THE POLITICS OF INVASION: DEFINING AND DEFENDING THE NATURAL, NATIVE AND LEGAL IN THE GALÁPAGOS ISLANDS OF ECUADOR

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A dissertation submitted to the faculty of the University of North Carolina at Chapel Hill in partial fulfillment of the requirements for the degree of Doctor of Philosophy in the Department of Geography.

Chapel Hill
2011

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Abstract

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The Politics of Invasion: Defining and Defending the Natural, Native and Legal in the Galápagos Islands of Ecuador
(Under the direction of Stephen J. Walsh)

This dissertation analyzes contemporary politics and practices designed to manage species invasions and human population impacts in the Galápagos Islands of Ecuador. Due to the high connectivity and movement of people around the world, non-native species are often introduced into protected areas, where human activity is also viewed as an 'invasion' into nature. In the Galápagos, population growth and more recently, tourism, have been linked to an increase in invasive species that pose threats to the local biodiversity. As a result, in 2007 Ecuadorian President Rafael Correa declared an ecological crisis in the islands, which continues to intensify with record tourist numbers (over 180,000 in 2009), a population growth rate of 6%, and new species introductions via air and sea.

Through the lens of political ecology, this research uses case studies to describe how invasion, writ large, is understood and experienced differently across stakeholder groups and the landscape. Remote sensing analysis of vegetation cover in an area of the Galápagos National Park that was invaded by feral goats shows landscape-level vegetation decline during the invasion, and regrowth following eradication, but not necessarily in areas where goats were heavily concentrated. The long-term environmental effects of large-scale eradication programs also call into question claims of ecosystem restoration, and naturalness itself.

Interviews among highland landowners and participation in land management practices show that the recent agricultural decline found on Isabela and Santa Cruz Islands is the result of interrelated environmental, economic and political factors, including species invasions, market instability, park-

only policies and labor shortages. Participatory remote sensing further illustrates that different highland user groups have divergent perceptions of landscape productivity and degradation due to invasive species.

Since the late 1990s, legislation has been implemented to control unlawful environmental behavior and illegal migration, but economic disparities perpetuate old tensions between residents of the islands and the Ecuadorian mainland. Cluster analysis of survey data finds that Galápagos residents have diverse stakes in island conservation and economic growth related to the booming tourism industry, while interviews among temporary and illegal migrants characterize the everyday vulnerability associated with migrant legal status in their own country.

Acknowledgments

I owe an immeasurable debt to those who participated in and contributed to the research for this dissertation.

I am grateful to members of the Isabela and Santa Cruz Island communities who generously shared their experiences with me. They invited me into their homes and their lives, feeding me, caring for me and teaching me their ways of knowing the islands. I would especially like to thank Felipe, Juana, Jose, Pedro, Javier, Carlos, Juan, Hernan, Homero, Efigenia, Mathias, Maria Teresa, Peter, Eliecer, Maria Elena, Raquel, Jack, Florencia, Marilyn, and Rubén. I thank Carlos Zapata and Martín Espinosa of FUNDAR-Galápagos for the opportunity to volunteer with the organization in 2010. Thank you to Paola Pozo, who was an always-helpful field contact, friend, and translator when my Spanish failed me. Peace Corps volunteers Nick Zetts and Kasia Jarmolowicz offered invaluable insights into island agriculture, while 'Gringo Jeff' Frazier and the Casa Rosada provided a tranquil oasis when stress caused me to forget my beautiful surroundings. Thank you also to Jeanette Warner, whose laughter and inspiring nature breathed new life into my fieldwork.

I am grateful to Wilson Cabrera, Fidelino Gaona and Unler Grefa who guided my trip to the Alcedo volcano in 2007, where their riotous sense of humor somehow compensated for the cold and damp surroundings. Thank you to Johannah Barry and Dr. Karl Campbell for their detailed descriptions of conservation project development. I thank David Arana of the Galápagos Inspection Quarantine Agency for his interest in my research and for giving me the opportunity to accompany him on very early morning inspections and patrols. Many more members of the Galápagos National Park Service, the Charles Darwin Research Station, and the Universidad San Francisco de Quito helped me compile information about introduced species, control and eradication protocols, and general management in the islands. I also thank the Charles Darwin Foundation, the Galápagos

National Institute and the Isabela and Santa Cruz Island municipal government offices for sharing their data and reports with me.

This research would not have been possible without the generous financial support provided by the Inter-American Foundation Grassroots Development Program, the Carolina Population Center, the Graduate School at the University of North Carolina, the Institute for the Study of the Americas and the Douglas Eyre Travel Fund. Thank you to Christiana Kasner for her confidence in my work.

I would also like to acknowledge the colleagues, friends and family members who have supported my work and research throughout the years.

I wish to thank my dissertation advisor and partner in the field, Dr. Stephen J. Walsh, for providing professional and personal guidance and opening up the Galápagos Islands to me. Dr. Wendy Wolford deserves special thanks for teaching me how to design a research project, tirelessly helping me develop my proposal and making me think critically about nature and geography. I thank Dr. Stephen Birdsall for exposing me to the multitude of relations between humans and the environment, however unconditioned and unexpected. I thank Dr. Peter White for his patience with my rudimentary knowledge of biology, and for showing me through Bob Dylan lyrics that nature is not always as natural as it seems. Dr. Ted Mouw deserves thanks for his insights into migration theory and the production of illegality as a parallel to invasion. I thank Dr. Elizabeth Havice for her optimism and for reminding me to believe in myself. Dr. Paul Robbins, Dr. Brendon Larson, Dr. Peter Wilshusen and Dr. John Browder also deserve thanks for engaging me in lively debates about invasion, parks and people. Special thanks to Amy McCleary, Julie Tuttle, Kim Engie, Leah Edwards, Evan Raczkowski, Heather Knorr, Liz Hennessy, Liza Guzman, Dr. Carlos Mena and Patricia Polo for their moral and logistical support. Thanks to Dr. Conghe Song, Dr. Benjamin Heumann and Phil McDaniel for their technical and analytical support. Thank you to Jan Hendrickson-Smith for so many home-cooked meals, and for always treating me like a scholar.

I would like to thank Barbara Taylor and Nell Phillips for their kindness and patience with a myriad of my scheduling, travel and general office requests. It has been an enormous pleasure to share their friendship, wit and bottomless candy jar.

Thank you to my parents, John and Resa Brewington, for their endless love and encouragement; and to my brother, Dr. John Brewington III, and his wife Lisa for endless joy and entertainment. Thank you to Herbert Kappel and Agatha Brewington for teaching me their strength and sharing their wisdom. I thank my aunt, Dr. Patricia Brewington, for giving me a home away from home and reminding me of the adventures in every day. Thank you to Dr. Gary Kappel and his wife Stephanie for showing me how to be a scholar and navigate academic life.

For all the late night talks and companionship I owe Brooke Millman, Dr. Jamie Perin, Lynda Curry, Chris Ketchie, Chris Allen, Dr. James Hull and Dr. Joseph Palis my deepest gratitude.

Before he was my husband, Michael Hauser listened to my proposals and learned about the Galápagos Islands so he would understand the place I chose to live and work over the next three years. I would like to thank him for his tireless patience, his partnership, his excellent cooking, and for his calm and certain nature.

This dissertation is dedicated to Wilda Jean Kappel, who passed away before she could read these words. She was always loving, generous and believed in me with every step that I have taken in life. Her faith compelled me to keep working and writing, and I could not have done this without her.

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Abbreviation	
CDF	Charles Darwin Foundation
CDRS	Charles Darwin Research Station
EVI	Enhanced Vegetation Index
IMA	Inter-institutional Management Authority
INEC	Ecuadorian Statistical Institute
INGALA	Galápagos National Institute
FUNDAR	Foundation for Alternative Responsible Development
GNP	Galápagos National Park
GNPS	Galápagos National Park Service
MAGAP	Ministry of Livestock, Agriculture and Fisheries
MODIS	Moderate Resolution Imaging Spectroradiometer
NOAA	National Oceanic and Atmospheric Administration
PMB	Participatory Management Board
SICGAL	Galápagos Inspection and Quarantine Agency, also Agrocalidad-Galápagos
UNESCO	United Nations Education, Scientific, and Cultural Organization
WHC	World Heritage Committee

Chapter 1: Introduction

Background

In his unpublished manuscript titled *Historia del Hombre en Galápagos* [History of Man in Galápagos], Isabela Island resident Jacinto Gordillo describes in detail the past 500 years of discovery, colonization, governance and conservation of the archipelago. When the former priest gave me the manuscript in 2008, his son Pablo was the Mayor of Isabela and in the midst of an indictment after he oversaw the destruction of a protected mangrove habitat in March 2007. A fisherman had provided video footage to the authorities that showed municipal employees cutting down 100 year-old mangroves while the Mayor defied the environmental police and the Ecuadorian Navy (O'Hearn-Giminez, personal communication 2007). Over tea in Don Jacinto's highland home we talked about his own half-century in the islands and the passion he developed for Galápagos conservation following his departure from the priesthood. Later, he led me through a garden he created to educate children and visitors about Isabela's native plants. We did not discuss his son, whose trial had fiercely divided the small port town of Puerto Villamil.

I draw on Don Jacinto's history, and his story, for two reasons. First, Galápagos scholarship has primarily focused on the archipelago's natural history, and rarely its human history.[1] The islands provided the foundation for Charles Darwin's theory of natural selection, earning them the distinction according to one book title as "The Islands that Changed the World" (Stewart 2007). By 2007 nearly 5,000 articles, theses, books and book chapters had been written about the islands, yet only 8% of

[1]A series of 'Galápagos Reports' published by the World Wildlife Fund and Fundación Natura (1998-2002) provided excellent social data for policy makers and researchers. Additionally, anthropologist Pablo Ospina's numerous publications (2001, 2003, 2005, 2006), as well as books and manuscripts written by geographer Christophe Grenier (2007), journalist Michael D'Orso (2002), Larson (2001), Gordillo (2000), Vanegas (1998), Woram (2005), Bassett (2009), Quiroga (2009) and Hennessy (2010) are notable and current exceptions.

those published in peer-reviewed journals were related to topics outside of the natural sciences (Santander et al. 2008). Tourists often arrive to the islands under the impression that they are uninhabited, knowing only what they read in guidebooks about the tragedies that befell early explorers and colonists. That only a fraction of the literature addresses the archipelago's human dimension entrenches the notion that the Galápagos remain untouched by mankind, in spite of centuries of extraction and habitation.

Second, the dichotomy between Don Jacinto's love of the unique environment and his son Pablo's apparent disrespect for it captures the tensions that exist today between Galápagos nature and humans. Humans have brought scores of plants, animals, insects and diseases previously unknown to the islands, altering ancient and isolated ecosystems. The fishing industry and, more recently, tourism have been linked to population pressures that directly or indirectly affect island biodiversity, creating a bridge that erodes the archipelago's isolation (Watkins and Cruz 2007). In spite of decades of policies to limit human development and environmental degradation, today there are twice as many introduced plants in Galápagos as there are native varieties, and the potential for new vertebrate and invertebrate arrivals increases with the demand for imported food and goods (Galápagos Conservancy 2010).

This dissertation investigates what I call 'the politics of invasion' through an analysis of knowledge production about Galápagos nature, the demarcation and management of a protected area by the Ecuadorian state, and legislation to control foreign species introductions and stabilize population growth. Throughout the twentieth century, conservation science-as-fact played an increasingly important role in Galápagos Island politics, producing spaces for humans and spaces for nature.[2] In the context of wilderness protection, international non-governmental organizations (NGOs) and government institutions have drawn physical, conceptual and territorial boundaries

[2]By the "production of space" I refer to the understanding, representation and control of space by individuals and institutions (Harvey 1990: 218-225).

around the human and non-human inhabitants of Galápagos, subjecting them to forms of governance inside spaces of enclosure and exclusion.

The geographical imaginary of Galápagos as a pristine, bounded space has also driven tourism beyond policy makers' wildest imaginations, eroding the very isolation in which it was formed. In spite of decades of regulation of people, plants and animals, the introduction of non-native species and undocumented human migration have continued to increase. These twin 'invasions' by human and non-human agents reached the international conservation arena on April 10, 2007, while an investigation against Mayor Gordillo's actions was underway. Ecuadorian President Rafael Correa announced that the islands were "facing crisis" due to the impacts of uncontrolled tourism, invasive introduced species and increasing population pressures, and one month later the thirty-first World Heritage Committee voted to place the Galápagos on the United Nations Educational, Scientific and Cultural Organization's (UNESCO) list of World Heritage Sites In Danger (UNESCO 2007). UNESCO's move highlighted the failure of institutions and NGOs to protect the islands from those threats in spite of decades of conservation practice: said Dan Rather in a 2008 special report, "It's poignant that a place that has been so historically important in our understanding of the natural world is under such great threat" (Dan Rather Reports 2008).

Finally, this research finds that recent conservation actions have unexpected (and unintended) consequences because the nature of invasion, writ large, often blurs the boundaries between pristine and degraded, native and non-native, or right and wrong. New relations between people, plants and animals in Galápagos call into question the utility of a management regime that is based on assumptions about ancient states. Whether or not it is intended, in the fight against very real environmental threats conservation NGOs and institutions have become the arbiters over everyday life in the islands. The goal of this research, therefore, is to inform future conservation measures that accurately reflect the roles of social and material agents in environmental change, instead of retreating to ideological absolutes.

In a 2010 interview the Director of the Charles Darwin Foundation (CDF), Gabriel Lopez, rightly concluded that, rather than focusing on the symptoms of the crisis, "What we need to address…are the causes – the *causes* – of environmental degradation." To understand environmental degradation in Galápagos through the lens of a politics of invasion, three questions are central to the study:

1) What are the processes of invasion, by plants, animals and people, in the contemporary Galápagos setting?

2) What institutions, interventions and regulations are in place to control or prevent these invasions?

3) How is the complexity of invasion revealed through environmental and social change, in the current context of crisis?

The argument is that in the absence of a long human presence and with the existence of strong institutional and research partnerships, environmental politics and their associated practices in Galápagos have gone largely unquestioned, particularly in the current discourse of crisis. In this dissertation, rather than taking invasion, by plants, animals and people, at face value I interrogate the complex relations that produce invasion using a variety of qualitative and quantitative methodologies. Achieving conservation goals in a populated protected area setting presents unique challenges and opportunities for innovative management, and this research demonstrates how a more nuanced conception of invasion can lead to new understandings about the ways that humans and nature coexist.

