapping efforts in place were functioning effectively at the numerous facilities we visited. However, some areas have nearby habitat (vegetation or stored material or both) that could harbor snakes.

### **Recommendations**

1.9.3 Further investigation of pathways for the movement of goods from Guam is needed to assess and adjust interdiction activities. Preliminary investigations were initiated some years ago and further work should be conducted in cooperation with the shipping industry. Document tracking systems (that already exist to some degree within the shipping industry) should be investigated for potential use as a means of monitoring shipments of goods through commercial channels. The workshop approach used by Wildlife Services to sensitize and educate industry employees to the critical nature of BTS interdiction and to provide guidelines and contacts tied to the Rapid Response Team efforts should be continued.

1.9.4 The Government of Guam and other government members of the interagency BTS Control Committee should consider regulatory mechanisms to require that all shipments are inspected. The most practical idea we heard was for destinations, particularly Hawaii, to require that shipments arriving from Guam be certified as inspected.

1.9.5 Storage and transfer facilities should have effective IPM programs, particularly for rodent control and weed control and other harborage reduction to minimize the potential food base and habitat for snakes. The Government of Guam should consider improved rodent control and harborage reduction programs, particularly in high-risk areas.

## **1.10 Coordination with Program Components Located Off Guam**

### **Observations**

1.10.1 Since it is recognized by all the coordinating agencies that some shipments, no matter how attentive the efforts, may leave Guam un-inspected, better communication is needed between Guam-based and recipient programs in areas that receive or transit shipments. Improvements likely can be achieved by full use of established networks, using the telephone and e-mail. Communication about shipments leaving Guam for Hawaii or Saipan is very good, and communication protocols are in place, through Wildlife Services on Guam. Attention to the wide spread of time zones across which shipments move and chronic limitations in personnel are needed to assure timely communication.

### **Recommendations**

1.10.2 Established communication networks should be documented for continuity and updated with new contacts as necessary. Responsible contact points and alternates should be identified and should function at all times, day and night. Managers should require and conduct periodic reviews to maintain network currency and effectiveness. Although funding may be a problem, periodic joint training (for example, Rapid Response and dog handler training) for Pacific Basin personnel participating in BTS interdiction programs should be planned and conducted. The interagency BTS Control Committee should consider how to coordinate communication needs in areas of BTS interdiction and control. For example, managers should continue to emphasize that un-inspected shipments should be treated as an emergency at the destination.

## **2.0 INTERDICTION OFF GUAM**

2.0.1 A combination of science-based techniques -- erection of barriers, trapping, use of detector dogs, fumigation of cargo -- currently reduces but does not eliminate opportunities for transport of BTS from Guam's airports and harbors. Guam is a key transportation hub for civilian and military traffic in the western Pacific, and individual snakes have traveled from Guam to as far away as Hawaii, Japan, Texas, Spain, and Diego Garcia. Efforts on Guam to keep BTS out of the transportation network comprise the single most important element of the overall program.

2.0.2 Many of the same science-based techniques are appropriate for use to detect BTS in potential recipient locations. Inspection of arrivals from Guam at ports-of-entry is essential to provide quality assurance and a crucial second line of defense against BTS invasion. A carefully coordinated system providing regulatory authority for mandatory inspections of goods leaving Guam is a closely related need. Other key program elements include an informed public that knows where, why, and how to report sightings of snakes, and local capacity for responding rapidly and effectively to such reports.

## **2.1 Regulatory and Enforcement Options**

### **Observations**

2.1.1 In response to the need for mandatory inspection of goods leaving Guam, planning for legislation to require pre-inspection prior to material arrival on Saipan is being pursued. In Hawaii, planning includes training dog handlers and conservation officers to have enforcement function parallel to quarantine officers.

2.1.2 Entities in Hawaii are evaluating potential legislation to require mandatory inspection of goods leaving Guam for import to or transit through Hawaii. A bill was introduced in the 2004 Hawaii State Legislature, authorizing the Hawaii Department of Agriculture “to restrict entry into the State of any articles originating from Guam that have not been inspected/certified by an appropriate agency, U.S. Department of Agriculture-Wildlife Services or other approved agency prior to shipment from Guam.” The bill was defeated in 2004. The State of Hawaii has recently funded a pilot study by Wildlife Services on Guam to assess the feasibility of a cargo certification program. The plan is to wait until the 2006 Hawaii legislative session when data is available from the pilot study to consider the legislation further.

2.1.3 Current BTS interdiction efforts may not take advantage of all existing regulations. Shipping regulations now require that a detailed electronic manifest be received at the United States port-of-entry at least 24 hours prior to arrival for all materials shipped from outside the United States, including Guam.

### **Recommendations**

2.1.4 Both Hawaii and Saipan should develop regulatory bases for requiring pre-clearance of shipped materials, and inform the Government of Guam about the progress of regulatory measures. Both Hawaii and the CNMI should sustain and expand current communication with Wildlife Services on Guam through development of standard operating procedures.

2.1.5 The BTS Control Committee should continue to provide information to Hawaii-based organizations (e.g., CGAPS and the island-based Invasive Species Committees (ISCs)), and to Hawaii state agencies and the shipping companies about proposed legislation to require mandatory inspection of goods leaving Guam.

2.1.6 To facilitate inspections for BTS interdiction, Federal agency leaders should assist State of Hawaii Department of Agriculture (HDOA) in gaining timely access to manifests that are required for all containers and materials shipped from Guam.

2.1.7 The BTS Control Committee should work with enforcement entities (port authorities, USFWS, U.S. Department of Homeland Security (DHS) and U.S. Department of Agriculture (USDA) inspectors, HDOA and Hawaii Department of Land and Natural Resources (HDLNR) to optimize the use of existing regulations for BTS interdiction and evaluate adequacy of resources for enforcement. All agencies concerned must recognize that legal requirement of inspections will be ineffective unless funds and personnel are provided to assure appropriate enforcement.

## **2.2 Integrated Pest Management**

### **Observations**

2.2.1 Some IPM principles are practiced at various ports and airports on and off Guam; great emphasis is placed on some elements (e.g., trapping) and less on the total suite of elements involved in IPM programs (administration, training, construction, maintenance, control tools, record keeping, monitoring, audits).

### **Recommendations**

2.2.2 Prepare IPM programs with written procedures tailored for each facility that receives materials from Guam and update these programs regularly. Identify at each facility one person responsible for the IPM program. Standardize procedures for implementing IPM programs and share lessons learned where feasible.

## **2.3 Barriers**

### **Observations**

2.3.1 Greater use of BTS barriers may be warranted in areas at high-risk for snake import from Guam. The recently constructed barrier for a cargo quarantine area at Saipan harbor provides a prototype. Funding was allocated in fiscal year 2004 (\$200K) through the USFWS to construct a barrier, still in the planning stages, in a designated site at the Tinian port. A barrier has been planned for Rota, but planning has been delayed by administrative issues.

### **Recommendations**

2.3.2 Researchers, operational personnel, and stakeholders should continue to refine efficient barrier and quarantine designs and should share lessons learned through the BTS Control Committee. Detailed drawings and specifications should be prepared for barrier construction and shared among the cooperating agencies. Written protocols for use of barriers in cargo quarantine should be developed based on the implementation experience gained on Saipan.

2.3.3 Criteria for barrier use at high-risk locations, particularly ports and airports, should be established. High-risk areas for snake import should be identified in the standardized criteria, and barrier designs should be recommended for use in these locations. Obstacles to construction of barriers on Tinian and other areas should be resolved.

## **2.4 Dog Programs**

### **Observations**

2.4.1 Hawaii has a major stake in preventing BTS infestation to protect the state's native wildlife and economic interests. However, because of Hawaii's heavy air and sea traffic, interdiction there is key to keeping snakes out of the Pacific-wide transportation network.

2.4.2 In June 2004, the panel was surprised to find that live BTS were not used for training dogs in Hawaii. The program was using frozen BTS for cuing dogs on the BTS scent, a highly questionable practice in our view. We also were concerned about reliability of dogs cross-trained to detect both agricultural products and snakes and the lack of monitoring data on BTS detection rates by the dog program in Hawaii. It may be difficult to obtain such data without use of live BTS in Hawaii. Although proven techniques now exist for producing healthy, sterilized male BTS outfitted with radiotransmitters, our understanding was that HDOA had not been using live snakes for at least two years. Later (in November 2004), we were pleased to learn that substantial progress was being made by HDOA to acquire live, sterile BTS for training dogs. Furthermore, the limitation on staffing the HDOA dog program that concerned us is being resolved by the addition of three dog handlers.

2.4.3 A dog inspection program is developing in the CNMI (on Saipan) using similar procedures employed by Wildlife Services on Guam. Live snakes are used in training. At the time of our visit to Saipan in June 2004, about 85-90% of cargo was being checked.

2.4.4 Research efforts are underway to investigate use of dogs for BTS searches in forested areas to support efforts of the Rapid Response Teams.

2.4.5 Better communication and coordination is needed among entities operating dog programs.

### **Recommendations**

2.4.6 HDOA needs to find a way to overcome obstacles to hiring an adequate number of inspectors and dog handlers and obtaining dogs necessary to provide inspection of incoming military and civilian cargo and passenger baggage from Guam. Agencies responsible for dog programs in Hawaii should include maintaining a stock of live BTS for training dogs and monitoring their performance. Sterile snakes for these purposes are available through USGS and Wildlife Services on Guam.

2.4.7 A quality assurance effort similar to those on Guam and Saipan should be implemented in Hawaii. This program would include teamwork, cooperation, and communication with other BTS dog programs. Hawaii should establish opportunities for joint training exercises with Wildlife Services and should maintain performance standards and written standard operating procedures for its dog program.



2.4.8 If the effectiveness of using detector dogs for BTS searches in forested areas is verified (which it likely will be, based on research elsewhere), the resources, personnel, and additional dog housing facilities should be secured to incorporate these surveys into the activities of the Rapid Response Teams.

## **2.5 Rapid Response and Surveillance**

### **Observations**

2.5.1 The rapid response component of BTS program, active on Guam and Saipan and in Hawaii, has made excellent progress in the past two to three years, and has begun training and organizational efforts in other archipelagoes in the Pacific Basin. The USGS Rapid Response program has conducted training throughout the Micronesia, including CNMI, Palau, Chuuk, Pohnpei, Kosrae, Kwajalein, Ebeye, and Majuro. They have provided special training of quarantine officers from Guam, CNMI, Federated States of Micronesia (FSM), and Palau. However, regional BTS monitoring is modest at best. Although the logistics and the number of personnel trained are limiting factors, cooperating personnel receive intensive training, and enthusiasm is high.

2.5.2 Rapid response actions and sightings are documented in incident reports and response times are substantially reduced by emphasizing training and public awareness. The creative campaign to increase public awareness and involvement in CNMI during 2003 appears to have been highly successful; the emphasis on rapid reporting of snake sightings by the public has helped reduce response times from 126 hours to two hours.

2.5.3 A major deficiency of the rapid response approach is the lack of refined technology for eradicating a small population of BTS on a recipient island once prevention and initial rapid response efforts have failed. Surveillance for individual snakes or small populations and monitoring of bird populations present a greater challenge than interdiction and rapid response for the State of Hawaii and for the CNMI.

### **Recommendations**

2.5.4 Continue to emphasize training and public awareness programs. Encourage broad participation in reporting snake sightings; train and utilize existing groups, such as conservation officers on Saipan, members of public, and private utility companies and pest management and horticulture professionals.

2.5.5 Expand the Pacific-wide rapid response capability for BTS as better detection techniques become available. Although Rapid Response Team members are intensively trained in spotting and hand-capturing snakes, the risk of snakes becoming established is so great that managers should consider adding low-powered firearms to the tools used by the teams and providing the necessary training for their safe and effective use.

2.5.6 Continue to establish and maintain centralized documentation and evaluation of rapid response efforts. Written standard operating procedures should be shared regionally and used consistently to the extent feasible. Encouraging competition among the teams in maintaining the lowest average response times might be valuable.

2.5.7 The newly emerging eradication technologies, particularly the snake toxicant acetaminophen, should be used to the extent possible as part of the rapid response effort. Other technologies currently being researched, particularly the use of search dogs, should become part of rapid response as quickly as practicable.

2.5.8 The exceptional value of public outreach to enlist community participation in detection of BTS has been established on Saipan. Saipan's program can serve as a model, though each vulnerable location will have its own needs and unique opportunities. For example, the individual island-based public relations efforts by Hawaii's five Island Invasive Species Committees may be better employed to raise public awareness of snake/BTS surveillance and monitoring.

2.5.9 The necessary resources for BTS monitoring, education, and rapid response on all islands where BTS may arrive (particularly on Saipan, Tinian and Rota) should be acquired and maintained, recognizing the importance of avian population monitoring as part of BTS surveillance. Long-term information on avian population changes and short-term observation of nest predation may aid in early detection of established snake populations and also further the understanding of avian population dynamics, conservation, and snake-related risks.

2.5.10 Monitoring and rapid response programs clearly need to function on a regional level. The need for broadening outreach efforts to stimulate detection of and timely response to snakes throughout the Pacific is obvious. Travel for outreach training to remote islands is expensive but warranted, and training trips may include identification of monitoring opportunities at individual locales. For example, the use of the harbor traffic list at the Port of Saipan may assist in identifying potentials for snake transport and could serve as a model for monitoring private marinas.

## **2.6 Communications and Planning**

### **Observations**

2.6.1 Excellent communication networks appear to be in place between Wildlife Services on Guam and CNMI Division of Fish and Wildlife (DFW) and Customs on Saipan. Communication about cargo inspections is shared, and protocols exist for dealing with the arrival of un-inspected cargo. Similar communication is needed between Guam and other ports of entry.

2.6.2 Because of uncertainty about the availability and amount of funding, long-term planning has been delayed in favor of annual proposals and reporting.

## **Recommendations**

2.6.3 As discussed in Section 1.10, a well-coordinated communication network needs to be established between Guam and all Pacific Islands with airports and seaports to assure that recipient sites are quickly informed of un-inspected flights or cargo on ships.

2.6.4 Long-term planning, particularly for Saipan, should be a part of the BTS regional planning effort. Long-term plans could help identify funding needs and, perhaps, help stabilize the funding process. The BTS Control Committee should coordinate the overall regional effort to ensure that the plans are updated and revised appropriately.

## **2.7 New Invasive Species Introductions Could Increase Prey Base**

### **Observations**

2.7.1 The establishment of new vertebrate or invertebrate species of the right body size and behavior could increase the BTS prey base. Research has shown that prey-rich environments can contribute to reduced success in trapping BTS. Abundant food supply is also likely to facilitate establishment of incipient BTS populations. Continued invasions of potential BTS prey species to islands are therefore of great concern. For example, non-native frog species on Guam have increased from three to eight since 2002. The breadth of issues related to invasive species is wide-ranging and should be considered holistically, taking into account shipping routes, ports of call, and pathways.

2.7.2 Although funds are currently not available, ongoing research and evaluation of other invasive species may be needed as part of containing and controlling BTS. As discussed in Section 4.0, other invasive species also may hamper restoration and remain a chronic concern even with the elimination of BTS. Traditionally, the international “plant quarantine” system places the burden of awareness and interdiction on recipient countries or territories. Recipient countries may strategically impose requirements for pre-departure inspections for critical pathways or shipments from infected areas.

### **Recommendations**

2.7.3 Because of the relevance of other invasive species problems, the BTS Control Committee should be proactive in encouraging improvement of invasive species management throughout the Pacific Basin, freely disseminating information about potential threats (for example, coqui and greenhouse frogs) and assisting in capacity-building for prevention efforts. Likewise, strengthening ties with existing Pacific regional programs that address invasive species issues, including the Secretariat of the Pacific Regional Environment Programme (SPREP-based in Samoa, [www.sprep.org](http://www.sprep.org)) and the Secretariat of the Pacific Community (SPC-based in Fiji, [www.spc.int](http://www.spc.int)) should be a priority.

2.7.4 Reduction of the alien BTS prey base and situations that could enhance it should be considered as an added objective during BTS interdiction efforts. Local production of native and

non-invasive non-native nursery plants should be encouraged, particularly on Guam, because local cultivation reduces the need for transport of nursery materials to Guam from highly-infested locations such as Hawaii and the Philippines. Amending the categories of injurious recognized by the USFWS to include reptiles and amphibians might be a useful adjunct to minimize introduction and establishment of frogs and lizards that might serve as BTS prey in Hawaii, CNMI, and other Pacific Basin areas.

### **3.0 BROWN TREESNAKE POPULATION CONTROL**

3.0.1 Understandably, most snake control efforts on Guam have been focused on the specific goal of snake interdiction to prevent dispersal to other Pacific Basin areas. On Saipan, other islands in the CNMI, and in Hawaii, efforts have focused on snake detection and prevention of snake introduction. The ultimate and overarching goal is broad-scale snake control or ideally, eradication. The topics of control and eradication are most pertinent to Guam because of its well-established snake population and the profound impact that BTS has had on Guam's wildlife -- extirpation or extinction of most native bird species.

3.0.2 Emerging threats exist on other islands, particularly Saipan, which has an incipient BTS population. Thus control and emergency eradication measures are important on this and on other islands in the Pacific region. If BTS becomes established elsewhere, the need for emergency measures to protect native birds and other wildlife will be urgent.

3.0.3 A clear and careful distinction between control and eradication is needed. Control could be defined as efforts to reduce snake populations to a level that limits localized and expanding risks or that allows some levels of avian populations to persist in the wild. Eradication could be defined as complete, or near complete, elimination of BTS from an island or part of an island where, for example, transport dispersal risks are high or restoration is planned.

3.0.4 The most immediate need for eradication technology and strategies actually may occur on an island other than Guam, if the existence of an established BTS population were to be confirmed. Immediate action may be needed to protect native birds and to prevent unchecked BTS population expansion within a newly colonized island or archipelago. Most importantly, colonization of new islands has the potential to provide opportunity for BTS to invade additional transportation networks, and thereby enhance the spread of BTS to other locations and increase regional risks and damage.

### **3.1 Planning for Landscape-scale Snake Population Reduction**

#### **Observations**

3.1.1 Major cost savings and re-orientation of interdiction efforts may be possible if local or island-wide snake eradication is achieved and maintained. The long-term goal of island-wide

eradication of BTS has scarcely been addressed. Although earlier planning documents made reference to snake population reduction over large areas, no specific planning exercises have been undertaken and budgetary needs for systematic, large-scale actions have not been assessed. The neglect of this area is somewhat understandable because the cooperating agencies were unable to make more than minimal year-to-year investments in the technologies that would make such programs possible.

3.1.2 Largely through grant funding to Wildlife Services and NWRC, a snake toxicant and a snake sterilant are nearing the stage where broad-scale implementation can be foreseen. In fact, the toxicant may now be used in concert with buffer zone maintenance in a pattern of expanding application. Unexpected termination of grant funding for this research may delay progress, but the data for Federal regulatory approval of field application of both materials are largely in place. Development of large-scale delivery systems is the principal task remaining to allow use of these materials to begin snake eradication or population suppression over large areas.

3.1.3 The strategy for staging a large-scale eradication program has not yet been developed. Research on control of small snakes, snake attractants, and delivery systems are most important for implementation of a large-scale and efficacious program. The delay in establishing capability for emergency eradication means that no contingency plans exist to address the expanding threat of snake establishment on Pacific Islands other than Guam. Costs and logistics of eradication on multiple islands would be significant, potentially many times more than for Guam alone. Long-term cost management thus would benefit from having emergency eradication capacity in place on high-risk islands as soon as possible.

## **Recommendations**

3.1.4 Wildlife Services, with the assistance of the other agency partners in the BTS Control Committee, should now begin use of acetaminophen to expand snake control efforts in areas considered high-risk for snake export. Obtaining funding for the research necessary to extend efforts to larger areas should be the highest priority.

3.1.5 After more than 20 years of BTS research and interdiction, virtually every control tactic with potential vertebrate application (including several with no proven basis of application on vertebrate species) has been explored. High priority for funding to develop application methods for toxicants and sterilants should now be the focus. The BTS Control Committee should at this stage resist proposals for work on unproven control tactics, such as biological control, that have no promise of timely application.

3.1.6 The BTS Control Committee should develop the procedures and sequence of events for localized and island-wide snake eradication. Planning for full implementation of new or developing technologies in eradication should proceed because eradication appears feasible and research efforts have been highly successful. Both short-term and long-term eradication goals should be defined.

3.1.7 Determine what further environmental assessment will be required by law for various types of eradication effort on Guam and what legal or administrative impediments might delay

emergency eradication efforts if snake populations were identified elsewhere. Ensure regulatory requirements are met to allow control and eradication projects to incorporate new technology for use of toxicants or sterilants as soon as they are available for practical application.