Study Site and Political Context

The Galápagos Islands emerged from the sea three to five million years ago, born out of the eruptions of deep ocean volcanoes (Grehan 2001). Situated just below the equator, the archipelago is 1,000 km off the coast of Ecuador in the Pacific Ocean, composed of 13 large islands and 100 smaller islands and islets that make up 7,880 km^2 of land, slightly larger than the state of Delaware (Figure 1.1). They sit atop the Nazca tectonic plate and move in a southeasterly direction toward the mainland

at a rate of three to four centimeters per year. Over time the oldest islands erode and sink beneath the surface of the sea.

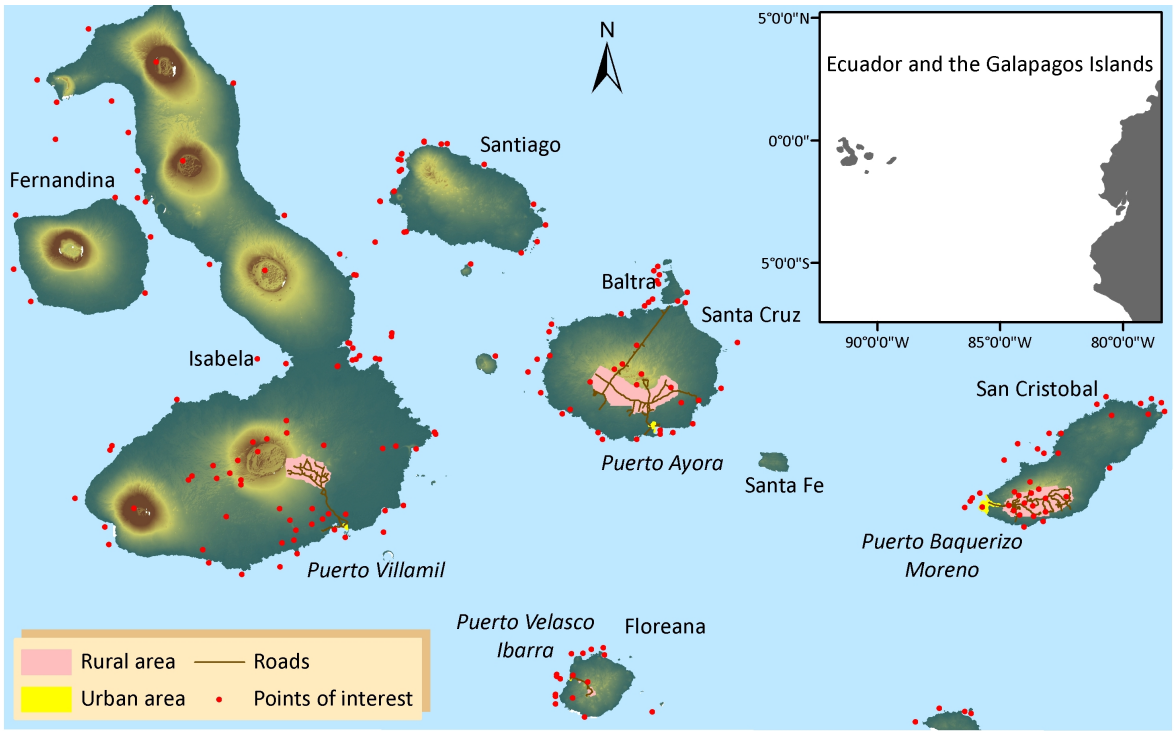

Figure 1.1. The central Galápagos archipelago relative to the Ecuadorian mainland. Urban areas are italicized.

The movements of the cold-water Humboldt and Cromwell currents and the warm-water Panama current combine with biannual shifts in the equatorial trade winds to create a warm, rainy season from January to June, followed by a cool, misty season from July to December. Each large island is characterized by an arid, coastal region that gradually slopes upward to the humid cone of one or more volcanoes (Mouginis-Mark et al. 1996). The archipelago's unusual flora and fauna are descended from South American specimens that traversed the long distance via wind and sea, but *Scalesia* forests, giant tortoises and blue-footed boobies would mean very little without the human history that lent them scientific importance.

Discovered by the Western world in 1535, plants, animals and invertebrates that arrived to Galápagos after that date are considered introduced. By Charles Darwin's famous visit 300 years

later, in fact, numerous species had already made their way to the islands on board pirate ships and whaling vessels that periodically sought refuge in the archipelago (Porter 1822; Mauchamp 1997). Some of these were more adaptable to the Galápagos climate than others, reproducing aggressively and out-competing native or endemic species, and became known as invasive. Among them are goats (*Capra hircus*), fruit-bearing guava trees (*Psidium gujyava*), and hill raspberry (*Rubus nivius*).

Since the late 1800s, an increased human presence in the Galápagos has paralleled growth in the number of non-native species. Of the more than 800 plant species in the islands that are non-native the majority were brought by early settlers who came to the islands in small numbers in the late 1800s and early 1900s, and the humid highlands of Santa Cruz, San Cristóbal, Isabela and Floreana Islands were transformed by agricultural production, as settlers raised livestock and grew crops on the rich volcanic soil. They also continued to introduce new fruits, vegetables, and animals (Tye 2006). At the advice of an American and European council, the Galápagos National Park (GNP) was created in 1959, enclosing 97% of the total land area in the archipelago (Grimwood and Snow 1966) and surrounding small urban and rural human-use zones on four islands. At the same time, the CDF and associated Charles Darwin Research Station (CDRS) were established to provide scientific support to the Galápagos National Park Service (GNPS). For the next two decades only a handful of settlers and scientists lived on the islands in designated human-use zones, and the islands became one of the first UESCO World Heritage Sites in 1979. But with the increased ease of international travel in the 1970s and 80s, commercial fishing and, more recently, tourism began to flourish in Galápagos, facilitating the human migration and introduction of non-native species that remain the top concerns for conservationists today (Watkins and Cruz 2007; Table 1.1).

Table 1.1. Parallel growth in the Galápagos human population and the number of introduced species.

		Plants	Birds	Reptiles	Mammals	Insects
Year	Humans	Number of Introduced Species				
1534	0	0	0	0	0	0
1800	> 100	-	0	0	2	-
1832	> 200	>10	0	0	5	-
1900	800	>50	1	1	7	<10
1970	3,000	100	5	3	7	>100
1990	9,000	400	6	4	7	>300
2001	18,810	800	10	4	13	490
2010	22,770	879	11	8	15	543

Sources: Vanegas 1998; INEC 1990; 2001; 2010; CDRS species database downloaded 12/2010

Economic growth throughout the latter half of the twentieth century dramatically altered the political and social settings in the islands. The 'gold rush' of sea cucumber and lobster fisheries led to over-harvests and violent conflicts between residents, migrants and policy makers, while the presence of a growing number of foreign guides and tourism investments took on the nature of a battle between resident 'insiders' and outsiders who residents feared were taking local jobs. As fisheries began to slow, tourism became the major economic means of survival for most island residents, and the rapid growth in that industry has required large increases in food, water, gasoline and other goods and supplies that come from the mainland. The sheer number of humans in the archipelago and associated introductions of plants, animals and diseases have pushed island resources to their limits. In 1998, following a threat by UNESCO to remove Galápagos from the World Heritage List due to concerns about development and migration, the Ecuadorian government passed the Special Law for the Conservation and Sustainable Development of the Galápagos Province. The complex set of 73 articles was the result of over 12 months of negotiations between government officials, conservation NGOs and Galápagos residents at a time of social and economic upheaval on the mainland, and attempted to bring together the many stakeholder visions and priorities for the archipelago's future.

Unfortunately, while the Special Law provided a legal framework for conservation and environmental management within the Galápagos archipelago, its implementation has been haphazard and inequitable. Educational reform promised by the Special law has been slow to come about, and rather than enroll their children in the foundering public school system many parents seek private offerings on Santa Cruz or San Cristóbal. Similarly, the tourism industry has resisted pressures to add fees and concessions that would benefit local communities, having been protected by outdated pricing structures that reflect foreign investments and interests. Municipal governance has been motivated by popular political platforms instead of seeking a streamlined path to sustainable development, keeping access to terrestrial and marine resources at the forefront of elections and debate.

Today there are at least 50 public and private institutions operating in Galápagos who have decision-making powers (and competing interests) that influence conservation values and policy. "Only some of these are tied into a centralized framework for decision making," write Watkins and Barry (unpublished manuscript, 2010), "and their presence creates satellite governing structures and frameworks in which decisions get made (and sometimes unmade)." As Poirine and Moyrand (2001) have shown, governance in geographically isolated or fractured territories has a tendency to become personalized. Given the complexity and relative power positions of politicians, scientists, NGOs and residents in the Galápagos Islands, it is not surprising that competing interests frequently arise. Instead of providing an exhaustive list, Blaikie's (1995: 208) framework is useful for grouping stakeholders useful in summarizing their general positions and sources of power, goals and influence (Table 1.2).

Table 1.2. Galápagos institutions and stakeholders.

Group	Position in political economy	Source of power	Interests and aims	Means to reach aims
Government organizations	Vertical structure, uneven access to tourism revenues, control over public works	Centralized Ecuadorian state	International funding and exchange	Laws and statutes, budgets
CDF/CDRS and researchers	Inform national policy, exert local influence	Science as legitimacy	International recognition, policy development	Publications, networking
International conservation NGOs	Represent prestigious global initiatives, legitimized by environmental value	Donor funding, government partnerships	Protection against biodiversity loss	National and international awareness campaigns
Galápagos residents	Varies: little to none (the poor, migrants) to significant (the wealthy, tourism operators)	Municipal representation, cooperatives and associations	Resource access, tourism development, goods and services	Varies: lobbying, poaching, voting, protests

At the level of the national government, the Environmental Ministry reports to the President, who also appoints the Governor of the Galápagos province. The Environmental Minister, in turn, appoints the Director of the GNPS. While a number of institutions influence decisions concerning the management of the GNP, the GNPS remains the sole institution that is mandated to manage the terrestrial and marine protected areas. Historically, the GNPS Director's position has been unstable, with an astonishing turnover of 12 Directors between 2004 and 2006 (Quiroga 2009). Since I began conducting fieldwork in the islands 2007 there have been four different Directors, prompting one resident's comment, "It does seem that we have a revolving door on the park Director's office." The Director is supported by around 20 managers and professionals who are involved in legal and technical planning, restoration, conservation, tourism management, education and administrative services. In 2009 the GNPS directory listed nearly 250 employees, making it one of the largest local employers in the archipelago, after the islands' municipalities and other government offices.

The GNPS is also responsible for invasive species control and eradication, alongside the Galápagos Inspection and Quarantine Agency (formerly SESA-SICGAL, now known as Agrocalidad-Galápagos) and the Ministry of Agriculture. Together they have achieved globally-recognized successes, including the eradication of pigs and goats from Santiago Island, the eradication of fire ants from Marchena Island, the eradication of rock doves and two species of invasive raspberry from Santa Cruz Island, and the eradication of cats from Baltra Island. Agrocalidad has particular responsibility for the detection and mitigation of new threats that arrive to the islands' various ports of entry, primarily through luggage, imported goods, and food.

In an effort to reduce political corruption, the institution formerly known as INGALA and the Galápagos Provincial Council are currently being incorporated into a unified Government Council, which will report to the President. The Ecuadorian Navy and local municipalities exercise further planning and control over maritime activity, land use planning, infrastructure and transportation. While government spending contributes an estimated 20% to the local economy (Taylor et al. 2006), these institutions also benefit from the distribution of the $100 fee that foreign tourists pay to visit the islands (Table 1.3).[3]

Table 1.3. Distribution of the $100 foreign visitor entrance fee among government institutions.

Organization	Percent	2008 Revenue
GNP	40	$4,811,535.20
Municipalities	25	$3,007,209.50
Provincial Council	10	$1,202,883.80
Galápagos Marine Reserve	10	$1,202,883.80
INGALA	5	$601,441.90
Ecuadorian Navy	5	$601,441.90
Agrocalidad	5	$601,441.90
Total	100	$12,028,838.00

Source: GNPS 2011

[3]Per the 1998 Special Law, Ecuadorian citizens and temporary residents of the islands pay only $6 to enter the province; therefore, a significant source of income for most Galápagos public offices is directly tied to foreign tourism.

International conservation NGOs operating in Galápagos are dedicated to protecting the unique environment and many of their concerns mirror those raised by UNESCO. For these institutions, conservation priorities are achieved by a variety of means: they differ in how they raise funds, how they choose to allocate those funds, and their level of extremism. They also inject millions of dollars each year into the Galápagos economy, contributing 8% to island income growth between 1999 and 2005 (Taylor et al. 2006). The World Wildlife Fund (WWF), Conservation International, WildAid, Sea Shepherds, The Nature Conservancy and others make up this group, but the most influential of these are the CDF and its local office, the CDRS. The CDF operates under a legal agreement with the government of Ecuador to collaborate with national and international scientific institutions and provide reports to the government regarding conservation in the islands. When the GNPS was established, it was staffed by fewer than 10 wardens and officials (Davies 1974); therefore, its partnership with the CDRS was essential to the development of effective hands-on management protocols. The primary funding comes from donors through the U.S.-based Galápagos Conservancy and its sister international offices, the Friends of the Galápagos. Table 1.4 summarizes the CDF's institutional statutes and statutes as stated in the most recent Strategic Plan.

Table 1.4. Summary of the CDF's institutional statutes and objectives.

1)	To perform scientific research and collaborate in activities of basic and applied research in the Archipelago
2)	To disseminate the results of its research and relevant research produced by other organizations
3)	To provide advice to the Ecuadorian Government on the conservation of the environment and biodiversity of Galápagos
4)	To contribute to the process of policy formation with precise and timely technical information
5)	To develop actions that increase the local and national capacity for conservation of the environment and biodiversity
6)	To obtain funds on a national and international basis, to finance its operation
7)	To make the necessary efforts to achieve excellence in the functioning of all areas of support for its mission
8)	To promote national and international cooperation in programs and projects with organizations compatible with the mission and objectives of the CDF

Source: CDF 2006a

Per the 1998 Special Law, the CDF is also authorized to provide advisory support to INGALA, now part of the new Government Council, and to promote management of the GNP and marine reserve. The CDRS and the GNPS have been instrumental in implementing numerous world-class conservation programs and work closely together; indeed, their main offices on Santa Cruz Island are separated by less than half a mile.

But low scores in public opinion polls conducted by Barber and Ospina (2008) reflect the perception among residents that the sole concern of the CDF is conservation, a tension that makes this foreign agency's political arrangement with the national government an uncomfortable barrier to local support. The CDF conservation science program is tightly integrated with foreign interests that translate directly into political action in the archipelago. As one resident and former CDRS employee pointed out during an interview, "Scientists do not make good politicians – they just don't think the way that politicians do." Understanding the need to strengthen their positive image, the organization has attempted to promote recognition of its contributions in Galápagos conservation through events like the 2009 Galápagos Science Symposium, but many years of communication barriers to public awareness remain to be overcome. Finally, the CDF relies on unstable sources of financing, as UNESCO reported in 2006, "resulting in a great deal of its limited resources having to be dedicated to sustaining itself, as opposed to focusing on the tasks at hand" (UNESCO 2006).