3.1.8 Economic assessment of the benefits of eradication and changing interdiction needs as snake eradication proceeds should be considered research activities and a part of ongoing management as work progresses. Prioritize early investment in eradication technology and plan development, because project costs will potentially soar in the future if delays continue.

## **3.2 Eradication Strategy**

### **Observations**

3.2.1 Some landscape-scale experiments using mouse/acetaminophen baits to reduce snake populations have shown success. However, delivery over large areas with diverse terrain and potentially dense vegetation presents a tremendous logistical problem. Snakes also are present in urban areas. Eradication is further complicated by limited knowledge of bait acceptance by small snakes or control of small snakes through alternative strategies.

3.2.2 An eradication effort may require use of temporary barriers as blocks of land are systematically reclaimed. Some temporary and permanent barrier designs have been developed and tested; an ongoing concern is the degree to which barriers are subject to weather impacts. Mapping and monitoring also will be needed for a successful eradication program.

3.2.3 Unresolved questions about snake survival and re-establishment in “clearance” areas are being addressed on a priority basis, albeit with limited funding, by USGS scientists. Awaiting the results of these long-term investigations should not delay initiation of expanding control efforts, but the need for close coordination among scientists and managers and rapid program adjustments based on new findings should be anticipated and planned.

3.2.4 Funding for planning and implementing an eradication program currently does not exist. Major cost savings and re-orientation of interdiction efforts may be possible if local or island-wide snake eradication is achieved and maintained.

### **Recommendations**

3.2.5 Initial eradication plans should expand from focal high-risk areas (such as transportation centers and military bases). Funding by the cooperating agencies should be devoted specifically to developing such a plan, and additional research should focus on rapid development of effective baits and delivery systems for tropical use. Projections should be made and updated annually, so that when the snake toxicant and snake sterilant technologies are fully available for large-scale use, they can be implemented immediately.

3.2.6 Conduct additional landscape-scale trials as technology is refined. Establish a team effort between USGS and NWRC researchers, to evaluate efficacy and population dynamics during

and following bait application. Make methods development a priority both for Guam and for other areas.

3.2.7 More resources are needed to advance bait delivery methods and systems planning by Wildlife Services. Significant developments in research by USGS in population measurement, detection, monitoring, and surveillance also are needed. The latter is critical because of the need to measure declining and small populations following bait application and to monitor for immigration. Thus research programs related to population measurement should be reinforced and supported.

3.2.8 Develop a strategy for systematic and sequential control (such as using a standard block mapping system, baiting, and block monitoring – similar to urban rat control procedures) with systematic transition of blocks from active to non-detect levels, beginning with one target area and progressing from there over several years. Recognize that logistical issues and habitat conditions are variable in Guam’s diverse landscapes, and tailor the baiting and monitoring activities accordingly. Work in urban or residential areas will require strong public interface and dedicated outreach personnel as part of the eradication plan. Include a schedule that could span 10-20 years.

3.2.9 Consider use of barrier systems as part of any eradication effort to reclaim and protect cleared areas. Identify the appropriate barrier system for that kind of application. Develop and use GIS as another tool needed as part of any large-scale eradication and monitoring program. Interdiction and control strategies and programs must be closely coordinated. These activities should also be closely coordinated with restoration planning.

3.2.10 Make funding available to implement a Guam BTS eradication plan as new technologies are refined. Full implementation of new or developing technologies for eradication programs should be planned recognizing that eradication appears to be a feasible, but a long-term, goal.

3.2.11 Emergency response capability is an immediate need off Guam, necessitating the availability of eradication methods and strategies now. Capability for emergency response includes baiting methods, teams, and various support for staging a field operation, and also requires skilled personnel for coordinating with local officials and the public. Such planning needs incorporate directly the Rapid Response Team effort.

#### **4.0 SPECIES AND ECOSYSTEM RESTORATION ON GUAM AND OTHER PACIFIC BASIN AREAS**

4.0.1 There are two overarching goals of the BTS work: (1) control and eradication to prevent further damage and minimize dispersal risk, and (2) adequate control so that restoration can occur one day and result in self-sustaining populations of some avian species. The topic of restoration is most pertinent to Guam because of the loss of species resulting from snake predation there.

4.0.2 Restoration of bird species or of particular ecosystems, if that is the course chosen, present special cases in relation to the overall BTS programs, since funding for such actions is not encompassed by the limited resources available for BTS interdiction and control efforts and since legal authorities and expertise reside principally with the USFWS and the Governments of Guam and CNMI.

4.0.3 BTS control or eradication is only one element needed in the overall restoration of endangered species. Habitat loss, quality, and restoration should be a primary concern along with the impacts from invasive species other than BTS. Personnel must be in place (for example, avian ecologists and possibly aviculturists) along with a separate funding base for restoration. Although restoration would be a separate program, it would need to be closely coordinated BTS control efforts.

## **4.1 Restoration Planning**

### **Observations**

4.1.1 Recovery plans now exist for most of the Federally threatened or endangered species, and some bird populations have been maintained either in captivity or by specialized snake control efforts. However, neither the plans nor programs are focused on specific snake control actions that need to occur and have not generally accepted an assumption that snake control efforts can be successful in the foreseeable future, removing this major impediment to restoration.

4.1.2 Well-defined restoration goals, milestones, or the kind of long-term planning needed for a restoration program do not appear to exist. Limited reintroductions by the Government of Guam have occurred on a pilot scale, but without demonstrated long-term success. However, some valuable information on limiting factors and methods for reintroducing avian species was obtained in the process. For example, feral cats were found to be limiting for Guam rails (*Gallirallus owstoni*) following BTS control.

4.1.3 Planning for restoration does not appear to be linked or systematically integrated with BTS population and control research. Strong linkages will be needed so that, as technology and planning proceeds for large-scale eradication, restoration planning occurs in parallel.

4.1.4 As the habitats on Guam are further degraded by natural and anthropogenic factors, it will become increasingly difficult to restore bird populations. Biologists are generally aware of factors causing habitat degradation, but specific habitat studies are either limited or have not been conducted. Many research questions need to be addressed to support reintroduction planning. These include habitat requirements, habitat restoration needs, direct impacts by other invasive species (particularly rats and cats), impacts of ungulates on habitat, and possibly multiple aspects of population ecology and behavior for each avian species.



## **Recommendations**

4.1.5 Establish short-term and long-term plans, milestones, and research objectives to support restoration activities on Guam. Restoration goals must be clearly defined and actions properly planned in relation to each other; otherwise valuable funding resources may not be used effectively and reintroductions are likely to fail.

4.1.6 Recognize the need to consider multiple factors when planning restoration and conservation activities. Control measures for other invasive species (cats, rats, ungulates) will be needed. Most importantly, habitat quality and components should be evaluated before significant reintroductions are attempted. Local social and economic factors also must be considered as part of a holistic strategy. Biological information may need to be acquired through research in CNMI or elsewhere. Review of current long-range plans of land management agencies, particularly military agencies, for lands identified for restoration efforts will be important.

4.1.7 Separate funding initiatives are needed for restoration planning and BTS programs. Funding mechanisms available from Pittman-Robertson Act and ESA Section 6 may be potential sources for implementing recovery actions that are closely coordinated with snake control.

## **4.2 Restoration Strategy**

### **Observations**

4.2.1 A clear strategy is not yet in place for restoration on Guam, and substantial efforts will be required to define it in context of the BTS control and eradication strategy. Restoration goals can be described on a sliding scale from localized to island-wide reintroductions for one to multiple extirpated species. Species priorities need to be defined based on habitat, population dynamics (reproductive ecology), and thus potential for achieving self-sustaining populations. Resources needed for successful reintroduction programs currently are not available, but, likewise, no detailed determination of the resources required to phase in such programs have been made.

4.2.2 CNMI biologists have performed some avian population analyses that suggest long-term declines in some species over periods during which BTS was not believed to be present. Thus regional changes in avian populations may be occurring in some areas independent of BTS establishment. Such changes raise key questions about actions other than BTS control necessary for restoration. However, these population declines could also suggest that BTS establishment in such areas would exacerbate an existing problem, or, like the first 25 years that BTS was present on Guam, snakes are present but occur in small populations that hamper detection.

## **Recommendations**

4.2.3 Establish restoration goals and tight linkages to BTS control and eradication programs. The two programs should have parallel strategies with ongoing points of communication and integrated milestones where appropriate.

4.2.4 Develop control and eradication programs for multiple invasive species other than BTS, and implement those actions prior to the reintroduction of vulnerable species. In coordination with BTS research, conduct studies and acquire necessary biological information for reintroduction efforts. Prepare up-to-date recovery plans, and conduct alternative analyses as part of restoration planning; determine an appropriate level of effort and priorities for recovery planning. Evaluate habitat quality and determine management needs. Reintroduction actions should be ordered and timed according to these multiple factors and should be carefully coordinated with the sequences and timelines for BTS eradication efforts.

4.2.5 Some pilot studies to implement actions in recovery plans may be appropriate under controlled conditions, but the objectives of those studies should be clearly defined and based on prioritization. Priorities must consider the status of individual species in the region and the potential for successful reintroductions.

## **5.0 RESEARCH**

5.0.1 An integrated research program that linked with BTS control, interdiction, and eradication will continue to be central to the overall BTS mission. The BTS research program is based on Guam and in Fort Collins, Colorado, and is carried out by investigators from USGS Biological Resources Discipline (BRD), USDA NWRC, and Colorado State University (CSU). The USGS group consists of a single full-time senior scientist researcher, who oversees research assistants and co-advises post-doctoral researchers and graduate students hired through CSU. A research coordinator on Guam is also part of the USGS team. Several scientists and research assistants at the NWRC have worked on various BTS studies and on the regulatory aspects of BTS control methods development, but no permanent positions are dedicated to BTS research because of the uncertain funding. Unlike the USGS effort, no research facilities for NWRC are available on Guam. Thus, the only federal positions fully dedicated to BTS research are the USGS scientist and one full-time assistant supervised by the scientist. In addition to research carried out directly by USGS, CSU, and NWRC, research projects have been conducted at other universities and research institutions, mostly under contract from USGS.

5.0.2 The well-developed Fort Collins research facilities, the proximity of key researchers to each other, the links with CSU, and the legacy of a successful research program together indicate that the current BTS research infrastructure and geographic location should be maintained.

5.0.3 Research is coordinated jointly by the three Fort Collins entities, with formal and informal mechanisms for communication and feedback. Examples of coordination are annual

BTS Control Committee meetings, scientific meetings and seminars, visits by researchers to operations offices, and reciprocal help among researchers and operations personnel in the field. The research scientists at USGS and CSU form a natural research group, partly because the CSU scientist and students are supported by USGS (with funding provided by OIA). Research by this group is coordinated via weekly conference calls that include participants at all levels in Colorado and on Guam. Research ideas are reviewed through a standardized process and promising ideas that are consistent with the priorities established in the BTS Control Plan are developed as formal proposals.

5.0.4 Research carried out by personnel at NWRC has followed a strategic plan aimed at developing fumigants, repellents, trapping technology, toxicants, baits, and BTS attractants. Despite unpredictable and remarkably little funding, significant successes have been made on all these fronts, including Environmental Protection Agency (EPA) registration of acetaminophen as a BTS toxicant. The current principal researcher has worked with very limited funding, and a post-doctoral researcher (hired through CSU) is working with very limited year-to-year funding. Expertise in methods development (including chemists, economists, modelers) available at NWRC has not been used to its full potential due to lack of funding. Hence, NWRC has been unable to realize the goals of its BTS research program. Research on BTS eradication could advance more rapidly with permanent infrastructure for research on Guam that would be available for inter-agency use. The NWRC activities would be enhanced significantly with a research station on Guam and full-time staff working on BTS studies. To accomplish this, NWRC should determine the personnel necessary to accomplish its goals for BTS research.

5.0.5 All research into the BTS problem stems from priorities set in the 1996 BTS Control Plan, and the panel noted that essentially every item on the research agenda in the plan has been addressed. An impressive feature of the BTS research program is the exemplary record of published findings and rapid implementation of research by Wildlife Services and other operations personnel. A few examples of practices based on research results include use of detector dogs to inspect cargo, snake population monitoring and surveillance techniques, the development of Rapid Response Teams, several generations of improved traps, and development and testing of snake barriers. Conversely, some lines of research prescribed by the BTS Control Plan did not yield practical results were discontinued (e.g., lighting as a BTS repellent, various biological projects).

5.0.6 After more than two decades of applied research, BTS control efforts are poised for major success. However, without significant, consistent funding, the research program cannot complete the final steps to achieving that success. Additional scientists and support staff are needed. Current research needs include bait development and delivery, results from the closed population studies, and monitoring and capacity-building tools linked to the Rapid Response Teams.

## **5.1 Coordination and Planning**

### **Observations**

5.1.1 The research based in Fort Collins at NWRC, USGS, and CSU is well coordinated. There is ongoing interface and communication between researchers from all institutions and with Wildlife Services personnel on Guam based at the Guam National Wildlife Refuge. USGS research personnel have facilities and sufficient staff on Guam. NWRC research personnel may request use of the existing facilities on Guam, but they have limited staff for research.

5.1.2 USGS has a single research scientist with research and programmatic duties. This dilutes the focus of USGS research effort, despite the critical need to develop technologies. NWRC does not have senior research scientists dedicated to and responsible for BTS-related research, despite the clear need. The overall BTS research effort, which will continue for many years, would proceed more rapidly and efficiently if a field station were developed on Guam.

### **Recommendations**

5.1.3 Maintain Fort Collins as the national center for BTS research, with its unique combination of federal agency and university personnel at one location. The Invasive Species Building being constructed at the NWRC will be an excellent additional resource.

5.1.4 Continue the current system of communication and coordination for identifying research ideas and proposals used by USGS and CSU and develop mechanisms to fully integrate NWRC researchers into the planning and review processes. Continue and encourage activities such as BTS lunches and other informal and formal information-sharing meetings and seminars. As more funding becomes available, the importance of research coordination should be maintained. Some of the informal linkages that have developed among researchers and NWRC, CSU, and USGS should, at that stage, be formalized.

5.1.5 Substantially increase research funding for NWRC, especially given the immediate risk of BTS establishment outside Guam, for example Saipan and Hawaii. Establish a field station on Guam that could be used by NWRC researchers as well as by USGS and CSU workers now based at the Guam National Wildlife Refuge. Establish sustainable funding for research for both NWRC and USGS so that objectives and schedules can be set and long-term goals can be achieved.

5.1.6 The panel recommends increased administrative and programmatic support for senior researchers, so they can focus on designing and completing research. An additional full-time research scientist for BTS at USGS would be beneficial. Two research scientist positions at NWRC, dedicated to BTS methods development would be well-justified.

## **5.2 Tools and Methods Development**

### **Observations**

5.2.1 Promising BTS control technologies have not been pursued rapidly enough because of limited and unpredictable funding. Some research on bait and delivery systems has been conducted; such work is essential to successful use of both BTS toxicants and reproductive sterilants. However, the development and testing of bait and snake attractants needs to be completed before these tools can be used by Wildlife Services. Mouse attractants have shown the most promise for trapping and baiting efforts, but practical considerations limit their use in large-scale control operations. Landscape-scale experiments on toxicant delivery systems are constrained by lack of funding.

5.2.2 USGS has in the past funded investigation of biological control methods for BTS, and recent reviews of these activities have been conducted. The history of biological control efforts for vertebrate pests has provided no promise of successful use and there appears to be no prospect for real-time development of useful biological control technology for BTS.

### **Recommendations**

5.2.3 Adequate funding is needed now for research to provide tools and applications for control efforts, especially given emerging concerns on Saipan. Research on bait attractants and delivery systems should be vigorously pursued, as should large-scale bait delivery experiments. Planning the use of new control methods should go hand-in-hand with research programs, including strategies and schedules for application. The practical logistical aspects of bait delivery should be considered as part of bait and attractant research. Logistics are a key element of any large-scale field operation and advance planning could help reduce time invested in maintaining live mice in traps and could facilitate broadcast bait application as part of an eradication operation.

5.2.4 NWRC should be fully funded but not at the expense of USGS and CSU research programs. The panel strongly believes that the limited research dollars available are wisely directed and efficiently at priorities established in the BTS Control Plan. Reprogramming of the limited funds is not a viable way to accomplish essential research. New, stable, and predictable research funding is needed.

5.2.5 Further funding and investment of research energies in biological control is not recommended because of the lack of theoretical basis to indicate potential for success, the low likelihood of timely application if biological controls were developed, risks to other snake species elsewhere if control agents could not be contained, and the likely high cost of development when other appropriate technology is nearly in hand.

## **5.3 Monitoring and Surveillance**

### **Observations**

5.3.1 Excellent surveillance and monitoring methods and tools are needed to facilitate interdiction and eradication efforts. Research on detecting incipient BTS populations and monitoring declining avian populations depends on integrative research projects. An example of one such project currently underway is the “closed population project” (CPP) established in a large enclosure on Guam by USGS and CSU personnel.

5.3.2 Research now underway on the use of detector dog teams to search forested habitats will likely refine an important surveillance and detection tool, both for monitoring and for rapid response work.

### **Recommendations**

5.3.3 Detection and surveillance methods are essential for interdiction, rapid response, and especially future control efforts. In particular, methods for detection and surveillance of small and incipient BTS populations need to be further developed and implemented and the existing surveillance methods need validation.

5.3.4 High priority should be placed on the current CPP to gain preliminary insights on several related questions on snake behavior, detection, and monitoring. As results become available, new studies will be needed to validate emerging surveillance techniques and to examine and refine existing techniques for field use. Planning should take place now for the necessary large-scale field studies, recognizing the development of such studies will depend on the results of current work.

5.3.5 High priority should be placed on developing detector dog technology to assist with capture of snakes in forested areas where snakes occur at low levels. Plans should be made for implementing this approach, including acquiring housing, hiring dog handlers, and training dogs.

## **5.4 Critical Ecological and Exploratory Research**

### **Observations**

5.4.1 Results to date indicate that more research is needed on several aspects of BTS behavior, life history, and population biology. New potential prey species for BTS have been introduced to Guam and elsewhere, particularly small frogs on Guam and Hawaii, and the implications of these introductions must be examined. Key ecological information is lacking about BTS, for example, the abundance and distribution of small snakes and the occurrence of their nesting habitat. These gaps in ecological knowledge bear directly on development and application of control methods. Trapping results indicate some, but not all, snakes larger than a certain size are easily trapped. Small snakes are not readily trapped in proportion to their abundance. Prey-rich environments have much lower trapping success. Successful snake control efforts may also

affect populations of other alien predators, such as rats and cats, that could affect avian restoration efforts.

## **Recommendations**

5.4.2 Research is needed to determine nesting habits, nesting habitats, and occurrence of small snakes. Research is also needed to determine why certain demographic groups of BTS, such as juveniles and gravid females, are resistant to trapping. The implications of prey-rich environments for the effectiveness of bait applications should be investigated to support development of baiting strategies. Rapid exchange of information is needed among researchers and managers that are working on potential prey species for BTS in the Pacific Basin and this exchange could be coordinated by the BTS Control Committee.

5.4.3 As research proceeds on vertebrate pest species that co-occur with BTS, the proposals for new science-based control approaches from diverse research institutions should be encouraged and should undergo review through the existing structures established by the BTS Control Committee.

5.4.4 The BTS Control Committee should continue to encourage research on techniques for rapid bait deployment for BTS control. Practical application methods and benign environmental affects should be prioritized in new research.

## **5.5 Technology Transfer from Research to Operations**

### **Observations**

5.5.1 The agencies comprising the BTS Control Committee want to be assured that technology moves rapidly from research to application and that researchers are fully responsive to feedback from operational personnel. Although the BTS coordination system works well, technology transfer currently is largely informal, based on collegial interactions at meetings, individual collaborations, or informal contacts of varying frequency.

### **Recommendations**

5.5.2 Consideration might be given to funding a full-time staff coordinator position (possibly within USFWS) for the BTS Control Committee to assist in the timely transfer of information from researchers to resource managers, to establish a filing system for committee documents, and to help avoid redundancy by the cooperating agencies.

5.6.3 With research managers and senior research personnel based in Fort Collins and operations managers based on Guam, in the CNMI, and in Hawaii, communications among these groups should be increased beyond the annual meetings sponsored by the BTS Control Committee.