The distrust that some locals have for the CDRS is also reserved for the GNPS. The recent instability of the Director's position has dissolved into what Watkins and Barry (unpublished manuscript, 2010) call an "unfortunate political theater, with the park directorship becoming a political football tossed between political factions seeking access to the significant economic opportunities managed and determined by the Director." The perception of the GNP/GNPS as a vertical organization with limited horizontal linkages serves to further alienate the GNPS from achieving meaningful community support and involvement.

Public opinion of the GNPS rises and falls, with many residents arguing that the organization is too political and bureaucratic, while putting too little time and effort into community engagement.

Extravagant anniversary celebrations held on Santa Cruz and Isabela Islands in 2009 and 2010 are one way the GNPS attempts to generate more public support, and in a controversial decision in 2010 it approved the municipality's plan to celebrate Santa Cruz Island's incorporation as a canton of Galápagos at Tortuga Bay, a beach inhabited by marine iguanas and other native plant and animal life. Other less populous projects have been implemented that are more in line with unifying conservation and development goals, including the installation of the first wind turbines in Ecuador on San Cristóbal Island in 2007. Funded by the Spanish cooperation program ARAUCARIA XXI, the turbines provided 31% of the island's total energy consumption in the first 12 months of operation. According to a 2007 report, 2,230 people archipelago-wide have been trained by the GNPS in invasive species control and dengue fever suppression. Twenty-eight farmers have experience controlling rat, plant, slug, and ant populations, and 30 have practice with invasive species monitoring (UNDP-GEF 2007). Even high school students on San Cristóbal have the opportunity to work with the GNPS at El Junco Lagoon to eliminate introduced plants and reforest the area, where they also gain practice using GPS equipment and keeping environmental monitoring logs.

There are three regional municipalities in Galápagos based on San Cristóbal, Santa Cruz and Isabela Islands, that represent the archipelago's resident populations. Each municipal unit is led by an elected Mayor whose four year regular terms may be renewed twice. The municipalities are key players in island development, education, waste collection, water distribution, infrastructure, energy and maintenance. When Ospina conducted his 2001 survey of community institutions, he identified 68 additional commercial (transportation cooperatives, trade and tourism associations, general store or business owners, credit unions), guilds (fishing cooperatives, associations of public employees and the self-employed), identity (indigenous and cultural associations) and educational institutions that represent the various socio-economic strata within Galápagos society (Ospina 2001). Very few conservation organizations exist at this local or grassroots level, which reinforces the split between those who are 'pro' development or conservation. It has also created a conservation politics of scale, in which the major formal institutions are in control of resource use decisions.

With the exception of the Inter-institutional Management Authority (IMA) and the Participatory Management Board (PMB), little genuine effort has been made to incorporate residents in policy making. The IMA is comprised of the Ecuadorian Ministries of the Environment, Defense, Tourism, and Trade and Fisheries, along with the Galápagos Chamber of Tourism and local representatives from conservation and fisheries groups. It establishes policies for the marine reserve, and approves planning, monitoring and management tools under principles of conservation and responsible development. The PMB is comprised of representatives of the islands' fishermen and tourism operators to provide a local-level forum to the users of the Galápagos Marine Reserve, creating effective participation and responsibility with respect to the area's management and advise the IMA. Outside of these institutions, the lack of a coherent environmental vision among community and regional stakeholders was frequently cited in my interviews, leading to disjointed regulations that reflect the visions of a small group of individuals and organizations who wield greater economic and political power.

Follow-up regulations to the Special Law have also been necessary to achieve the application of goals set out in the original legislation. The government institution formerly known as INGALA received the lowest scores in public opinion surveys in the years following the passage of the Special Law because the economic benefits residents had anticipated were not immediately received. INGALA was later tasked with the enforcement of migration regulations and restrictions, which did little to improve the institution's favor among local residents. Several thousand migrants have since been returned to the mainland. INGALA was also responsible for the study and mitigation of the impacts of introduced species related to the growing human presence, and the creation of a "Total Control Plan for Invasive Species" in 2003, as part of a Galápagos Regional Plan for development, has been seen as a positive indicator of a streamlined approach to conservation policy and management. With INGALA's current institutional reform, it remains to be seen how decision making structures for the archipelago's human populations will be unified under the new Government Council.

In summary, the Galápagos Islands make up an ideal setting in which to study the interactions between humans and the environment. They are islands within a protected area, as well as a territory of the Ecuadorian state to which it is illegal for citizens from the mainland to migrate. While the political and economic autonomy of their inhabitants has, to an extent, been achieved out of progressive and participatory legislation related to the Special Law, international conservation interests and funding continue to hold primacy in decision-making processes.

Furthermore, in spite of advances in protected area patrols and migration control, the 2007 crisis declaration underscored the fact that policies enacted since the Special Law have been ineffective in reducing the associated effects of non-native species and population pressures. There are nearly twice as many introduced plants in Galápagos as there are native varieties, and the potential for new arrivals increases as visitors come in record numbers demanding imported food and goods. In 2010 there were 22,770 legal residents living on five islands, making Galápagos the least populated Ecuadorian province, but the annual growth rate is the highest in the nation. Estimates of the number of illegal residents in Galápagos range from 2,000 to 10,000, and hundreds of Ecuadorians are deported each year from their own country. In a glaring omission, neither the Special Law nor any follow-up legislation (making up over 240 laws, decrees and regulations) has made real attempts to focus on critical tourism issues that continue to drive social and environmental change. Therefore, the conditions of the crisis, in the form of invasion by non-native species and human impacts in this World Heritage Site and sovereign territory of Ecuador, are the central focus of this dissertation.

Research Aims and Conceptual Framework

As critical environmental writers like William Cronon (1996) have shown, what is 'natural' or 'wild' is viewed by the modern scientific imagination in opposition to that which is 'unnatural' or 'social'. This predominantly Western idea about the environment has been taken up by conservationists in the creation of the GNP: bounded spaces that set up and maintain opposition between organisms believed to be natural and their unnatural (or human-influenced) counterparts. In

the Galápagos, a plant, animal or organism is considered native if it was present in the islands prior to 1535, the date of European discovery. Once encouraged to settle the archipelago, in 1998 humans were reclassified as permanent or temporary residents, tourists, and illegal migrants according to legislation enacted to control unchecked population growth. Policies based on such naturalized definitions and bounded spaces, however, rely on border patrols and checkpoints to remove or prevent the presence of unwanted people and things without considering the possibility for interrelationships that do not fit within the current political framework for combating invasion, writ large. Only by breaking down naturalized physical (protected area/human use zone), conceptual (native/non-native), and territorial (legal/illegal) divides is it possible to identify the entangled processes that lead to undesirable environmental outcomes. These may occur not in spite of the current politics of invasion, but precisely because of them.

The chapters that follow use case studies to investigate how ideas about nature, nativeness and legality are defined and defended, showing how the conditions of possibility for environmental degradation arise out of complex interactions between people, places and things:

1) Chapter 2 describes the political geography of the Galápagos Islands, emphasizing the historical production of island nature and territory that creates the conditions of possibility for invasion;

2) Chapter 3 demonstrates the effects of invasion and eradication of feral goats from Isabela Island at the landscape level, which extend beyond biodiversity goals and ideas of nativeness;

3) Chapter 4 compares the contemporary state of agricultural production and environmental protection in the highlands of Isabela and Santa Cruz Islands, finding important feedbacks between land management, food sovereignty and species invasions;

4) Chapter 5 evaluates competing perceptions of the Isabela highland landscape and the continued presence of invasive plants at the boundary of farmland and the surrounding national park;

5) Chapter 6 considers the 'human invasions' of illegal behavior and migration in the context of tourism-related development, dismantling implicit stereotypes between legal and illegal, right and wrong.

In this dissertation I adopt a political ecology lens to critically analyze conservation politics concerning invasion, writ large, in Galápagos, drawing on human-environment research by geographers, social theorists and anthropologists. My intention is not to suggest that the conditions of an environmental crisis do not exist in Galápagos or that urgent actions are not needed. Invasion in Galápagos, however, is more than an objective reality defined by science and controlled by policy. It is perceived and experienced differently by stakeholders with divergent ways of knowing and accessing the environment. This research conceptualizes invasion as a process of social and material relations (Haraway 2003; Rocheleau 2007), not enclosed by boundaries but emergent from linkages to the outsides. In tracing the interactions between plants, animals and people, particular attention is given to their productive geographies and what a new politics for Galápagos nature might look like.

While often focused on the local-scale relationships between people and the environment such as property relations, livelihoods and conflicts, studies in political ecology look beyond regional or national boundaries to investigate how discourses, transnational politics and networks shape local social and ecological processes (Peet and Watts 2004; McCarthy 2005). By investigating the macro-level politics and local everyday use of environmental resources, these studies have provided researchers with insights into how conservation policy can actually induce environmental conflict and degradation, particularly in protected areas (Escobar 1998; Brown 2002; Robbins 2004; Stonich 2004). In addition to this multi-scale approach that traces the causes of environmental change back to larger units of analysis, political ecology locates agents of change within a particular historical context (Blakie and Brookfield 1987; Stonich 1993).

Environmental degradation research often wrongly assumes that "human-environmental interactions can be understood in terms of selected social concerns…without the need to grasp the nettle of political and economic interests and conflicts that are typically associated with those concerns" (Bryant 1997: 6). Political ecology can serve as a critique of particular perceptions of environmental degradation that are used to legitimate political action by scientific or research organizations (Robbins 2004: 12). Critical study has explored how categories of belonging, identity,

or particular subjectivities are formed not only as a product of governance, but also out of environmental and social change (Raffles 2002; Peet and Watts 2004; Agrawal 2005; Kosek 2006; Braun 2007).

An important subset of political ecology deconstructs management policies that are predicated on essentialized understandings of environmental degradation, showing how they can produce such outcomes and reinforce existing governance regimes that are used to control people and resources (Blakie and Brookfield 1987; Hecht and Cockburn 1989; Bassett and Zuéli 2000). Rather than taking outcomes such as deforestation, erosion and desertification at face value, political ecologists seek to identify the social, political and ecological conditions of possibility for them. In the particular case of environmental degradation due to species invasions, writes Robbins (2004), "Together, invasion definition, social preparation for invasion, and uneven distribution of invasion effects among people and other species indicate a cultural and political ecology of species invasion." Although political ecology studies have traditionally focused on the land manager, more recent work applies post-structuralist theory to examine policy narratives and discourses, looking across scales at the influences they have on the landscape as well as local populations, especially vulnerable or marginal groups (Watts and Peet 2004: 31; Moore 2005; Kosek 2006). In some cases, the power of conservation discourses and degradation narratives draw attention away from very real ecological threats (Bassett and Zuéli 2000). Locating the agents of environmental change through an analysis at community, regional and national scales, therefore, is an appropriate contribution to the literature on human-environment interactions.

Protected Area Governance

National parks and protected areas are a relatively recent phenomenon, initially promoted in early twentieth century North America for the preservation of nature (Hecht and Cockburn 1989; Oates 1999). Today 70,000 protected areas comprise nearly 18,000,000 km^2 worldwide (Mascia and Pailler 2010). A renewed appreciation for landscapes that showed no evidence of human influence

provided further impetus for the creation of nature reserves, producing spaces and people in particular social and material ways (West 2006). Protected area creation has often been called fortress conservation because it frequently excludes people from wilderness enclosures, obscuring the relationship between humans and nature (Evernden 1993; Neumann 1998).

Scientific research, tourism and environmental politics in protected areas frequently rely on these fixed physical and conceptual boundaries, reinforcing the separation between humans and the environment through protected area demarcation and defense. Neumann (1998) has shown how national park creation facilitated the form of rule over and preservation of what became known as the new and naturalized African nature, or environmental ideal, a reminder that the modern (Western) conceptualization of nature always has a "clear social and political function" (Smith 1990: 15). Environmental governance over places that lack a long human-environment history, such as Galápagos, can be particularly dangerous and risks reenacting colonial relations (Willems-Braun 1997: 6) under the guise of conservation.

Bryant (2002) and Agrawal (2005) liken the act of protected area governance to a form of Foucault's governmentality (1991), whereby knowledge, politics and institutions set up power relations that enlist subjects in the project of their own rule. In this dissertation I take the materiality of the environment seriously and explore the ways that environmental politics in the Galápagos produce both human and non-human subjects through embodied relationships that condition each other. In the Galápagos, not only have spaces of protection and extraction been created, new conceptual and territorial divides have been established between groups of humans and non-humans. Through what Goldman (2004) calls 'eco-governmentality' and Agrawal dubs 'environmentality' (2005), species eradications and migrant removal are rationalized as the solutions to environmental problems, legitimating political actions against those agents that are discursively set up as 'others' (Neumann 2004).

Invasion Biology

Conservation practice is often predicated on assumptions of a benchmark pristine or natural state, and in the field of invasion biology, words like native, exotic and invasive describe the degree of belonging and behavior of particular organisms. They refer to scientific understandings of biophysical characteristics, but are also social and political designations (Larson 2007). When translated into management policy, Rejmanek et al. (2005) have called the diversity of scale- and biology-dependent factors related to species invasion "the overriding frustration of invasion ecology", while ongoing debates have failed to agree upon what types of ecological communities are inherently more invadable than others (Fargione and Tilman 2005; Stohlgren et al. 2003). A great deal of social and ecological work is done by the state in defining an organism as invasive and responding to it, emphasizing the political subjectivity of such designations (Awanyo 2001; Hall 2003). As Robbins (2004) points out, "the first key component of invasion is the culturally and politically laden recognition of a species as 'exotic'."

Invasive species policy in the Galápagos is predicated on fixed ecological definitions that mandate the removal and prevention of non-native and invasive species. In the case of volcanic islands, however, all inhabitants are descended from invaders, which raises the question of whether a pristine or natural state exists that can (and should) be preserved (Brown and Sax 2004, 2005). Cole et al. (2008) believe that the concept of naturalness can no longer provide the impetus for conservation intervention today, in part because intervention by humans in park protection is a violation of the assumptions of naturalness itself. Dismantling notions of nature and nativeness in Galápagos facilitates an understanding of ecological change beyond the naturalized, bounded spaces of protected areas and human-use zones. Furthermore, where some restoration projects have clear goals and means to achieve them, in many situations different values and ways of knowing certain species impede conservation efforts and blur the lines between the native and the non. As White and Walker (1997) imply, flexible conservation goals may be economically and environmentally superior to management efforts that attempt to resurrect past conditions.