## 6.0 FUNDING

6.0.1 The funding history of BTS research and control can be characterized as a grant-driven program, despite the scale and interdisciplinary nature of the problem. The original research that revealed that BTS was the culprit behind avian extirpations on Guam relied on temporary funding for avian disease research. The following years of research on BTS and the beginnings of control operations were funded by grants and contracts to individual researchers, largely from OIA. OIA continues to fund most of the research and many other BTS-related activities based on long-term relationships that have produced the high-quality results from the BTS program. In fiscal year 2005, OIA is providing approximately \$2.8M for research, operations, and education as follows:

- HDLNR = \$20,000
- CGAPS through the University of Hawaii = \$40,000
- NWRC = \$60,000
- HDOA = \$190,000
- USFWS = \$239,288 (CNMI staff support funded through USFWS and temporary USFWS staff support for BTS)
- GDAWR = \$250,000
- CNMI DLNR = \$295,000
- Wildlife Services (USDA Guam)= \$546,223
- USGS = \$1,160,000

6.0.2 The central role that OIA has played in funding BTS programs cannot be overstated. OIA recognized the threat of BTS invasions as a serious issue and had the flexibility and the capability to dedicate funds to specific objectives. Additionally, OIA is a small enough agency with broad enough aims that program managers can allocate funding without layers of bureaucracy that in other instances might dilute funding initiatives. OIA continues to fund BTS activities via an informed decision-making team that is deeply committed to the BTS problem. The success of the BTS program, despite its being underfunded, is largely due to the approach taken by individual champions. In short, OIA has relied on champions of the BTS problem to work within a relatively simplified bureaucracy to direct funding efficiently at the most urgent priorities.

6.0.3 Since about 1993, \$1,000,000/year has been appropriated for BTS in the DOD Health Affairs budget. These funds are not permanent, and not a standard part of DOD budgets. Although military funds pay for much of the operational work, particularly Wildlife Services on military lands on Guam, the amount of this annual funding has not increased or been adjusted for inflation.

6.0.4 The DOD Legacy Program has funded critical research carried out by NWRC. The Legacy Program has not previously provided funding for interdiction work, although in fiscal year 2005, \$389,000 was directed into Wildlife Services. In addition, the Navy and Andersen Air Force Base are providing \$250,000 each for BTS operations on Guam in fiscal year 2005. The panel was informed this was a “one-time fix”, and it is unclear what the budget situation for BTS operations on Guam will be in fiscal year 2006.



6.0.5 OIA has provided \$546,223 in fiscal year 2005 for interdiction efforts on Guam, targeting commercial cargo. The USFWS allocates about \$175,000/year to BTS-related activities, and USDA provided \$178,700 for fiscal year 2005.

6.0.6 BTS-related operations on Guam and elsewhere are currently strained to the fiscal limit, and survive on a year-to-year basis. The network of dedicated individuals that has helped secure annual funding for BTS has been successful, but no other mechanism exists to ensure future funding from OIA and DOD.

6.0.7 Despite the scope of the problem, and acknowledgment that BTS eradication would require more than a decade, dedicated personnel support for the entire BTS program is limited. Whatever agency employs them, most personnel are supported to do BTS-related work through funding from DOD, OIA, and the USDA directive that provides for the Hawaii program.

6.0.8 All entities interviewed by the panel were in agreement that controlling and eradicating BTS, not to mention restoring Guam's native fauna, will not happen without significant increases in funding. Significant funding challenges include: a mechanism for financing cargo inspections that takes into account increase in shipping over time; funding for research that is predictable and allows long-term development of landscape-scale control or eradication methods; open exchange of information about funding for BTS among different agencies during planning phases; and agencies' perceptions of BTS funding when so many other invasive species problems merit attention and funding. The Brown Tree Snake Act of 2004 was passed into law during the Panel Review. This act is an important step toward addressing these outstanding institutional needs; it authorizes funding for BTS programs that could result in important changes in the future.

## **6.1 Overview**

### **Observations**

6.1.1 There has been a piecemeal approach to funding, with annual shortages for proper program planning and execution. The BTS program funding has been based on short-term availability of funds, often during only parts of a fiscal year. Communication about funding among scientist and technical program personnel is often based on incorrect information and becomes confusing. There is no centralized reporting that facilitates tracking funds for BTS research and control. Budget tracking and decisions about allocation are performed principally by OIA in consultation with USFWS and USGS representatives.

### **Recommendations**

6.1.2 Establish significant and long-term financial resources based on clearly defined goals, schedules, and an integrated program. Budgeting needs to be projected over long periods (10 years or more) for effective planning; even minor annual inflationary costs become substantial over time.

6.1.3 Develop the budget tracking process to provide timely information and long-term summaries in relation to program priorities and goals. This will become especially important once appropriate funding levels are achieved.

6.1.4 BTS funding needs should be expressed as measurable tasks and expected results to facilitate acquisition of funding and understanding of program needs by funding entities. Senior managers must play a greater role in budgetary issues, in particular by obtaining base funding for the lead agencies.

## **6.2 Office of Insular Affairs**

### **Observations**

6.2.1 OIA has been the historic major source of funds for BTS research by USGS, and Territorial and State agencies. Funding by OIA in the near future may not reach past levels. The OIA grants program was moved to Honolulu in 2004. OIA distributes research dollars in consultation with USFWS and USGS staff. In recent years, OIA has played a key role in supplementing underfunded programs to maintain momentum or in assisting in start-up initiatives.

### **Recommendations**

6.2.2 Broad-based approaches to funding are needed to establish long-term program stability and to maximize the likelihood of BTS containment and eradication. If funding for a staff coordination position with the BTS Control Committee is made a priority, emphasis should be placed on defining and funding long-term goals, particularly to provide better coordination of funding for ecological and control methods research.

## **6.3 Department of Defense**

### **Observations**

6.3.1 DOD's primary mission is not to fund invasive species control or research. However, as a major landholder on Guam and a major source of transport of cargo and people in the Pacific Basin, DOD has played a key role in planning BTS control efforts on bases and has provided much of the funding for control methods development. The DOD agencies have operated their BTS programs primarily by passing grants or contract funds to other agencies. Since these funds are often not available at the beginning of the fiscal year because of the appropriation process, it is difficult for managers or researchers to maintain project continuity. It was unclear to the panel what internal attempts may be made by DOD to secure funding for BTS or to budget BTS work as part of operations and infrastructure planning.

## **Recommendations**

6.3.2 Permanent, sustained funding needs to be established to ensure sustainability of BTS programs that are necessary because of military activities. The operational costs to DOD of BTS control should be articulated and budgeted accordingly. The planning philosophy needs to shift to recognize that BTS control and interdiction costs are an ongoing part of the military presence on Guam and regional operations; BTS control and interdiction should be budgeted as a routine “cost of doing business” for DOD activities on Guam. To a degree, funding for BTS interdiction should be based on amount of military transportation, because increased activity means more demand for inspections.

6.3.3 Budgetary participation by DOD is essential for overall program execution and the DOD contributions to research funding have been essential for the progress achieved and control methods developed. Among the cooperating agencies, there should be better communication about the availability of funds, and funding initiatives in DOD programs.

## **6.4 U.S. Department of Agriculture**

### **Observations**

6.4.1 USDA Wildlife Services has been a key agency in conducting operational BTS interdiction and control and in developing BTS control methods. However, BTS control efforts have been conducted by Wildlife Services as cooperating programs; nearly all operational and research functions are funded by other agencies.

6.4.2 USDA has made very good use of available funds and has demonstrated a clear recognition of the need to support and increase funding for BTS to maintain effective field operations and to complete research tasks efficiently. Apparently numerous attempts to obtain funding for BTS through the USDA budgeting process have been unsuccessful.

### **Recommendations**

6.4.3 Managers of BTS programs should continue to seek commitment at the national level for invasive species control initiatives. Funding for Wildlife Services research and control efforts needs to be provided through the USDA budgetary process and should be incorporated into the base funding of the agency.

## **6.5 U.S. Geological Survey**

### **Observations**

6.5.1 The panel perceived what might be best described as an attitude that within USGS the BTS program is well funded. However, OIA funds the USGS brown treesnake research, and because this funding is provided year to year; there is no base funding in USGS. Many of the

USGS personnel apparently do not recognize the competitive, grant-driven nature of BTS funding.

6.5.2 The panel also learned that USGS has never attempted to develop funding initiatives to incorporate BTS program funding into the USGS budgetary base

### **Recommendations**

6.5.3 Perceptions about funding appear to be based on underfunding of other BTS efforts, rather than over-funding of USGS. Comprehensive budget development and tracking tools would help to balance immediate BTS program needs and long-term requirements. Budgets should be based on agency plans and tasks to support the BTS program and its goals. Communication should be improved within the agency about the availability of funds and funding initiatives that are needed.

## **6.6 U.S. Fish and Wildlife Service**

### **Observations**

6.6.1 About \$175,000/year is allocated by USFWS for BTS-related activities. Of this, about \$15,000/year is allocated to the North American BTS Control Team based at Texas A&M University. The website (<http://users.tamuk.edu/ksmah00/>) states that the groups' mission includes maintaining a website that posts current BTS information, development of educational material that can be downloaded, and development of guidelines for a Rapid Response Team that will be responsible for BTS investigating any potential BTS sightings in the continental United States.

6.6.2 Despite the availability of recovery plans for endangered species, efforts to restore endangered species on Guam are woefully underfunded. Most recovery plans acknowledge the need for more research before recovery efforts can proceed. BTS-related issues are a major issue, but not the only issue surrounding endangered species recovery.

### **Recommendations**

6.6.3 USFWS should make a commitment at the national level to invasive species research, interdiction, and control. Species restoration on Guam is feasible and should receive adequate funding from the agency.

6.6.4 The panel saw the use of funds for the North American BTS Control Team as largely redundant, focusing on maintaining an Internet website that duplicates better known and better presented efforts. Nonetheless, agency preparation to respond to continental introductions of BTS is appropriate.

## **6.7 Island Governments**

### **Observations**

6.7.1 Although the Government of Guam provides in-kind support to BTS programs, BTS activities are mostly funded through OIA. CNMI dedicates inspectors to BTS interdiction programs, but operates with very limited personnel and funding primarily from OIA and USFWS. The principle aims of island governments, restoration of fauna and eradication of BTS, are not sufficiently funded and will not be accomplished in the foreseeable future/any time soon.

### **Recommendations**

6.7.2 Insofar as BTS eradication and species restoration remain long-term goals of the island governments, it is prudent for them to establish independent funding for research, development, and planning to reach these goals. Naturally, these activities should be coordinated and integrated with all other BTS program aspects. In particular, the CNMI level of effort and funding should be evaluated as part of the BTS program, because BTS in the CNMI signal the emergence of regional BTS issues and the threat to wildlife outside Guam.

## **6.8 Transportation Industry**

### **Observations**

6.8.1 Currently, transportation carriers or owners of the materials being shipped are not charged a fee for BTS inspection. Discussions with industry personnel suggested a fee system might be feasible.

### **Recommendations**

6.8.2 The BTS Control Committee should work with the transportation industry to determine how support for BTS interdiction efforts might be integrated into ongoing quarantine functions, some of which are fee-supported.

## **7.0 EDUCATION AND AWARENESS**

7.0.1 Awareness is the cornerstone for moving the BTS program forward. Regulations and interdiction programs to prevent the spread of invasive species are obligatory, as is scientific research, but such efforts will fail without in-depth understanding, support, and involvement by all levels of society. Essential information on BTS, packaged and disseminated through public outreach and education programs, needs to reach and be thoroughly assimilated by all “stakeholders” -- school children, pilots, and dock workers, as well as politicians, military commanders, and regional and national policy makers. These and a host of other stakeholders

are the ones who will ultimately benefit from the protected or restored resources and reduced economic problems that will result from BTS control or eradication. No single approach to prevention or management of any invasive species will suffice, but enlightened self-interest in the local community is among the most important sources of support for such conservation projects.

7.0.2 The BTS program has already done a stellar job of informing the general public about the threat of BTS establishment. For example, in a recent survey by Hawaii's Coordinating Group on Alien Pest Species (CGAPS), 83% of citizens of Hawaii perceived BTS as a threat. Hawaii clearly excels in the frequency of media coverage of invasive species and BTS receives its share of attention. In an April 2004 cover story in *Hawaii Business*, "Unwanted Dead or Alive: How Invasive Species Could Kill Our Economy," David K. Choo offered this insight on BTS and public outreach: "For a little more than a decade, wildlife and conservation officials have been sounding the alarm in a series of increasingly compelling public information campaigns, which warn against the accidental or purposeful importation of such invasive species as the brown tree snake, the red imported fire ant and the biting sand fly, among others. However, while it has elevated the name recognition of several of these species, the campaigns haven't won the hearts and minds of the general public. The longer the brown tree snake isn't discovered slithering through a Hawaiian rain forest, the further it slides from the public consciousness."

7.0.3 Hawaii's CGAPS chose BTS as the slinking symbol for its inaugural "Silent Invasion" campaign for statewide invasive species awareness in 1996. So much is obviously at stake in terms of biodiversity, economics, and human quality of life with the BTS program, that its successes (or failures) will inevitably have a huge influence on other invasive species control programs worldwide. But without more than superficial understanding by the public and policy makers, support to sustain the BTS control program or any invasive species prevention and management program likely will remain inadequate and at risk.

## **7.1 Materials for Education and Awareness**

### **Observations**

7.1.1 Multiple organizations are participating in development and use of public education and outreach materials, and a variety of such materials exist. Many of them are very good, but there is room for improvement, especially in targeting materials to particular audiences.

7.1.2 Although not officially involved in the BTS Control Committee, the National Park Service (NPS) has enabling legislation that would allow it to assist with BTS prevention and management through its 1916 Organic Act: national parks are to be kept "unimpaired for the enjoyment of future generations." NPS has been a consistent leader in protection of native biological diversity in Hawaii for the past 35 years. The agency also has extensive contact with the public and significant expertise and experience in public education in the Pacific Basin related to preserving native biota and addressing the threats posed by invasive species.

7.1.3 There are numerous opportunities for use and distribution of educational and public awareness materials for BTS in Hawaii. The Nature Conservancy of Hawaii has been a leader, as have HDLNR and HDOA. Hawaii's CGAPS started BTS education as part of its "Silent Invasion" campaign in 1996 and has been highly successful in its public information efforts. Hawaii also has individual island-based Invasive Species Committees (ISCs) with field crews for eradication and containment of incipient invasive species. The ISCs have increasing capabilities for public education.

## **Recommendations**

7.1.4 Encourage production of BTS-specific educational materials for use in schools. One good model that could be developed further is the "Hoike Curriculum," currently in use in schools on Maui, Hawaii ([www.hear.org/hoike](http://www.hear.org/hoike)).

7.1.5 Invite the NPS to participate in the BTS Control Committee and associated efforts and to help the cooperating agencies to increase their education and outreach efforts, including production of educational materials, in Guam, Saipan, Hawaii, and American Samoa. Share documents, materials, and expertise among agencies to minimize development costs. Prioritize regional education on invasive species.

7.1.6 Encourage CGAPS in Hawaii to facilitate production of materials appropriate for outreach to employees of utility companies, landscaping firms, ports, and shippers, with the goal of early detection and effective response to BTS.

## **7.2 Brown Treesnake Information Available on the Internet**

### **Observations**

7.2.1 Anyone curious about BTS would have no problem finding abundant information on the Internet. There is excellent material on websites, especially those of USGS-Fort Collins Science Center, USDA Wildlife Services, and the National Invasive Species Council. Electronic availability exists for a broad range of detail from simple fact sheets to many articles from scientific journals. A search for information on BTS via [www.google.com](http://www.google.com) results in a huge number of "hits." The following sites currently are excellent resources:

[http://www.mesc.usgs.gov/resources/education/bts/bts\\_home.asp](http://www.mesc.usgs.gov/resources/education/bts/bts_home.asp)

<http://www.aphis.usda.gov/ws/btsproj.html>

<http://www.invasivespecies.gov/profiles/bts.shtml>

### **Recommendations**

7.2.2 The panel wishes to emphasize the importance of maintaining websites providing BTS information and keeping them accessible relevant; clearly agency funding is required to do this. The BTS Control Committee should review the availability, accuracy, and relevance of Internet-based materials annually.

## **7.3 Outreach to Achieve Public Support and Involvement in Early Detection**

### **Observations**

7.3.1 The USGS-led Rapid Response Team effort has pioneered the production of training materials and has helped build BTS knowledge and skills among agencies in vulnerable Pacific Basin areas.

7.3.2 An innovative, high-intensity outreach program on Saipan by CNMI DFW appears to be working exceptionally well at generating timely reports of snake sightings to responders. Radio announcements, outreach materials, information technology, and attracting corporate donors on Saipan are good examples of elements of a successful program. The program seems to have been substantially energized over the past two to three years with such innovations as the “snake trucks,” the Verizon “28-snake” Hotline, the “Don’t Give Snakes a Break” radio jingle and associated bumper stickers, and the dramatic reduction in response times for snake sightings. The Saipan program is a model for invasive species outreach in general.

7.3.3 The panel noted unexploited opportunities for strategic outreach aimed at people engaged in activities where BTS may be encountered. For example, field employees at utility companies and landscaping firms are among those likely to see snakes. Personal yachts and fishing boats as well as the commercial transportation industry, can be possible carriers of BTS. Small fishing boats are sometimes contracted to carry supplies or cargo from Guam to Saipan or other islands in the CNMI. The potential movement of BTS by privately-owned craft is a valid concern that could be addressed by increasing public awareness.

7.3.4 The panel was impressed by the knowledgeable leadership and strategic planning efforts of the HDLNR; however, only \$200,000 of the \$4 million appropriated by the Hawaii Legislature for invasive species issues in 2005 was allocated to outreach and education.

7.3.5 Wildlife Services is broadly aiding at ports and airports with outreach and planning. Their outreach efforts to the commercial transport industry on Guam seemed excellent. The panel attended an exceptionally well-organized workshop for shipping company personnel in June 2004. Such sessions are needed in all potential recipient areas as well.

### **Recommendations**

7.3.6 The panel stresses the exceptional value of public outreach for enlisting local citizens in BTS detection. The BTS Rapid Response program depends so much on snake detection and timely reporting by citizens that it might be renamed the “Rapid Response and Outreach” program. The Saipan program provides a good model, but each vulnerable location will have its own needs.

7.3.7 The responsible coordinators in each agency and the BTS Control Committee should continue to seek new ideas and opportunities for marketing educational messages, sharing ideas with counterparts throughout the Pacific Basin. Development costs and redundancy could be minimized through information sharing.



7.3.8 Work towards sustained accountability and actions by the port operators, where feasible, thereby helping to reduce long-term dependency on Wildlife Services' limited resources. Emphasize outreach to private industry, marinas, and the public involved with transporting goods and materials or operating pleasure craft or fishing boats among islands. For example, improved communication with Guam's commercial fishing industry might be achieved by working with the international companies that own many of the boats.

7.3.9 The State of Hawaii should continue its efforts to establish funding for invasive species outreach and should continue to work on increasing public involvement in awareness of and action on invasive species problems, including BTS.

## **7.4 Building Local Capacity for Brown Treesnake Control**

### **Observations**

7.4.1 The Pacific Islands generally lack capacity for involving local citizens in programs of biodiversity protection and invasive species prevention and management. CNMI and Guam, especially, have a huge need for local expertise in ecology, conservation and restoration biology, and quarantine, relevant to the BTS program. It is important to spark the interest of students in conservation at an early age, provide mentoring and programs/courses in natural science and conservation in the local colleges and university, and target qualified members of local community when recruiting for the increasing number of BTS-related jobs. The greatest need is for getting locally-educated "role models" into supervisory and research positions.

### **Recommendations**

7.4.2 Nurture university involvement and student interest in BTS-related employment, especially on Guam, where employment opportunities currently exist and are likely to exist in the future. Local universities need to find opportunities for student development and devise courses in applied ecology and conservation biology to enhance the local capacity for fulfilling agency and private sector needs for knowledgeable personnel.

7.4.3 The BTS Control Committee and its cooperating agencies should continue to develop relationships with government leaders and universities, establishing mentoring programs and collaborative research where feasible. Opportunities for grant funding (for example, National Science Foundation Development Grants) should be sought for local capacity building without taking funds earmarked for BTS operations and research.

## **7.5 Training for Brown Treesnake Program Personnel**

### **Observations**

7.5.1 The need for training was a common theme expressed among many of the individuals the panel contacted. Expressed needs included control methods information, joint training exercises, and increased information exchange. Information sharing among professionals -- such as at technical meetings -- helps build a knowledge base. It is important to expand the technical knowledge base because of the limited number of technical people with program or research knowledge and experience. However, general technical meetings for research and natural resources management professionals often occur at mainland sites and opportunities for BTS personnel to attend are limited.