Science Studies, Space, and Place

When scientists today refer to Galápagos as a living laboratory or evolution's workshop, they invoke impressions of isolation and uniqueness, a landscape "essentially unaltered by humankind" (Heslinga 2003). Such understandings of the physical world can be traced back to Western realism and a belief in a pre-existing state of nature, apart from human nature (Evernden 1992). The methodological purity of Galápagos science has divided groups of plants, animals and people, for which policies of control and removal are created based on science as fact (Hinchliffe 2007: 88). This holds that nature is "real and knowable," writes Proctor (2001: 231), and that facts uncovered by science "are not just made-up things …but rather are claims about the real world that are true to the extent that they correspond to this reality."

Science scholars, on the other hand, understand science to be "the contingent processes of making assemblages and linkages, of creating spaces in which knowledge is possible" (Turnbull 2003: 39), making invasive species eradication and migrant removal the common sense solutions to environmental problems in Galápagos. This process has occurred over the last 50 years, through relations of research organizations and political institutions that are dominated by the GNPS and the CDF. Indeed, conservation policy and practice have transformed Galápagos *spaces* into *places*, sites of shifting power relations. Rather than seeing the boundaries between people, places and things as fixed, however, human geographers understand space as being produced through social practices and history (Lefebvre 1991; Smith 1996; Harvey 1989). It is material and discursive, experienced and understood through symbols, language, and images (Tuan 1977). In the arena of biodiversity protection, "the *facts* of conservation, the real issues, emerge through practice, in the fields of activity, and are not prior to those practices" (Hinchliffe 2007: 126).

Doreen Massey's geographic understanding of place recognizes the open and porous boundaries of place as well as the interdependencies between places (Massey 1994, 1997). I conceptualize the invasion of Galápagos as the movement of people or things 'out of place' (Cresswell 1996) through the degradation of pristine sites, the corruption of native ecosystems and the

defiance of legal status and norms. To get around such ontological divides, post-modernism and post-structuralism offer guidance through neo-environmentalist studies and sustainability science (Whatmore 2002; Peet and Watts 2004; Hinchliffe 2007). Following Raffles (2002), I conceptualize Galápagos places as processes, not enclosed by boundaries but emergent from linkages to the outside where everyday relationships between humans and nonhumans are made, politicized, destroyed and made anew.

Theories of Migration

Though the concept of migration is generally tied to a nation-state and associated notions of citizenship, protected area territories are political uses of such spaces (Elden 2005), within which a constellation of legal and illegal practices can be defined and policed. Illegal migration has frequently been cited as a crisis or state of emergency for both sending and receiving territories around the world (Hanson 2007: v; Baldwin-Edwards 2008), and Behdad (1998) draws on Foucault to explore migration from the perspective of the state, through discipline, knowledge and surveillance, and the production of delinquency.

Heyman and Smart expose the everyday ambiguity and duplicity of migration by emphasizing "the incompleteness of formal states and the unlikelihood that they will master their own and people's 'illegal' maneuvers" (1999:2). They suggest that to more accurately assess the impact of migration we should emphasize the associated practices and processes rather than state-directed rules or structures (1999:7). Similarly, Coutin (2000) describes the lived reality of illegality and vulnerability to deportation among migrants. Critical social theorists argue that these studies take state and territorial boundaries (and migrant illegality) as ontologically fixed (De Genova 2002), and by reconceptualizing states or territories as bundles of social practices rather than fixed spatial categories (Ferguson and Gupta 2002) we can break down naturalized distinctions of legal-as-good and illegal-as-bad. This shift facilitates a departure from a preoccupation with Galápagos territory and an entry into an exploration of social relations, practices and behavior.

Methods

In cutting across physical, conceptual and territorial boundaries, this project traverses disciplinary boundaries as well, using mixed methods to triangulate the causes and consequences of invasion, writ large. Archival research, remote sensing, quantitative analysis and qualitative assessment of stakeholder interests, concerns and mundane daily activities provide a rich analytical framework for evaluating particular relations between humans and the environment. Although detailed descriptions of the methods for each case study are provided in their respective chapters, I give an overview here.

Political ecologists often use case studies to evaluate local-level human-environment interactions thought to be linked to global processes like tourism, development and conservation (Nietschmann 1971; Zimmerer 1996; Slater 2003; Greenough 2003; Sawyer 2004). The central unit of analysis for this research is the individual – through engagements with island residents, conservation practitioners, land managers or migrants I was able to characterize what development and conservation trajectories mean for various members of Galápagos politics and society. I chose to conduct case studies because they would place me in close proximity to Galápagos communities while fostering relationships with local stakeholders, facilitating a deeper understanding of politics and everyday practices. Although the 'invasions' with which this project is concerned occur on all four of the inhabited islands in the archipelago, due to logistical and financial limitations my fieldwork was conducted primarily on Isabela and Santa Cruz Islands.

Of the Galápagos Islands, Isabela Island is by far the largest and one of the youngest. The GNP comprises 99% of the island's arable land, significantly more than the other three inhabited islands. Since its colonization in 1896, Isabela has maintained a small permanent population and low tourist visitation due to its isolation from the archipelago's main port of entry. A small airport and recently remodeled boat dock accommodate inter-island travel, but aside from the occasional military flight there is no direct traffic from the mainland. The southern coastal village of Puerto Villamil is the island's only port, and a much larger agricultural zone lies along the southeastern flank of the

Sierra Negra volcano. While the more accessible islands of Santa Cruz and, to some extent, San Cristóbal have already undergone significant development related to the tourism industry, Isabela's approximately 2,000 residents have traditionally lived off of subsistence farming and fishing. In the last five years, however, Isabela has begun to experience considerable change as a consequence of economic development to meet the needs of a growing tourism industry. Its large size and high endemic biodiversity make the island especially valuable to the scientific community, and the convergence of species invasion and increased human activity present new challenges for policy design and management.

The second largest island after Isabela, Santa Cruz contains the archipelago's most populated urban center with 11,262 residents in 2006 (INEC 2006). Although it was the last settled island, today Santa Cruz is the main Galápagos tourism hub. Proximity to the airport on Baltra facilitated the island's colonization throughout the twentieth century with the establishment of the coastal town of Puerto Ayora and the highland settlements of Bellavista and Santa Rosa. Following a 2009 land swap with the GNP, the municipal region of bustling Puerto Ayora continues to expand with development planned for over 1,000 additional homes that will nearly double the town's spatial footprint (Hardter, personal communication 2010). Oceanfront hotels, outdoor bars, dive shops and an avenue of boutiques cater to the thousands of tourists who pass through the island en route to more far-flung destinations in the archipelago. Among Santa Cruz's large resident population and constant stream of foreigners, authorities argue, is the highest concentration of undocumented, illegal migrants in the archipelago.

Santa Cruz Island, with its much more rapid economic and urban development, provides a unique comparative case for Isabela in this research. San Cristóbal Island, on the other hand, represents a sort of 'middle ground' where, as the provincial capital, political power is concentrated and the slow development of a local tourism industry has encouraged more directed development initiatives. Sparsely-populated Floreana Island is the earliest settled island and the most degraded by species introductions, making it the target for extensive restoration work by the CDRS and GNPS. It

is accessible only by tour boats and an infrequent ferry service, making it unrealistic for inclusion in this research.

I have visited Ecuador and the Galápagos Islands several times since 2007, and lived on Isabela and Santa Cruz from June 2009 to May 2010, for a total of 15 months of fieldwork.

On Santa Cruz, Isabela and San Cristóbal Islands, as well as the mainland, I conducted interviews with 33 members of local research and management institutions and 12 visiting scientists, the majority of which were recorded and transcribed along with my notes. Key members of the institutions represented in Figure 1.2 participated in this study. Interviews generally lasted about an hour and were semi-structured to allow maximum flexibility around the discussion of their role (as an institution or individual) in conservation science or management. Semi-structured interviews also allowed me to pursue other lines of questioning that arose, and the interactive dialogue furthered meaningful understandings of the topic under discussion (Mason 2002; Dunn 2005). Open-ended questions were asked regarding the history of the GNP and environmental protection in general, the changing ecology of the islands, current threats to biodiversity and the 2007 crisis declaration.

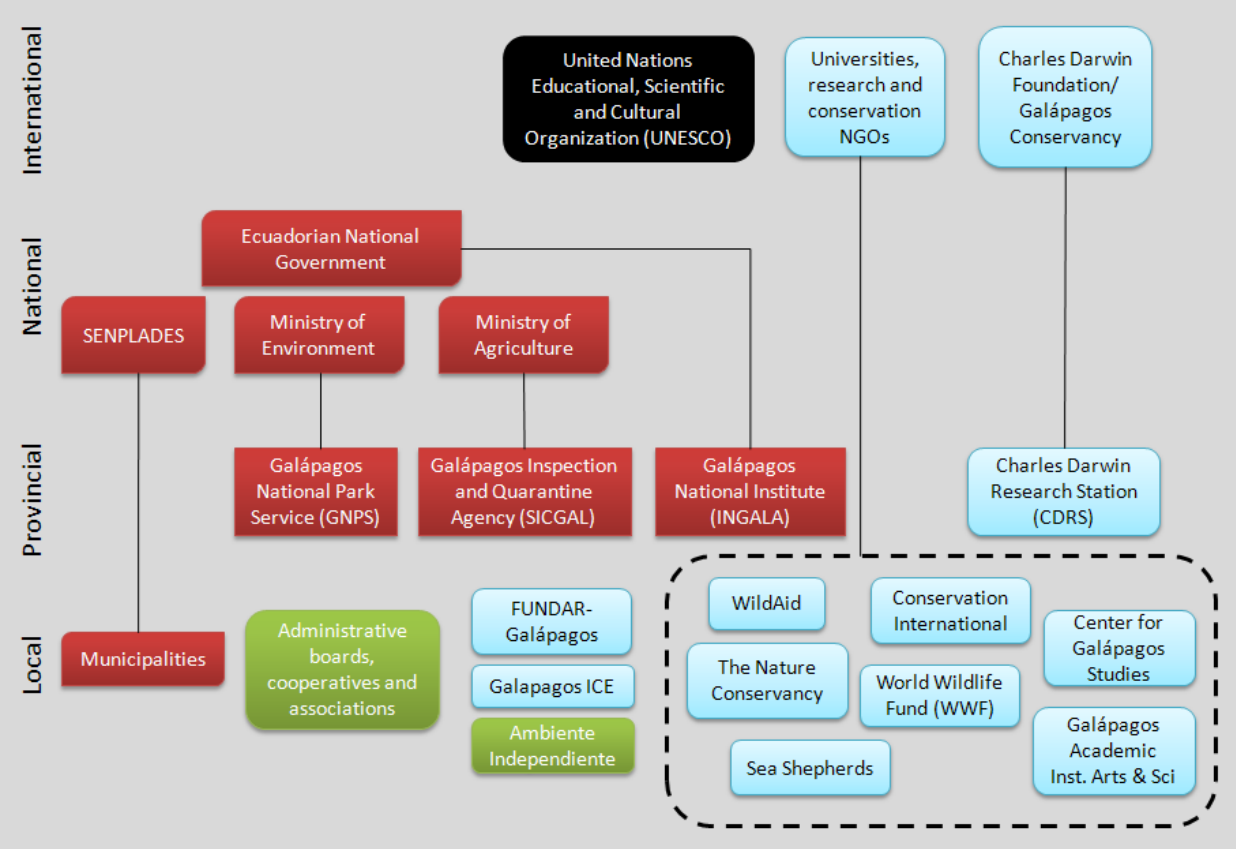

Figure 1.2. Key institutions and stakeholder groups in Galápagos conservation and management. Blue boxes refer to NGOs/research groups; Red boxes refer to government institutions; Green boxes are local economic or social organizations.

On Santa Cruz and Isabela Islands I also conducted interviews with 115 members of Galápagos society, particularly farmers and tourism operators or employees. These interviews were usually not recorded according to the informant's preference. Most did not wish to be identified, so I provide a pseudonym here, but other informants expressed a keen interest in disseminating their opinions or concerns to a broader audience and their real names are given. In 2010 I volunteered with a rural development foundation, FUNDAR-Galápagos, on its demonstration farm in the highlands of Santa Cruz. Over the course of my field visits I collected approximately 150 Global Positioning System (GPS) points of various land cover types in the urban and rural areas, and within Isabela's parkland. I was also a participant and an observer of mundane island activities, engaging in festivals, rodeos, soccer matches and parades, which allowed me to condense meaning from the vapor of everyday life in a way that would not have been possible through interviews alone.

In researching this dissertation I also relied heavily on archived reports including explorers' logs, academic publications, Ecuadorian law, institutional management plans and news articles to fill gaps in the history of knowledge production and nature protection in Galápagos. I attempt to knit these various sources together through time and space, blending the archipelago's human history with its natural one. In reassembling Galápagos spaces where humans and non-humans mix, I hope to show how people, plants, animals, currents and climates engage with one another in ways that, according to anthropologist Don Moore, "make histories in conditions of none of their choosing" (2005: 25).

Chapter Summaries

Chapter 2 describes the history of the Galápagos Islands and the production of pristine space and territory, from the moment of Western discovery to contemporary research and tourism that characterizes the archipelago today. The purpose of this chapter is to provide descriptive and background information on how the islands have come to be 'in danger' from human-induced threats, which will support the case studies that form the bulk of the research for this dissertation. The twin invasions of the islands by humans and human-introduced species are further developed in the context of the ongoing environmental crisis and the production of boundaries between people, places and things to control the processes of invasion, writ large.

Completed in 2006, Project Isabela was the most successful mammal eradication program in the world to date, deployed at enormous economic and ecological scales. Chapter 3 examines the effects of feral goats, giant tortoises, people and plants on the vegetation of a protected zone on northern Isabela Island, raising questions about the utility of nativeness and pristine nature in an environmental narrative of eradication-as-restoration. The spatial data used for this chapter were MODIS composite satellite images from February 2000 to December 2010, and goat kill GPS points collected by aerial hunters. Landscape-level vegetation index transitions before, during and after invasion/eradication are calculated, while interviews with project personnel and policy-makers detail

the evolution of the project, challenges in its design and execution, and findings during follow-up species monitoring.

A park-only land management regime, combined with species invasions, market fluctuations and labor scarcity, have led to a decline in local agriculture in the highland regions of Isabela and Santa Cruz, the topic of Chapter 4. As island food production decreases, the resulting dependence on food imports via cargo ship perpetuates what one GNPS employee called a "vicious cycle of invasion", threatening island biodiversity and rural livelihoods. Household surveys and participant observation are used to develop a theoretical framework for understanding these relations, which are interpreted through interviews, observations and focus groups conducted with local landowners.

In Chapter 5, I use participatory remote sensing to explore the causes and consequences of divergent views of land use and land cover. Fine-resolution QuickBird and WorldView2 satellite images were selected to identify vegetation clusters in and around Isabela Island's agricultural zone. Using photograph identification, supervised classification was carried out based on the beliefs and knowledge of two stakeholder groups in the Isabela highlands, GNPS personnel and landowners, to create two land cover change trajectories from 2004 and 2010. A landscape marked by agreement in some areas and profound contradictions in others underscores the fact that satellite imagery is not an impartial tool for developing management protocols, and in fact reflects highly political and particular knowledges about nature.

The final chapter explores the 'double bind' of the Galápagos tourism industry in relation to illicit, clandestine behavior and migration among members of Galápagos society. The human populations of Galápagos have been reframed as an introduced species, subject to new forms of governance, tracking and removal to control their numbers and behavior. Island residents, who now number over 20,000, engage in a variety of economic activities that are increasingly regulated and restricted. Cluster analysis was performed on data from a 2009 Living Standards Survey of 1,334 households to identify four key groups of the resident population with similar attitudes about the tourism industry, development and conservation. This information was combined with qualitative

data from interviews, observation and opinion surveys carried out with residents, migrants and population control officials concerning legal status and behavioral norms in the shadow of the tourism boom.

Contributions

"A wonderful thing about islands," wrote Sierra Club Director Eliot Porter in 1968, "is their capacity for discovery. They can be discovered, rediscovered, and rediscovered again, yet still seem virgin ground" (Porter 1968). The production and maintenance of a pristine Galápagos image, for study by scientists and consumption by tourists, has been accomplished over centuries of interactions between humans and non-humans in this unique Pacific archipelago. The management regime for the last 50 years, however, has relied on a geographical imaginary that separates humans and human influence from a nature that is increasingly less natural. As Galápagos institutions and individuals become more dependent on tourism as a source of revenue, the costs of maintaining a pristine image translate into expensive eradications and controversial deportations, creating wilderness spaces with our very natures etched upon them. These "so-called wildernesses are peopled, have histories and geographies, and so in some way or another are social as well as natural productions" (Hinchliffe 2007: 12).

This research was undertaken because of a need for a comprehensive understanding of the conditions of possibility for environmental degradation and social vulnerability not only in the Galápagos, but in other places throughout the world that experience similar cross-cutting challenges and vulnerabilities. If such places are to continue to experience population and tourist growth, management techniques should be developed that optimize social, economic and ecological health, and this research identifies new forms of engagement between Galápagos communities and the environment that may advance a more sustainable future for the archipelago. The primary methodologies used in this research are qualitative interviews, remote sensing and surveys, but the ordinary interactions that I had during my fieldwork with farmers, taxi drivers, children and the

milieu of everyday Galápagos life proved to be invaluable sources of information that richly colored, and frequently directed, my interpretations of data and analyses. The interdisciplinary approach employed by this project is essential to presenting an analytical and nuanced view of policy and practice, creating a template that can be extended more broadly to other populated protected areas and island systems worldwide.

Chapter 2: A Natural and Social History of the Galápagos Islands

The natural history of this archipelago is very remarkable. … It seems to be a little world within itself; the greater number of its inhabitants, both vegetable and animal, being found nowhere else.
Charles Darwin, 1839: 454-455

The history of nature presupposes not only biology, soil science, and so on, but also political and legal history.
James O'Connor, 1998: 54

According to anthropologist Paige West, "everything *comes to be*. Then, once brought into the world, space is always in process of becoming something else and contributing to the production of other spaces, objects, and subjects" (2006: 27). In the previous chapter, I introduced the problematic of invasion, writ large; that is, under the banner of environmental conservation particular ideas about nature certain people, places and things are defined and defended according to their degree of belonging. Rather than taking Galápagos nature and territory as fixed, immutable categories, however, I argue that the Galápagos Islands have been produced through entangled natural and social histories, and are made up of people, places and things that are both real and imagined.

In this chapter, I provide general background information on the Galápagos Islands, attending to historical conjunctures that produced the current ideas we have about Galápagos nature and belonging. I show how the archipelago as we know it came to be the site of paradise under siege (Quiroga 2009), by non-native species and a growing population of illegal migrants, both of which are tied to rapid growth in the currently unregulated tourism industry. Two key resolutions in the 1998 Special Law, which established criteria for the control and removal of introduced species, and established legal Galápagos residency and migration restrictions, are discussed, setting up a framework for understanding the case studies concerning the 'politics of invasion' to be explored in subsequent chapters.

Discovery

Humans met their non-human counterparts in Galápagos after millennia of isolation. In early 1535 the Spanish Bishop to Panama, Tomás de Berlanga, was blown off course while sailing from Central America to Peru (Latorre 1996). Becalmed near the equator, after drifting for nearly two weeks they sighted an island, but upon landing could not find fresh water. Two crew members and 10 horses perished from dehydration, and the rest of the crew resorted to squeezing out the little water contained within the pads of prickly pear cactuses. "[M]ost of it is full of very big stones," said Berlanga of the archipelago in a letter to the King of Spain, "so much so that it seems as though at some time God had showered stones; and the earth that there is, is like slag, worthless" ([1535] 1884: 539).

Berlanga never referred to the islands by a name but they appear as early as 1569 on two world maps as *y: de los galopegos* and *Insulae de los Galopegos*.[4] British buccaneer William Ambrose Cowley later sailed through the archipelago twice during his circumnavigation of the globe, and his account emphasized their fleeting, ephemeral nature: "We sailed away to the Westward to see if we could find those islands called the Gallipoloes, which made the Spaniards laugh at us, telling us they were enchanted islands, and that there was never any but one Capt. Porialto that had ever seen them, but could not come near them to anchor at them" (Cowley 1686). His descriptions earned Galápagos the moniker the 'Enchanted Islands', and perhaps in a rebuke to the Spaniards who mocked him he named one small island to the east of what is now known as Isabela 'Cowley's Enchanted Island' in his 1698 chart.

Berlanga's communication was "the first awareness that the civilized world of Renaissance Europe had of the Galápagos Islands" (Porter 1968: 21). The absence of any permanent human settlements at that time has enabled subsequent scientists to define an ideological Galápagos nature,

[4]Although it is widely accepted that the Galápagos Islands were so-named because the shells of the giant land tortoises resembled a Spanish riding saddle, the *galápago* (Larson 2001: 24), it is more likely that '*galápago*' was actually an old Spanish word for tortoise, revived in the 1800s to refer to a particular kind of saddle, the '*silla galápago*' (Woram 2010).

uncontaminated by human beings, or what evolutionary biologist Richard Dawkins would later call "an almost perfect natural laboratory of evolution – scene of an experiment planned in scientific heaven" (Stewart 2007: xx). It is interesting to note, however, that although the islands were uninhabited at the time of Berlanga's encounter, in a 1952 expedition Norwegian archaeologist Thor Heyerdahl discovered pre-Incan ceramics dispersed at various sites throughout the archipelago (Heyerdahl 1955). Early written accounts describe in detail the journeys of fifteenth century Tupac Inca Yupanqui's dynasty, which reportedly traded prisoners, gold, silver and copper between the South American coast and the islands (Cabello de Balboa 1586; Saramiento de Gamboa 1572 [2007]: par 46). Heyerdahl's reconstruction of the *guara*, a kind of raft, further proved that travel across such distances was possible, but no graves or permanent constructions from this period have ever been found (Heyerdahl 1957; Lundh 1995).

For the next two centuries, Galápagos human history was characterized by resource extraction and exploitation by those seeking refuge or food reserves, firewood and freshwater (González et al. 2008). The islands' dismal, cursed aura clung to them like a ghost; as Herman Melville wrote (1854), "Another feature in these isles is their emphatic uninhabitableness. It is deemed a fit type of all forsaken overthrow that the jackal should den in the wastes of weedy Babylon, but the *Encantadas* refuse to harbor even the outcasts of the beasts. Man and wolf alike disown them." As with other islands around the world, early Europeans quickly altered the environment they found. Entire populations of giant tortoises, in particular, were devastated when pirates and whalers took scores of them on board their ships for food (James, personal communication 2009). One tortoise, strapped upside down and kept alive without food or water, could provide a ship's crew with a reliable supply of meat for up to a year.

But the islands that only conjured up images of desolation and despair would soon play a paradigmatic role in the development of modern evolutionary science. By the early 1800s, the Western world had undergone a "slow transformation of worldviews" that emphasized biological origins and development (Larson 2001: 7-8). European interest in the Galápagos was growing, and

when a young Englishman named Charles Darwin was offered the opportunity to join a global collecting expedition as ship's naturalist, the future of Galápagos was forever altered. Although Darwin's visit to the islands spanned only five weeks, his observations of Galápagos flora and fauna helped form his theories of speciation and adaptive radiation. *On the Origin of Species by Means of Natural Selection*, published in 1859, revolutionized biology and the way that naturalists viewed life on earth (Stewart 2007: 78).

Following Darwin's publication, a growing acceptance that species had evolved to their present state around the globe led to studies of their geographic distribution through exploration and collecting (Bowler 1996). Darwin's contemporary, Alfred Russell Wallace, published *The Geographic Distribution of Animals* in 1876, paving the way for the developing science of biogeography and extensive global exploration and collecting. As evolution's influence spread within the scientific community, the idea of Galápagos as a natural laboratory developed as well, and the worthless earth that Berlanga encountered became a field for study. Collecting expeditions to the Galápagos were financially limited to British and American universities and museums, and were characterized by competing scientific and theological interests (Larson 2001: 102). One of the largest of these was carried out by the California Academy of Science in 1905 and 1906. Academy Director Leverett Mills Loomis had no connection to Darwin or his theories of natural selection, and was in fact a devout creationist.[5] Nevertheless, he wanted to obtain the products of evolution for California's collections (James, personal communication 2009). Under the instruction of Rollo Beck, a team of seven men accumulated 75,000 specimens, including birds, reptiles, fossils, insects and reportedly the last giant tortoise on Fernandina Island (Larson 2001: 128), under the prevailing attitude at the time that salvaging was, in essence, protection. As long-time Galápagos scholar Matthew James recalls, "Dead tortoises in collections were better than those lost to pirates" (personal communication 2009).

[5]Darwin's theories did not advocate the abandonment of natural theology entirely, but instead provided scientists wtiha set of natural laws that they could investigate "without looking over their shoulders for a divine designer" (Larson 2001: 90). Nevertheless, scientists like Harvard Professor Louis Agassiz, for example, were compelled to carry out collecting expeditions to attempt to prove Darwin wrong, *in situ*.

Galápagos Nature and Territory

In the geopolitical setting of the early 1800s, Galápagos possessed a clear territorial presence. Although Ecuador annexed the islands in 1832 and established small colonies on Floreana and San Cristóbal Islands, there were various attempts by international powers to rent, exchange, purchase or occupy the islands during the latter half of the century. In an exercise of sovereignty, the Ecuadorian National Congress passed a Special Law for the Galápagos Islands in 1885, which represented the economic rights of citizens within island territory and encouraged colonial settlement (Grenier 2007: 87). Global interest continued into the twentieth century, however, including one anonymous millionaire who offered to buy the islands for use as a game preserve and the American government's desire to secure them as "a long-desired naval base" (Parks and Rippy 1940). To the latter, World War II provided the opportunity to do just that. Following the 1941 Japanese attack on Pearl Harbor, the U.S. military identified Galápagos as a strategic Pacific outpost, and in 1943 President Roosevelt acquired Ecuadorian consent to build a military base on Baltra that was occupied by American troops until 1946 (Vanegas 1998: 55; Larson 2001: 175).

Although protected areas have existed in many forms worldwide for centuries, their modern incarnation stems from a Judeo-Christian idea that nature is evidence of divine creation (Glacken 1967). The duty of mankind was to exercise dominion over while simultaneously being stewards of the natural world. By the Industrial Revolution, human use of the environment had led to widespread environmental modification and the potential for irrevocable damage, according to American diplomat George Perkins Marsh (1864). A contemporary of Darwin's, Marsh emphasized the destructive capacity of civilizations interacting with nature, drawing on the materialism of the environment to invoke responsible resource use. This combination of the belief that humans were environmentally destructive when left to their own devices and a renewed appreciation for landscapes that showed no evidence of human influence strengthened the call for the creation of protected areas as a modernist project worldwide, gaining the scientific support that further entrenched the physical and conceptual boundaries between people and nature (Evernden 1993).

In the Galápagos, international conservation interests in the islands eventually took precedence over economic or strategic importance. In fact, the Academy of Science's collection of the threatened "tropical treasures from the south seas" ran counter to the conservationist movement being led by fellow Californian John Muir at the turn of the twentieth century (Larson 2001: 131).[6] Following Marsh, John Muir, Gifford Pinchot and Aldo Leopold all adopted slightly different views of the value of nature in North America: Muir founded the American National Park system and the Sierra Club, which advocated preservation and the exclusion of human activity from protected areas, while Pinchot and Leopold advocated a responsible human use ethic of the earth and its resources. This new national park ideal, sometimes called 'fortress conservation', became known around the world and in 1936 Ecuador established a Galápagos wildlife sanctuary, where "private ownership was to be recognized only where the land had been cultivated" (Parks and Rippy 1940) and hunting of native species was prohibited (Zapata 2005). A visiting German ornithologist, Irenäus Eibl-Eibesfeldt, concluded that it was vital that the islands be protected, "for even short visits by settlers or fishermen are likely to change things" (1958: 23). His concerns prompted UNESCO and other members of the international scientific community to back the Ecuadorian government in the establishment of a Galápagos National Park (GNP) in 1959, the country's first. Ecuador's decision to create such a large protected area was considered progressive by the global conservation community (Heslinga 2003): More than 70% of Latin American national parks were not established until the 1970s and 80s, a period of time during which conservation NGOs began working in developing countries worldwide, energetically pursuing the goals of biodiversity protection.

Also in 1959, the CDF was founded in Belgium, and Eibl-Eibesfeldt was appointed its first Director. Plans for an affiliated research station based in the islands were already in the works. "The Ecuadorian Minister of the Environment has promised his support, and if the Biological Station can

[6]In spite of a collecting ethic that Larson (2001: 131) calls 'rapacious', the 1905-1906 California Academy of Science expedition contributed hugely to Galápagos science, textbooks and field guides. It includes specimens from Santa Cruz, uninhabited at the time, making it valuable for recent plant, animal and pathogen research (James, personal communication 2009; cf. Parker et al. 2011).

be set up soon, there is every reason to hope that the islands will, at least in part, be preserved in their natural state," he maintained (1958: 23). With financial support from the WWF, the CDRS was constructed on Santa Cruz in 1964 to provide scientific advice to GNP management.[7] When the GNPS was established in 1968, GNP boundaries were redrawn to include 97% of land area, where "there were to be no residents, private property or developments outside the clearly defined and limited areas of settlement" (Corley Smith 1990).