7.5.2 It is essential to recognize that the BTS control effort will be a long-term endeavor with evolving technology; new, skilled employees and continuing education for existing personnel will be required in the years ahead. Given the limited recruitment pools in program areas, the BTS program clearly must organize their own in-house training programs as needed.

### **Recommendations**

7.5.3 The cooperating agencies should include training in ongoing program implementation and improvement. The technical knowledge held by relatively few individuals needs to be maintained over time, given the anticipated duration of BTS management and control work. Incorporate lessons learned and information sharing in training and develop improvements over time. This is particularly important for organizations that have similar responsibilities and related issues. Coordination through the BTS Control Committee could help assure that training is recognized as an important part of future program management.

## **8.0 PROGRAM MANAGEMENT**

8.0.1 Numerous and diverse stakeholders are directly involved in the planning and implementation of BTS control programs. Government agencies (USFWS, USDA, U.S. Air Force, U.S. Navy, State of Hawaii, Government of Guam, CNMI Government), private sector components (particularly the transport industry), and the general public are all involved in some way. Each of these entities has a different style and means of operation and communication, and different priorities, leadership, and organizational structure.

8.0.2 This diversity among those involved with BTS control highlights the significance of and need for strong program management and organizational skills, partnerships, open communication, and interdisciplinary approaches. Not only must the BTS control effort be interdisciplinary, it also entails an interagency cooperative effort involving policy makers, wildlife managers, and scientists. Despite potential hurdles, the interdisciplinary and inter-

agency concept is established and should be nurtured and recognized as a model for invasive species management.

8.0.3 “Successful” invasive species generally have a life-history strategy that can result in rapid spread, resistance to control, and severe impacts within novel environments. Thus, program management must be equally aggressive and adaptable, with distinct actions and personnel roles defined to effectively counter that life-history strategy. Specifically, the program management methods and level of organizational support typical of most biological programs are not appropriate for invasive species and should be replaced with more decisive, aggressive, and rapidly executed actions. To accomplish this, managers that oversee BTS research and control efforts should practice the type of mission-directed project management used more commonly for emergency environmental remediation projects.

8.0.4 However, a number of management-related topics should be considered as BTS research and control programs continue to move forward. An issue as serious as BTS necessitates defined management systems with clear program ownership, accountability, structure, and integration. Funding concerns, described in a separate section of this report, are closely related to how this and similar programs should be organized and managed.

## **8.1 Leadership and Planning**

### **Observations**

8.1.1 The BTS problem has been addressed in legislation as part in the Non-indigenous Aquatic Nuisance Prevention and Control Act of 1990; thus the BTS Control Committee is authorized under the Aquatic Nuisance Species Task Force established under USFWS leadership. The BTS is only one among many terrestrial invasive species in the United States, yet no equivalent terrestrial task force or similar structure exists for these species. Overall management responsibility for BTS is thus buried within an inappropriate disciplinary group, making policy development more difficult for all concerned.

8.1.2 The involvement and participation of governmental organizations in addressing the BTS problem is positive. However, because of this interagency approach, true problem ownership, accountability, and management structure are difficult to define. This lack of definition clearly is one of the factors underlying the chronically unstable funding and reactionary planning for BTS control.

8.1.3 Broad-scale, long-range planning is performed largely through the interagency BTS Control Committee and cooperation has been good, dynamic, and interactive. The current BTS Control Plan was prepared by the committee in 1996 and amended in 1999. The committee has met annually, with staff support primarily provided by USFWS, to discuss progress on meeting objectives, share agency concerns, and discuss funding issues. A new five-year BTS Control Plan is being developed in 2005.

8.1.4 Much of the funding for BTS efforts and the overall view of strategy and program management have been organized through OIA and the sustained senior leadership and support provided have been critical to the successes of the program. The interest among top management of the other cooperating agencies over the past two decades has been highly variable. Funding for the cooperating agencies now is authorized through the Brown Tree Snake Act of 2004. Committed leadership and cooperation at all organizational levels will be critical to assure that the funds come into the agency budgets and to manage the program so that the efforts envisioned in the new BTS Control Plan succeed.

## **Recommendations**

8.1.5 Senior leadership is needed to set policies and obtain resources to implement the new BTS Control Plan. Policy makers and senior leadership across all the agencies and organizations involved in the effort should be more visible, and should actively track and proactively resolve constraints faced by field, research, and planning personnel. All agencies involved should achieve the same level of leadership commitment demonstrated by OIA.

8.1.6 Recognize that multi-agency and regional cooperation must be sustained and assured, without geographic or interagency differences becoming impediments to progress. Planning and participation should be based on sound science and policy. Policy-makers should consistently seek counsel from field and research personnel, so that policy and regulatory development is timely and appropriately worded and defined.

8.1.7 Each participating organization should begin shifting to a proactive work plan, integrated among agencies, and incorporating program management principles. This work plan would include defining short-term and long-term goals and mission, and making decisions about BTS interdiction, eradication, and species or ecosystem restoration. As part of that process, risk assessment and alternatives analysis should be used to help define priorities, milestones, and the path forward. Consideration should be given to the use of a centralized and comprehensive tracking system by the BTS Control Committee that would allow all agencies and senior managers to see the overall program status and the status of major, inter-related actions and milestones.

8.1.8 The BTS program should undergo periodic oversight review as part of continuous improvement and to help assure that program milestones are met or that constraints are recognized. In some cases this may involve a specialist to review or mentor a particular program aspect.

8.1.9 Although the next BTS Control Plan must, of necessity, focus on a five-year time frame, the agencies and their planners working through the BTS Control Committee must recognize that continuous snake interdiction in regional transport networks, snake eradication from all or parts of Guam, ongoing surveillance for new snake introductions, and restoration of avian species and habitats are efforts that may require decades of work to achieve and sustain. The new planning effort should proceed in this context of long-term accomplishment.

## **8.2 Coordination and Communication**

### **Observations**

8.2.1 Coordination among personnel and among agencies is critical to the success of the BTS program. A USFWS biologist currently facilitates program management and coordination and maintains communication linkages among the various program components. This individual apparently functions largely in a “volunteer” role, and demonstrates strong leadership qualities, commitment, and budgetary knowledge, but he has multiple other responsibilities that restrict the time available for the BTS issues.

8.2.2 The division of responsibility among agencies appears consistent with their primary missions. However, the role of the Government of Guam does not appear to be as clear or integrated in the overall BTS program as Guam personnel desire. In part, this may result from the turnover rate in professional staff within the Guam agencies.

8.2.3 Policy development for BTS-related issues at times has appeared fragmented and somewhat inconsistent among agencies. The principal policy initiatives have appeared to focus primarily on Guam and Hawaii rather than on the Pacific Basin as a whole. Direct communications among the personnel conducting program activities for the various agencies have largely overcome these deficiencies.

8.2.4 Wildlife Services personnel on Guam fulfill a major leadership role in the BTS program, particularly in interdiction efforts. Wildlife Services personnel have the vision, knowledge, and skill to lead any control and eradication programs. However, Wildlife Services has not obtained a commitment of support from USDA for snake control work and methods development research, seemingly because these programs must compete at the departmental level with programs that are more directly related to agriculture.

### **Recommendations**

8.2.5 The agencies should work to establish a full-time BTS program coordinator position to function as staff to the BTS Control Committee. This position would coordinate the planning of priorities, facilitate interagency communication to assure timely information sharing, coordinate and track schedule management for the committee, track funding related to function and assist in resolving budgetary concerns, and, most importantly, assist the committee and the cooperating agencies with policy development. A designated program coordinator would provide a stable and primary point of contact for BTS coordination that does not now exist and help ensure that the many interdisciplinary and interagency tasks are properly integrated and timed. Such a position would logically be within the USFWS, which now performs these functions informally.

8.2.6 Common goals exist among agencies and these should be affirmed through the new BTS Control Plan and interrelated work plans and objectives. The plan should also confirm and clarify the division of responsibilities among agencies for establishing priorities and critical milestones and for implementing actions. In most cases, responsibilities will be defined by existing organizational missions. However, by consolidating tasks or activities that may be

overlapping or redundant among agencies, greater efficiency in work and supervisory oversight may be achievable in some cases (for example, both USFWS and USGS fund BTS websites).

8.2.7 Greater emphasis should be placed on regional governmental and private industry involvement in BTS programs. Relationships will remain important among governmental agencies, but private sector stakeholders must clearly play a larger and long-term role in devising solutions and improving program function and efficiency. Effort is needed to better define and enhance the Government of Guam's participation, in partnership with other agencies, including resolving challenges that the Government of Guam faces in recruiting a herpetologist to help with program guidance.

8.2.8 Maintain greater program involvement at the senior management and policy levels of the cooperating agencies to assure an adequately funded, sustainable, and comprehensive program. Senior managers must assure that communication and partnership occurs laterally and vertically within their respective agencies and should establish lead points of contact for each agency or group functioning within the BTS Control Committee.

8.2.9 The committee should emphasize to USDA the importance of the BTS control work and methods development research conducted by Wildlife Services. The program clearly cannot function without the full participation of Wildlife Services, which serves as a primary coordination hub in operations. Efficiency requires that each agency provide a funding base for its own activities, even though some cooperative funding will need to be maintained for work with other agencies.

8.2.10 Given the critical role and the land management responsibilities of DOD agencies, high-level involvement and stabilized funding for BTS control actions in base operations budgets is essential, especially given the long-term military presence and infrastructure planning in the region.

### **8.3 Program Integration and Milestones**

#### **Observations**

8.3.1 Field and research personnel have made many positive and essential efforts to integrate various activities within the BTS program. Beyond the BTS Control Committee, these efforts appear to happen informally or are based on mutual necessity rather than a formalized process. However, systems management and integration are not sufficiently well established for a project such as this that requires aggressive and decisive action. Schedule dates are loosely provided in the BTS Control Plan, and schedules have not always been maintained. Furthermore, critical tasks and priorities are not firmly defined, integrated, and scheduled.

#### **Recommendations**

8.3.2 System integration should become a significant, centralized part of BTS program management. This means integrating and tracking priorities, schedules, and personnel resources

among agencies to maximize program momentum. Field biologists and research personnel should not be expected to become trained project managers, and the skills of agency management personnel and coordinators will be important as the program progresses. If the new five-year plan developed by the cooperating agencies in the BTS Control Committee includes defined goals, objectives, responsibilities, schedules, and milestones and high-level communication paths, this plan can help justify commitments within each agency of the funding, procedures, and program management needed to assure overall program efficiency and sustainability. For the new plan, the committee should attempt to develop a master schedule that integrates priorities and links tasks by various organizations; this will help with setting priorities, accountability, and inter-agency coordination. Schedules should help articulate how tasks by one agency support or facilitate tasks by other agencies – and demonstrate the need for integrated budget and senior management support.