The designation of protected areas, as Neumann (1998) has argued, facilitates human rule over and preservation of a new and naturalized 'nature' or environmental ideal. But Hinchliffe elaborates: "These so-called wildernesses are peopled, have histories and geographies, and so are in some way or another social as well as natural productions" (2007: 12).

At the time of the establishment of the GNP, fewer than 2,000 people lived on four of the larger islands, and the bounding of a protected area achieved a form of social control, preventing extraction while providing the impetus for future scientific research (cf. Smith 1990: 4). As Davies (1974) writes, "A much talked about event in 1971 was the removal and resettlement of 15 families living illegally in park territory. This was seen as unequivocal evidence that the government would even act against its own subjects in maintenance of the park." In 1973, the Galápagos was incorporated as the twenty-second province of Ecuador. Six years later the archipelago was inscribed as one of the first UNESCO World Heritage Sites under all four natural criteria (Table 2.1). Throughout the 1980s and 90s, the islands were the site of a number of other spatial productions. Ecuador partnered with the WWF and the Nature Conservancy in a "debt-for-nature" swap (Heslinga 2003), and UNESCO later designated them a Man and the Biosphere reserve in 1984. The Galápagos Marine Reserve, established in 1986, was more than doubled in size in 1998 to extend 40 nautical miles (133,000 km^2) from a baseline around the archipelago and today is the fourth largest in the world.

[7]In this dissertation I generally use the abbreviation CDF when I am discussing broader political/institutional concerns, and use CDRS to refer to science and research carried out in the islands. In reality, however, the two are virtually interchangeable. As Galápagos Conservancy President Johannah Barry stated in a 2010 interview, "The CDF *is* the CDRS."

Table 2.1. Summary of the four criteria for inscription of the Galápagos Islands as a UNESCO World Heritage Site.

Criteria	Description
I. Exceptional Natural Beauty	"…the assemblage of 18 large and 107 smaller rocks and islets emerging from a 'hot spot' in the middle of the Pacific, with still active volcanoes and a striking vegetation composed of giant cacti and daisy trees does make the Galápagos an area of superlative natural phenomena. With its steep-sided volcanic islands descending abruptly into a crystalline sea, it is considered by many as of exceptional natural beauty."
II. Ongoing Geological Processes	"The islands, both above water and below, are still active volcanoes thereby providing a significant on-going example of geological processes in the development of landforms as well as ecological barriers nurturing processes of speciation."
III. Ongoing Evolutionary Processes	"Given their almost pristine nature on some of the islands, the Galápagos is one of the few places on Earth where significant on-going ecological and biological processes in both plant and animal evolution have been recently demonstrated. In addition the Galápagos are almost synonymous with evolutionary processes, given the enormous historical contribution they made to Darwin's theory of evolution after his visit in 1835."
IV. High Endemic Biodiversity	"The islands' significant concentrations of plants or animals which are rare or endangered justify the inclusion. The islands have a high diversity for such young oceanic islands, and contain emblematic taxa such as giant tortoises and land iguanas, the most northerly species of penguin in the world, as well as the historically important Darwin's finches."

Source: UNESCO 2006

Conceptualizing the Native

Following the creation of the first national parks and inspired by evolutionary theory, ecology and the biological sciences gave rise to particular valuations of certain species or places, which could accordingly be protected or eliminated. Once a Galápagos research base had been established, in situ investigations were carried out on the islands that were concerned with the arrival and departure of organisms, their distribution and their effects. Baseline studies and examinations of old collections were combined with new techniques for dating specimens and worldwide, biodiversity, a measure of species richness and range, had become a focal point for biology. Advances in transportation and technology under the specter of World War II spurred global environmental concern that for the first time, humans had reached the earth's carrying capacity (McCormick 1995; Bocking 1997). If biodiversity was linked to planetary health, nature's biological capital must be protected for current

and future generations (West 2006: 38-39; Larson 2008). The ensuing decades witnessed advances in conservation advocacy and science, and a new environmental paradigm emphasizing the need to protect biodiversity from human destruction emerged through the new disciplines of conservation and invasion biology (Farnham 2007).

CDRS scientists classified organisms that arrived after the islands' (Western) discovery as non-native, and extensive surveys were carried out to determine how 'natural' the islands had remained since 1535. Conservation zoning distinguished between complete protection, conservation restoration, impact reduction, rural and urban human use zones, while whole islands and regions were further subdivided into pristine, near pristine and not pristine areas. During a 1999 Galápagos Biodiversity Workshop, researchers from the CDRS and WWF defined their ultimate goal to be "the restoration of the populations and distributions of all extant native biodiversity and of natural ecological/evolutionary processes to the conditions prior to human settlement…the restoration of the biological nature of the Galápagos Islands almost to the conditions of 1534" (CDF and WWF 2002: 48).

The questionable feasibility of a return to a 'pre-discovery' landscape aside, this type of geographical imaginary is important because it draws a clear line between the 'native' nature and the 'non-native', or human-influenced. It also sets up the conditions of possibility for environmental degradation-as-invasion. By the end of the twentieth century, the CDRS had standardized their species classification system to Native (*Na*) and Introduced (*In*), followed by the 15 sub-origin categories listed in Table 2.2. Organisms classified as Introduced-Accidental and Introduced-Escaped are known more generally as 'invasive'.

Table 2.2. CDRS sub-origin classifications for species found in Galápagos.

Taxon	Suborigin	CDRS Definition
Ac	Accidental	Accidentally introduced species that is naturalized in the wild
AcE	Accidental Eradicated	Eradicated (for species accidentally introduced)
AcQ	Questionable Accidental	Species which is introduced and naturalized but for which it is not known if it was introduced accidentally or on purpose
Cu[8]	Cultivated	Introduced for cultivation, agricultural, or domestic use and not naturalized
CuE	Cultivated Eradicated	Eradicated (for species introduced for cultivation, agricultural, or domestic use)
En	Endemic	Species which only occurs in Galápagos
EnQ	Questionable Endemic	Species which is currently known from Galápagos but where knowledge about general distribution is too poor to be certain of its endemic status
Es	Escaped	Introduced for cultivation, agricultural, or domestic use and naturalized
EsE	Escaped Eradicated	Eradicated (for escaped species)
Hy	Hypothetic	Species for which it is very probable that it passes through the Galápagos area, but was never found/observed
Ic	Intercepted	Introduced species found during quarantine inspections by personnel of AGROCALIDAD or the National Park
Id	Indigenous	Species which is native but not endemic to Galápagos
Mi	Migrant	Native species which spends part of its life in or around Galápagos but for some time migrates to other regions
NaQ	Questionable Native	Possibly introduced species
Va	Vagrant	Species which is found/observed once or twice, but never again

According to the CDRS 2010 species database, the Galápagos Islands have as many as 85 different species of birds, half of which are endemic, or found only in the islands. In the most recent update of their species database, the CDRS found that another 95% of reptiles, 40% of vascular plants, up to 80% of insects and 45 of the 61 terrestrial and marine mammals are also endemic to Galápagos. In addition to the high rates of endemism that are characteristic of oceanic archipelagos, the Galápagos Islands possess seven subspecies of giant tortoises who are island-specific genetic

[8]In the CDRS database, *Homo sapiens* are filed under Origin: Introduced, Sub-origin: Cultivated.

variants of a single South American ancestor that migrated millions of years ago. As of 2007, over a third of the native plants in Galápagos were listed as endangered, critically endangered or extinct by the International Union for the Conservation of Nature (IUCN, Table 2.3). According to Jiménez-Uzcátegui et al. (2008), the primary cause of extinction for Galápagos endangered species are the arrival of predators, competitors or diseases that are introduced by humans.

Table 2.3. Conservation status of Galápagos native species.

	Number and Percent of Native Species[a]				
IUCN Conservation Status	Plants	Birds	Reptiles	Mammals	Insects
Extinct	3 (2%)	0	5 (14%)	8 (50%)	2 (2%)
Critically endangered	20 (12%)	4 (7%)	3 (8%)	0	26 (25%)
Endangered	26 (15%)	3 (5%)	6 (16%)	0	9 (9%)
Vulnerable	54 (31%)	6 (11%)	11 (31%)	5 (31%)	26 (25%)
Near threatened	13 (8%)	0	11 (31%)	1 (6%)	0
Least concern	55 (32%)	42 (76%)	0	2 (13%)	40 (39%)

Sources: Tye 2008; Jiménez-Uzcátegui et al. 2008

[a] Species numbers are the results of a survey conducted by the CDRS and do not reflect population totals

Botanist Alan Tye has estimated that at least 37 plant and animal species are highly invasive and require immediate control (Tye 2006), while 34% of the nearly 900 introduced plant species are able to reproduce without cultivation, known as 'naturalized' (Trueman 2010). Most of the existing invasive species in Galápagos are found on the inhabited islands (Tye et al. 2002), and countless studies of their arrival and dispersal have been carried out by CDRS scientists and visiting researchers. To reduce the potential for extinction and slow the current trend of native species becoming threatened by their introduced counterparts, said Tye (2008), "decisive action must be taken over the next few years." The recent tourism boom, however, is among the principle concerns that scientists have for native flora and fauna, as the industry is directly linked to increasing human impacts and the arrival of new species and diseases.

The 'Catch-22' of Galápagos

"Nature," writes ecotourism expert Martha Honey, "is the allure of the Galápagos" (2008: 155). The preservation of Galápagos nature inspired GNP proponents to argue that its creation would encourage tourist spending, providing extra revenue for the developing Ecuadorian state and assuring Galápagos well-being (Grimwood and Snow 1966). A 1958 issue of Life Magazine emphasized the archipelago's timeless qualities, advertising its unpeopled image while at the same time promoting tourism: "Until now man's invasions of the Galápagos have been happily infrequent. It is this circumstance which has preserved aboriginal life and endowed the Enchanted Isles with the look of eternity, as though the river of time had frozen in some peaceful epoch of the prehistoric past" (Barnett 1958: 66; Figure 2.1). Commercial Galápagos tourism in the form of 'floating hotels' began in the 1960s when New York-based Lindblad Travel began offering multi-day cruises on their 66-passenger ship, the *Lina A*. Quito companies Metropolitan Touring and Turismundial joined Lindblad to expand the market, and between 1974 and 1980 the cruise ship fleet grew from 13 to 42 (Honey 2008: 125).

Figure 2.1. Artist's renderings of the Galápagos Islands' 'prehistoric' past from a 1958 issue of Life Magazine.

Land-based tourism began in the 1970s with the availability of inter-island shuttles and small boats for charter (Epler 2007: 3), but by 1982 only 18 hotels archipelago-wide had a total capacity for

214 guests. Economist Bruce Epler recalls, “There was so little activity it was considered insignificant. The government was giving out *cupos* [tourism operator permits] to anyone who wanted them, but most people were still fishing and farming” (personal communication 2007). As environmental tourism, increasingly referred to as ‘ecotourism’, gathered momentum in Galápagos, however, world attention was soon directed to the islands.

Despite the fact that by this time the terrestrial and marine areas of Galápagos had already been divided into protected areas, no regulations have ever been put in place to control tourist numbers. The current tourism model is the result of rapid and uncontrolled terrestrial expansion that occurred largely in the last three decades. In the 1980s and 90s island entrepreneurs began offering more land-based options for budget travelers, including Ecuadorian citizens and backpackers, and the dollar-based tourism economy enticed farmers and fishermen to explore alternatives to their traditional livelihoods. By that time, 26 hotels could accommodate 880 guests and 67 ships matched them with over 1,000 berths between them (Epler 2007: 13, 16). Within 15 years 170,000 annual visitors were arriving to the islands, where over 20,000 people now live. “No one envisioned that the islands would emerge as one of the world’s premier ecotourism destinations; that Galápagos tourism would contribute hundreds of millions of dollars to Ecuador’s national economy, and in turn, that it would generate revenues and population growth in Galápagos exceeding anyone’s wildest expectation,” Epler concludes (2007: iii). The annual growth rate in the number of tourists between 2000 and 2006 was 14%, falling behind only Panama, El Salvador and Guatemala in percent visitor increase in countries within the Americas (Proaño and Epler 2008). If that rate were to continue, in under a decade more than half a million people will visit the islands every year (Figure 2.2).

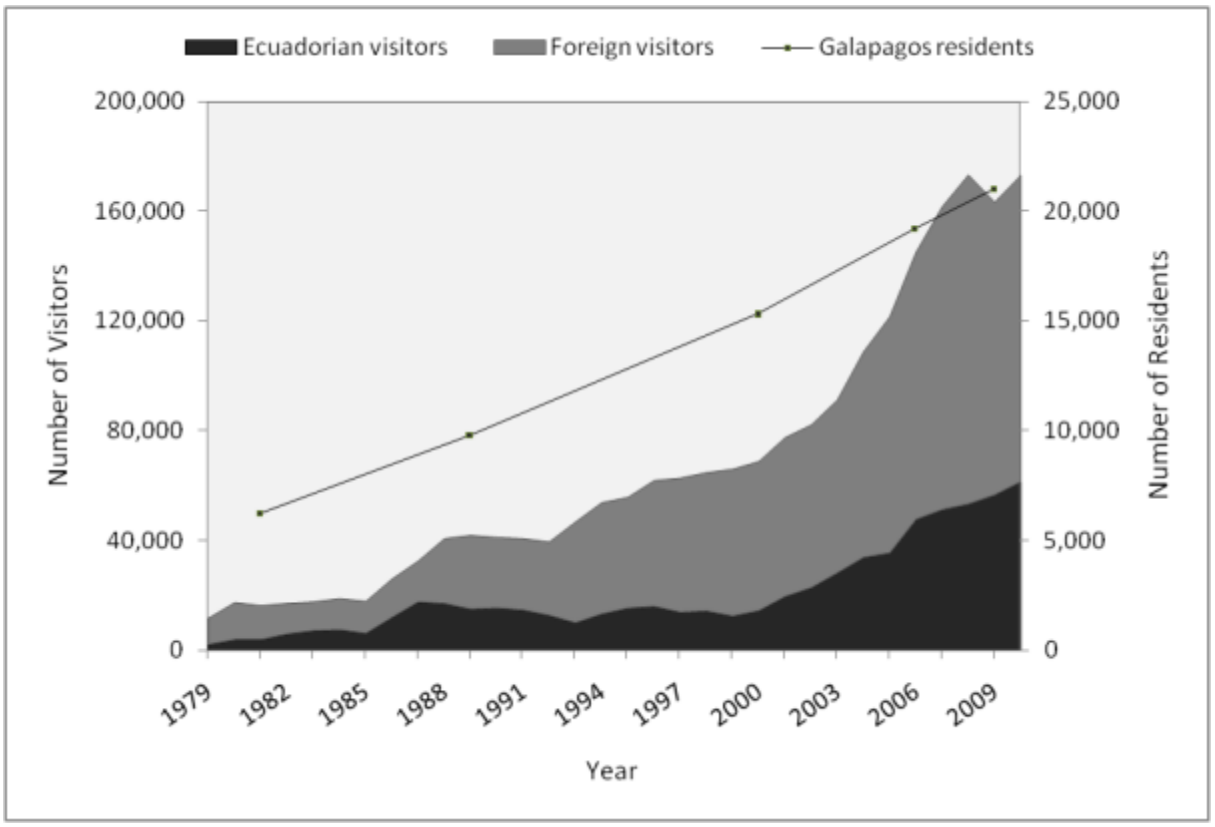

Figure 2.2. The growth in tourist visitation to Galápagos and the resident population, 1979-2010. Source: GNPS 2011; INEC 1982, 1990, 2001, 2006, 2010.

The tourism boom of the 1980s and 1990s also brought improvements such as widespread electricity, higher wages, regular transportation and other modern luxuries that drew mainland residents to move to the islands. Economic instability and political unrest further contributed to an increase in migration to Galápagos: between 1980 and 1991, the value of the Ecuadorian *sucre* fell from 25 to 1,250 *sucres* per dollar and continued to collapse until 2000 when the country underwent dollarization. Rebel violence along the Colombian border, riots among indigenous groups and a border skirmish with Peru culminated in a series of overthrown presidents in the late 1990s, while the comparatively calm situation in Galápagos fueled migration (Epler 2007: 7). The archipelago's population tripled in the last quarter of the twentieth century, two-thirds of which was attributed to migrants attracted by the lucrative growth in the fishing and tourism industries (WWF 2003). When Sports Illustrated Magazine shot its 1998 swimsuit issue in the Galápagos, the islands' began to

develop a hip and trendy appeal, and their reputation as an international sailing and surfing destination draws thousands of young athletes and admirers to annual competitions.

The exponential growth in tourism has also directly compromised the isolation of the destination itself, what one researcher calls the 'Catch-22' of Galápagos (Price, personal communication 2009). It is the archipelago's 'pristine' image that fuels visitation, while increasing human access and impacts threaten the sanctity of that image. According to CDRS marine scientist Stuart Banks, "Now if you take another example for a stress in Galápagos, if you take, for example, patterns of increase in tourism with more rapid development and the increase in marine traffic and human traffic between Galápagos and the continent you're breaking up the traditional barriers, if you like, between Galápagos and other parts of the world" (personal communication 2010). Elicier Cruz, regional Director for the WWF in Galápagos, echoes Banks: "There's a bridge – the geographic isolation that existed between the mainland and Galápagos is physically there, but currently it's *not there*…the connection between Galápagos and the mainland is very strong" (personal communication 2010; Figure 2.3).

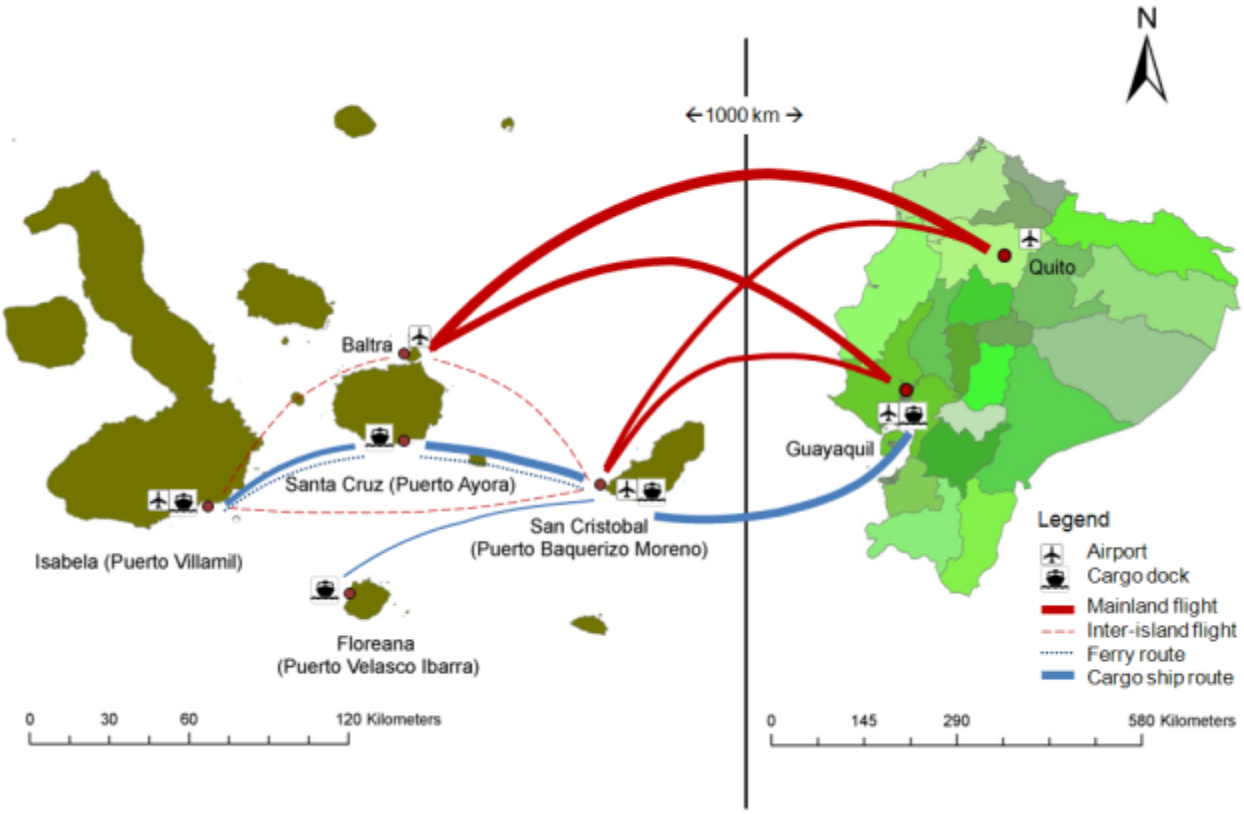

Figure 2.3. Map of Galápagos mainland and inter-island air (red) and sea (blue) access.

At the end of 2010, 11 air and sea ports formed this bridge between the islands and the mainland, in spite of calls for their reduction or consolidation (UNESCO 2006, 2010). Three airlines operate over 40 flights per week to the Baltra and San Cristóbal Island airports from Quito and Guayaquil, transporting up to 80 passengers per flight. The Baltra airport is slated to undergo a $20 million renovation in 2011-2012 and will supposedly be able to accommodate half a million visitors per year, although the transport authority assured UNESCO's 2010 monitoring mission that this was a function of industry standards, not intended capacity (UNESCO 2010). An inter-island airline has the capacity to provide 42 passengers daily access from Baltra to Isabela and San Cristóbal Islands, which is augmented by multiple 18-passenger ferries that depart from Santa Cruz's central tourist terminal every afternoon. In addition to cargo ships and ferries, increasing numbers of private yachts and tour boats circulate in and around the Galápagos Marine Reserve. "Tourism is directly moving –

in one week literally you'll have dozens if not maybe 100 boats moving between different colonies," said Banks, "and to date there's no established method to try and ensure that these ships aren't bringing things with them that could establish here in Galápagos."

Keeping Nature Natural

Per the 1998 Special Law, in 2001 the GNPS was joined by SICGAL (now Agrocalidad), which was assigned the daunting task of identifying and containing plants, animals, foods and other organisms that could pose a threat to the archipelago's native biodiversity. Over 90% of imported goods arrive to Galápagos by sea on weekly cargo ships, and the risk of invasion increases with tourism and the demand for more imports (Zapata 2007). Since 2001, however, Agrocalidad's staff numbers have dropped by 25%, and on Isabela Island the three current employees are in charge of monitoring all departures and arrivals by air and sea without even a motorized vehicle among them. Although 25 new hires are expected for Agrocalidad in 2011, as one visiting researcher observed, "Galápagos is a world class destination thanks to its incredible wildlife, but if it doesn't start implementing world class inspections it's going to be the greatest conservation tragedy in history" (personal communication 2009).

While latent biosecurity continues to permit the introduction of an unknown number of organisms, particularly insects and diseases, the GNPS is improving eradication and control. Of its 400 employees, 74 are trained in the use of rifles with telescopic sights, radio telemetry and GPS, in addition to radio communication, hunters' ethics and wildlife management (UNDP-GEF 2007). The UNESCO 2006 report listed a number of conservation successes, including the rehabilitation of Española Island through the eradication of goats and the reintroduction of land iguanas to Baltra Island. CDF Director Gabriel Lopez agrees that the islands retain approximately 95% of their original biodiversity, making them one of the best-maintained oceanic archipelagos in the world (Bensted-Smith 2002), but he believes that there's only a decade left to avoid an ecological disaster. "Yes, Galápagos will still be there but the richness will be lost" (Lopez, personal communication 2010).

Keeping Galápagos nature pristine involves much more than cargo inspections and sharp shooting. CDRS scientists have been raising giant tortoises and land iguanas in captivity for many years, finding that this results in some populations being moved to less threatened IUCN categories. In 2010, following the failure of the last known member of the giant tortoise population from Pinta Island, 'Lonesome George', to reproduce in captivity, the CDRS determined it was time to return non-Pinta tortoises to that island. Their decision was prompted by research suggesting that vegetation diversity after goat eradication was markedly different from its state prior to invasion, and in a $350,000 project financed by the Galápagos Conservancy, in 2010 Pinta was repopulated with 39 giant tortoises from Española Island. The animals were equipped with radio transmitters for tracking, and sterilized so that if genetically pure members of the population are found in the future these tortoises cannot breed with them (Barry, personal communication 2010). While the use of a functional substitute for Pinta's giant tortoise population is a commendable step in habitat mitigation, other examples such as those in Table 2.4 raise important questions about the utility of the current management paradigm. "Is the concept of naturalness," Cole et al. (2008) ask, "still sufficient to guide protected area stewardship?"

Table 2.4. Native/introduced mutualisms, doubtful natives and habitat restoration blur the boundaries between native and non-native, pure and human-altered nature.

Conservation challenge	Source	Quotes
Introduced caltrop pods sustain Darwin's finches during periods of drought; seeds also enlarge with finch predation	Weiner 1994: 65	"The finches may be driving the evolution of caltrop while caltrop is driving the evolution of the finches"
Plant fossils show that a species of hibiscus thought to be invasive predates the arrival of humans	van Leeuwen et al. 2008	"The risk of applying inappropriate management to what are in fact native species is highlighted by these results"
For 51 plant species, classification of introduced and native differs based on early recorded observations	Tye 2006	"[T]he majority of them were recorded so early that their status is uncertain; we do not know whether they came on the feathers of birds or the socks of pirates"
Native Galápagos hawk population declines following eradication of invasive feral goats from Santiago Island	PiperNotes 2008	"[C]hanging the habitats where those species were living with goats through the last century may change our understanding of the ecology of these islands"
Endemic giant tortoises transport seeds from invasive plants into protected areas	Blake, personal communication 2009	"[I]f they're moving invasive species 15 kilometers and they're moving thousands of seeds every month, that's important for management"
Feral goat eradication facilitates vegetation overgrowth in the absence of giant tortoises	Quiroga 2009	"Although restoration efforts in the Galápagos were successful in different ways, they also caused unexpected consequences in the environments being restored"

The isolation of oceanic islands, island biogeographers maintain, holds the number of species present at a relatively steady state; that is, extinction and introduction rates are roughly balanced out by each other. This makes island tourist destinations like Galápagos particularly susceptible to invasion, because human traffic has increased colonization rates of non-native species, thereby destabilizing the island equilibrium. Although there are invasion scholars who argue that some island introductions should be viewed positively as increasing local species richness (Brown and Sax 2004; Larson 2008), there are numerous cases in which an invading species has directly caused the extinction of a native one.[9] In those situations, ecosystem restoration efforts (through eradications or

[9]Perhaps the most dramatic example of species invasion is provided by our own, which has brought extinction to scores of plants and animals worldwide through colonization, hunting and disease. In Galápagos, human-induced extinction rates have remained fairly low: six of the 109 endemic and native animal species in the

control measures) are often considered to be the most appropriate recourse by environmental managers.

But as some critics argue, "ecological restoration legitimizes further human intervention into nature. Restoration thus not only gives license to continued ecological transformations, since we believe that we can always restore them later, but also it distracts from what they see as the more important work of wilderness preservation" (O'Brien 2006). The creation of a 'false', or partly human, nature is problematic for those who wish to maintain a rigid binary between nature and culture, but has been applauded by environmentalists who wish to see greater recognition of the productive capacity for humans with nature. Restoration efforts are also criticized for reinforcing xenophobic sentiments through the deployment of terms like 'native' versus 'aliens', 'exotics', and 'invaders'. In the most extreme circumstance, some campaigns against non-native species are reminiscent of Nazi gardening concepts or anti-immigrant sentiments (Pollan 1994); as Donna Haraway writes, "my own suspicious hackles are raised by restoration ecology's potentials for deepening nativism and xenophobia" (Haraway and Harvey 1995). The 'alien' metaphor in Galápagos environmental discourse closely identifies non-human environmental agents with humans, where the "struggle now to cope with the hordes of invading alien species" comprises the bulk of the effort to return Galápagos to its pre-human state (CDF-and WWF 2002). Under the current politics of invasion, newcomers, both human and non, are viewed as a critical threat to community stability, and they are intermixing at a moment when access to the islands is higher than ever.

Illegal Migrants and Behavior

With the human and environmental conditions of the archipelago so closely intertwined, at the end of the twentieth century conservation institutions began to focus more closely on population growth and impacts. Since colonization, each of the four inhabited islands has experienced a very

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islands were extinct prior to 1535, while another seven have disappeared since that time (Jiménez-Uzcátegui et al. 2008).

different trajectory of population growth. In contrast to Santa Cruz's late colonization and rapid growth, Floreana Island was the earliest settled, but now has the smallest population (fewer than 120 residents) and is only infrequently visited by tour groups and cargo vessels. Since the 1970s, Isabela's population has increased five-fold, from 450 to around 2,000, while San Cristóbal's resident population has only tripled to approach 8,000. Meanwhile Santa Cruz has seen an almost 10-fold increase in the number of island residents to around 12,000, reflecting the fact that particularly during the height of fisheries and tourism development in the 1980s and 90s, population growth rates were over 6% per year, corresponding to a doubling time of only 11 years (Proaño and Epler 2008).