8.3.3 Define, prioritize, and track tasks that are essential for significant forward progress. For BTS, at this time, there are multiple research topics that fall into the essential category. These include development of better detection and surveillance methods, the ecology and behavior of small snakes, and development of snake attractants, efficient bait formulations, and practical bait delivery systems. These tasks are the precursors to moving into full-scale population control operations, and thus are high priorities.

8.3.4 A central repository for all BTS documentation should be established, so information can be effectively shared, retained, and used. In some cases, particularly where data are used to support regulatory actions, document retention and archiving is required and NWRC and USGS have well-established systems. BTS control is a long-term effort, and past and current information may be of particular value to future research and management personnel. Document archiving also should help prevent redundancy of actions and costs when there is personnel turnover.

## **8.4 Human Resources**

### **Observations**

8.4.1 The operational programs, particularly those concerned with trapping and dog inspections, present a challenge to managers to maintain the necessary personnel trained and ready to conduct programs efficiently. In addition, supervision is constrained when supervisors are responsible for numerous staff in diverse operations. These problems were repeatedly emphasized to the Panel and in part reflect the tight, variable budgets on which the programs operate. The island settings also make employee recruitment and retention difficult.

8.4.2 Staffing issues ultimately are a result of the soft-money environment that changes annually and of increasing workloads with no commensurate increase in support. As programs grow more complex with the application of new technology and the expansion of snake control efforts to landscape-scale, these human resource problems will increasingly hinder the successful accomplishment of program objectives.

8.4.3 The Pacific Basin area, including Guam, offers a limited recruitment pool, particularly for technical personnel. High turnover in critical staff positions is common, and the total pool of knowledgeable and skilled personnel is relatively small. Frequent rotation of key military personnel that oversee base operations and wildlife management also is common, resulting in a chronic need to educate new base commanders and staff on BTS problems and programs and to establish new working relationships.

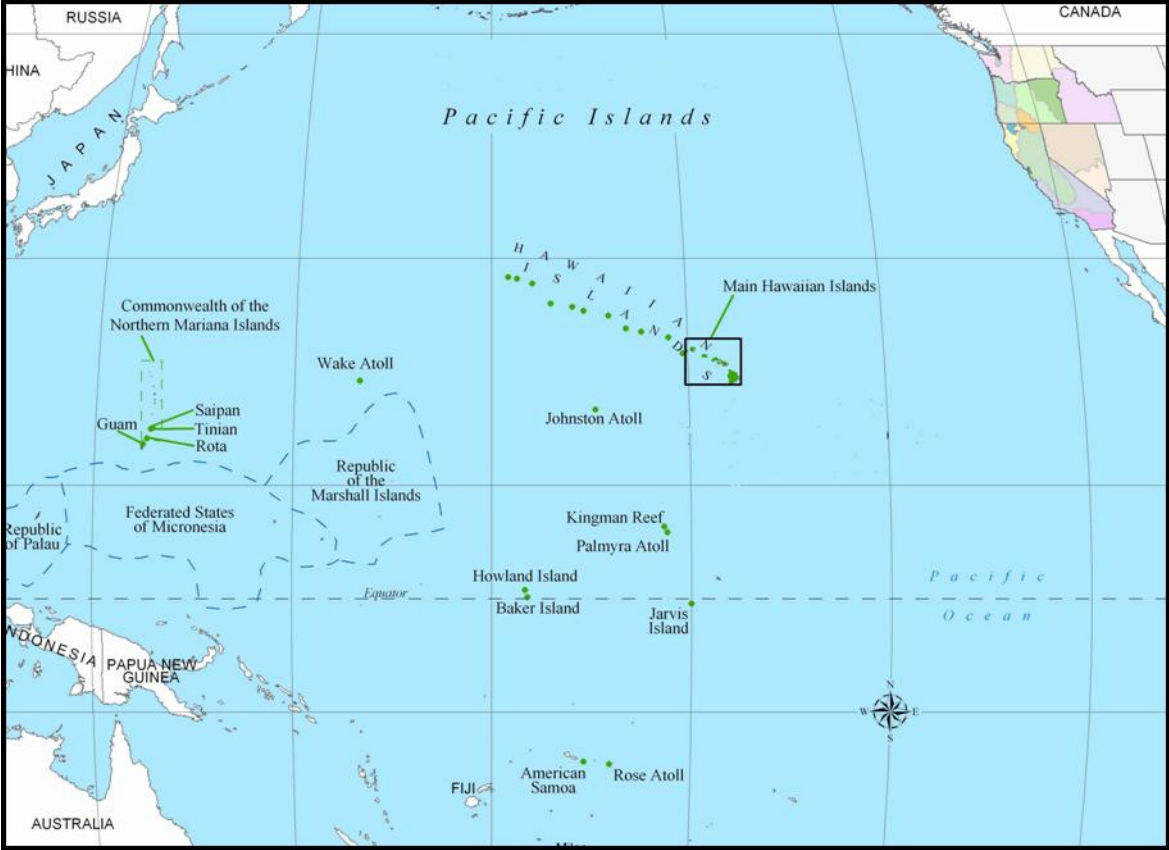
## **Recommendations**

8.4.4 Management of human resource issues in both the short and long term must be recognized by the agencies as high priority. A diverse and long-range staffing plan should be defined that maintains senior and supervisory involvement and appropriate employment conditions and compensation. The staffing plan must be based on stable, realistic funding for program progress, but also consider retention of staff with unique skills and abilities. In technical programs, supervision is a particularly critical feature of project or program groups, and agencies should aim to achieve a ratio of one supervisor for every five to seven staff positions.

8.4.5 Because the BTS program includes relatively few scientists and senior wildlife managers, and these often work independently at remote locations, loss of just one critical person – a senior researcher, for example – could be a major setback. This fact and the desirability for long-term commitment to the BTS program highlight the need to have training and career development available for scientific and technical personnel. This should include mentoring by more experienced staff, to ensure knowledge transfer and consistent program skills. Overall, the necessary infrastructure and materials needed to support staff positions should be put in place and carefully maintained.



Appendix A. Pacific Region Map



## Appendix B. Interview List of Public and Private Sectors

Ambyth Shipping Micronesia Inc., Saipan  
CNMI Department of Land and Natural Resources  
CNMI Department of Land and Natural Resources, Division of Fish and Wildlife, Saipan  
CNMI Department of Land and Natural Resources, Division of Fish and Wildlife, Tinian  
Colorado State University  
Commonwealth Ports Authority, Saipan  
Continental Micronesia, Guam  
Continental Micronesia, Saipan  
Department of Agriculture, Hawaii  
Department of Defense, Armed Forces Pest Management Board, Washington D.C.  
Department of Defense, Conservation Program, Washington D.C.  
Department of Interior, National Invasive Species Council, Washington D.C.  
DeWitt Moving and Storage, Guam  
Guam Department of Agriculture  
Guam Division of Aquatic and Wildlife Resources  
Guam International Airport Authority  
Guam Power Authority  
Guam Visitors Bureau  
Hawaii Department of Agriculture, Plant Quarantine Branch  
Hawaii Department of Land and Natural Resources  
Hawaii Department of Land and Natural Resources, Division of Forestry and Wildlife  
Hawaiian Electric Company, Inc.  
Marianas Steamship Agencies, Inc., Guam  
Matson Navigation Company, Guam  
National Park Services, Washington D.C.  
Office of Insular Affairs, Washington D.C.  
Office of Management and Budget, Washington D.C.  
Office of the Governor of Guam  
Port Authority of Guam  
U.S. Air Force, Guam  
U.S. Department of Agriculture, Wildlife Services, Guam  
U.S. Department of Agriculture, Wildlife Service, Hawaii  
U.S. Department of Agriculture, Wildlife Services, Washington D.C.  
U.S. Department of Agriculture, National Wildlife Research Center, Colorado  
U.S. Fish and Wildlife Service, Fisheries and Habitat, Branch of Invasive Species, Virginia  
U.S. Fish and Wildlife Service, Pacific Islands Office, Hawaii  
U.S. Fish and Wildlife Service, National Wildlife Refuge, Guam  
U.S. Fish and Wildlife Service, National Wildlife Refuges, Wildlife Resources Branch, Virginia  
U.S. Geological Survey, Biological Resources Discipline, Brown Treesnake Project, Guam  
U.S. Geological Survey, Biological Resources Discipline, Colorado  
U.S. Geological Survey, Biological Resources Discipline, Rapid Response Team, Guam  
U.S. Geological Survey, Biological Resources Discipline, Washington D.C.  
U.S. Navy, Guam

## Appendix C. Acronym List

APHIS - Animal and Plant Health Inspection Service  
BRD - Biological Resources Discipline  
BTS - Brown Treesnake  
CGAPS - Coordinating Group on Alien Pest Species  
CNMI - Commonwealth of the Northern Mariana Islands  
CNMI DFW - Commonwealth of the Northern Mariana Islands Division of Fish and Wildlife  
CNMI DLNR - Commonwealth of the Northern Mariana Islands Department of Land and Natural Resources  
CPP - closed population project  
CSU - Colorado State University  
DHS - U.S. Department of Homeland Security  
DOD - Department of Defense  
DOI - Department of Interior  
ES&H - Environmental, Safety, and Health  
ESA - Endangered Species Act  
FSM - Federated States of Micronesia  
GDAWR - Guam Department of Agriculture and Wildlife Resources  
GIS - Geographic Information System  
HDLNR - Hawaii Department of Land and Natural Resources  
HDOA - Hawaii Department of Agriculture  
INRMPS - Integrated Natural Resource Management Plans  
IPM - Integrated Pest Management  
ISCs - Invasive Species Committees  
NEPA - National Environmental Policy Act  
NGOs - Non-Governmental Organizations  
NPS - National Park Service  
NWRC - National Wildlife Research Center  
OIA - Office of Insular Affairs  
SPC - Secretariat for the Pacific Community  
SPREP - Secretariat for the Pacific Regional Environment Programme  
USDA - U.S. Department of Agriculture  
USFWS - U.S. Fish and Wildlife Service  
USGS - U.S. Geological Survey