Throughout this period of growth, the overall age of the Galápagos population increased, along with the average skill level (Kerr et al. 2004). The primary sending area was the coastal province of Guayas, an area of high population density and a large portion of residents engaging in fisheries or related industries. Poorer provinces with low amenities made up the remaining migrants, who came to the islands seeking a higher quality of life and cultural tolerance (Fundación Natura and TNC 2000). In contrast, a much lesser trend of out migration to the mainland occurred primarily among those seeking higher education or economic opportunities not available in the islands (Kerr et al. 2004). In summary, the 1990s were a period during which growth outpaced regulations, leading to crowding and crime in the urban areas of Santa Cruz and San Cristóbal, deficiencies in solid waste and water management, and other problems with civil infrastructure (Heslinga 2003).

In an attempt to restrict population growth the 1998 Special Law added a legal existence to a physical one, dividing Ecuadorian citizens into residents of the mainland provinces or those of the islands. When legal Galápagos residency was established as part of the Special Law, therefore, illegal status was assigned to many mainland residents who wished to call the islands home, justifying their removal under the banner of biodiversity protection. The Law stipulated that only those who had lived on the islands for five consecutive years before or within five years after it was passed were eligible to apply for permanent residency. Other Ecuadorians seeking work in the lucrative economy can acquire a temporary residency permit that is valid and renewable for one year at a time, provided

they have a contract with a local employer. Tourists and business visitors are allowed to stay for 90 days, and those who remain in the islands after their time is up will be deported to their place of origin.

The Special Law was a landmark piece of legislation that, in part, sought to alleviate residents' concerns about the security of their livelihoods with the influx of recent migrants. It also served to reframe concerns about the impacts of tourism to more general population effects, and while the 2007 crisis declaration acknowledged tourism's tight linkage with undocumented migration and human population impacts in the islands, many scientists and policy makers do not.[10] A decade after the Law was passed Galápagos Conservancy President Johannah Barry maintained, "The problem is not so much the number of tourists as the ancillary economy that's going up around it. It makes sense to limit the strain" (Carroll 2008). A CDRS scientist agreed, "We're not worried about the numbers of tourists, per se, but the indirect impacts – the houses, the food, the imports" (personal communication 2010). In 2001 the CDF reported that nearly 1,200 Ecuadorians living illegally in the Galápagos Islands had been deported to their own country in 2000. In 2007 INGALA began issuing an electronic Transit Control Card to all residents and visitors to the islands and in 2008 a record number of over 2,000 Ecuadorians were forced to return to the mainland, a trend that has continued in the years since (Sotomayor, personal communication 2010).

Not surprisingly, Ecuador's measures to limit population pressures by targeting its own citizens have made international news. Rory Carroll (2008) writes in The Observer, "Checkpoints and patrols have been set up to catch illegal residents who are then marched onto aircraft and flown 600 miles east back to the mainland. … However, there are no plans to curb the soaring number of tourists – mostly well-heeled Europeans and Americans who visit for a few days – which this year is set to reach 180,000." In an interview with the Los Angeles Times (Kraul 2008), the Ecuadorian

[10]Representatives of Galápagos conservation organizations often consider park officials, tourists, and tourism acceptable human influences, but not local populations. Although they rightly point to a history of unsustainable resource extraction by local communities, they do not acknowledge the similarly poor environmental track record of tourism (cf. Terborgh and van Schaik 2002).

Environmental Minister, Marcela Aguiñaga, reported that the tourist industry was not "oversaturated", and emphasized the need for tighter migration legislation and controls. Headlines such as "Galápagos Islands: Is there room for humans in 'nature's laboratory'?" (Miller Llana 2009) continue to raise eyebrows as Correa's self-described green environmentalism and populist political platform come under close scrutiny in the political waters that surround Galápagos.

Unlawful environmental behavior such as poaching is another major concern that conservation institutions have for the development of responsible communities. One of the primary places where this occurs is within the Galápagos Marine Reserve, with the presence of numerous illegal sea cucumber camps in the early 2000s and more recently, shark finning. The GNPS currently operates 11 marine patrol boats, three of which are suitable for long-range ocean operations, and one hydroplane for aerial monitoring of the marine reserve. As Reyes and Murillo (2008) note, however, there are only enough crew personnel to staff half of those vessels, and the deficit results in inadequate patrols. Furthermore, the GNPS has a small legal office and has not traditionally imposed maximum fines for illegal fishing ($4,000) on those convicted of committing infractions. The licenses for local fishermen who engage in serious offenses are not to be renewed, according to marine reserve regulations, but this too has been somewhat loosely enforced (Murillo, personal communication 2010).

Poaching within the marine reserve, in defiance of legal restrictions on livelihood activities, has been matched by protests and violent demonstrations. On several occasions since the 1990s, fishermen and their supporters have taken over the offices of the GNPS and CDRS, threatening to kill giant tortoises and ransacking the homes of local Directors in response to the failure of those organizations to provide communities with economic alternatives to offset restrictions on fishing calendars and catches. Finally, there is a third category of unlawful environmental activity that occurs in reaction against conservation-related regulations perceived as outdated, unnecessary or inequitable. Some of my older informants recalled stories from their parents or grandparents at a time when giant tortoise meat was served to commemorate holidays or special occasions such as weddings and

funerals. Those practices are now forbidden – the killing of a giant tortoise carries a hefty fine and jail sentence – but from time to time GNPS employees find the animals gutted and strategically placed near park trails, as though the person behind the act wanted their defiance to be known.

For many of the legal and illegal human inhabitants of the archipelago, the façade of Galápagos tourism and economic prosperity is all too clear. The cost of living in Galápagos is three times that of the mainland, and although imported goods and supplies such as food and gasoline are subsidized by the government, products are high-priced and often limited in availability. The basic healthcare facilities on each inhabited island are not equipped to handle most medical needs beyond minor surgeries, but flying to the mainland for hospital attention is not a financial option for many residents and migrants. Because the majority of tourism-related income remains in the hands of wealthy mainland or foreign-based tour operators, per capita income in Galápagos increased by less than 2% per year between 1999 and 2005, due largely to migration-induced population growth. "In real terms," write Taylor et al. (2006), "income per capita almost certainly declined." And despite years of promises and popular platforms for municipal elections, none of the islands have potable water or wastewater treatment, resulting in frequent intestinal problems and skin diseases, especially among women and children. In the meantime, the permanent resident population alone is projected to increase to over 100,000 by 2030, if current growth rates hold (Proaño and Epler 2008).

Conclusions

This chapter traced the linked human and natural histories of the Galápagos Islands, showing how their invasion by plants, animals and people is as much a consequence of ecology and mobility as it is of scientific valuation of particular places and species. The naturalness of Galápagos drives the multi-million dollar industry that threatens to destroy it; yet the revenue that tourism generates for conservation makes it critical to maintain the illusion of nature unadorned. As the following chapters will demonstrate, this maintenance has sometimes reinforced the conditions of possibility for invasion by alien organisms and undocumented migrants. Nevertheless, there is a growing recognition that

patrolling the boundaries between groups of plants, animals and people cannot always keep them in place. “Galápagos has never been a paradise under glass,” concluded one visiting researcher in 2009. “But here we are, projecting a pristine myth onto a landscape that has been irreversibly altered by people, when there is no pristine, stable ecosystem to get back to. What’s important now is to develop realistic policy goals and the means to achieve them, not by the erasure of every inconvenient reminder of humanity.”

Contemporary population growth and the introduction of non-native species remains directly tied to the tourism industry, however, and although the GNP has advocated setting limits on the number of tourists entering the islands for decades, local municipalities contend that industry development is vital to realizing the goals set forth in the Special Law. “In every protected zone there are some problems,” says GNPS Director Edwin Naula (personal communication 2010), “but the main thing is to be prepared to tackle the problems. But these are mainly coming from outside the zones where the local people live, so we have to better manage the population and develop adequate politics for both populated and protected zones.” Naula had recently assumed his position as Director, and expressed a desire for effective leadership that ensures long-term conservation of the islands while emphasizing the provision of local economic growth and stability. The case studies presented in the chapters that follow will begin to put forth unique solutions to the very real environmental problems that Galápagos is facing, embracing the humanity of island nature rather than erasing it.

Chapter 3: Invasion and Eradication of Feral Goats in the Alcedo Region of Isabela Island

I feel an anguish at the thought of losing something unbelievably valuable. I have visited Alcedo before, years ago when there was no sight or sound of goats. Today, they are within a stone's throw of that delicate landscape of evergreen *Scalesia*, within a moment of a small tortoise seeking a few blades of grass under a crystal-blue sky. … I believe that it would be worth the clattering roar of helicopters, the chatter of guns, the movement of many people, and the endless inversion of money to ensure the survival of this milieu *Galapagueño* before it is too late.
Godfrey Merlen, 1992

The only good goat in Galápagos is a dead goat.
Project Isabela hunter, 2007

Introduction

It is generally believed that pirates and whalers first introduced goats (*Capra hircus*) to the Galápagos Islands during the 1600s and 1700s, and they were later brought to the islands by settlers who raised them in the highlands as livestock (CDF 2006b). Escaped, feral goats were known to be present on Isabela Island's Alcedo Volcano in small numbers by the end of the 1970s, but it wasn't until the 1990s that Alcedo's goat population suddenly began to multiply. Visiting scientist Stephen Herrero noted a few animals in 1989 and immediately called for their removal (1990), and when biologist Godfrey Merlen visited the Alcedo region in 1995, he discovered hundreds: "It was total chaos" (Guo 2006). The 'milieu *Galapagueño*' Merlen describes above is the Isabela Island subspecies of the Galápagos giant tortoise (*Chelonoidis nigra vicina*),[11] whose numbers dwindled in the late twentieth century due to habitat destruction by feral goats. Concerns in the late 1990s about the goat threat to tortoise populations and native plant species led to the development of Project

[11]At one time there were at least 10 subspecies of the Galápagos giant tortoise, seven of which remain in existence. Alcedo's giant tortoises were formerly known as (*C. n. vandenburghi*). Isabela Island was thought to have five unique subspecies that inhabited different volcanoes, but they have since been shown to have dispersed from southern Isabela's populations near the Sierra Negra volcano and are now all known as *vicina* (Ciofi et al. 2006).

Isabela, a mammal eradication program that was designed and executed at a previously unmatched scale.

Although the full project included feral goat, donkey and pig eradications from central and southern Isabela Island, and all of Santiago Island, this chapter traces 11 years of Project Isabela's planning, deployment, and aftermath in the Alcedo region from above, using coarse-resolution satellite imagery, and below, through interviews and *in situ* vegetation surveys. With an $8 million budget, it employed dozens of trained hunters and a team of eradication professionals from New Zealand to exterminate over 100,000 goats, making Project Isabela the largest successful mammal eradication campaign in the world to date. The central questions that guide this chapter are:

1) How can we evaluate large-scale vegetation changes through periods of disturbance like mammal invasions and eradications? And;

2) What are the impacts of attempts to restore environmental systems to a pre-disturbance state?

Henderson and Dawson (2009) recently used normalized difference vegetation index (NDVI) data from the National Oceanic and Atmospheric Administration's (NOAA) Advanced Very High Resolution Radiometer (AVHRR), a multispectral satellite sensor system with a 1.1 km spatial resolution, to identify zones of vegetation loss in the Alcedo region prior to goat eradication. This chapter extends their analysis to link remotely sensed vegetation indices with ground data on the presence of feral goats to identify regions of vegetation reduction or regrowth throughout invasion and eradication. Interviews with project personnel and *in situ* vegetation monitoring complement this large-scale spatial analysis to interpret technical challenges faced by the Project Isabela team and post-eradication changes on Alcedo at the landscape and species-level.

In evaluating Project Isabela from the air and on the ground, this chapter also demonstrates the power that beliefs about nativeness and pristine nature wield in conservation practice. Animal invasions and eradications exemplify the very real material consequences of such beliefs, which may extend far beyond project expectations. Put another way, eradicating or controlling any invasive species is rarely an 'end' in itself – the goal is to restore habitats by removing particular, and

unnatural, threats to the native flora and fauna. But based on the modern, Western conception of nature as that which is not human, the enormous modifications the Alcedo region underwent due to goats and humans embody two conservation paradoxes that are present in Galápagos. Quiroga (2009) has demonstrated how the 2007 crisis declaration calls attention to the paradox of pristine nature under siege, invaded not only by mammals but also by plants and humans. Similarly, environmental managers become engaged in what White and Bratton (1980) refer to as "the paradox of preservation," in which human involvement in the return of a landscape to a pre-human state violates the pristine assumption in the first place. In describing the effects of goats, tortoises, people, seasons and plants on Alcedo, this chapter raises important questions about the use and utility of nativeness and pristine nature in the invasion/eradication narrative, and conservation politics more generally.

Mammal Invasions on Islands

Mammals such as cats, rats, foxes, goats and pigs that are brought intentionally or unintentionally to island ecosystems can have a particularly devastating effect on native plant and animal species where prior competition for resources was almost non-existent (Nogales et al. 2004; Croll et al. 2005; Cruz et al. 2005; Jones et al. 2005; Krajick 2005; Maron et al. 2006; Knowlton et al. 2007). Globally, the success of mammal invasion control and prevention measures varies widely, and recently a commercial industry has been developed around the elimination of such animals from island ecosystems, "preventing extinctions", as the website for one NGO advertises (Hilton and Cuthbert 2010; Island Conservation 2010).

Animal eradication as a restoration technique had its start during the 1960s, when the New Zealand Department of Conservation began training residents to hunt deer, goats and pigs, testing eradication and control measures on many of the country's small islands. They developed aerial hunting techniques in the 1970s and soon became international leaders in the removal of invasive animals. As Science Magazine reported in 2005, "Every day around the world, terminators are pursuing human-introduced creatures accused of threatening island biota" (Krajick 2005), and

California-based Island Conservation claims to have restored 35 islands, promoting the protection and survival of 73 endemic species and 750 bird, mammal and reptile populations (Island Conservation 2010). In spite of the rapid development of new invasive control and eradication techniques at the end of the twentieth century, Donlan (2003) and Phillips (2010) have recently expressed concern about the lack of available eradication data. GIS and spatial information, in particular, have been under-utilized in maximizing eradication efficiency and assisting in the analysis of results (Lavoie et al. 2007a).

Species invasions and their eradication involve a constellation of interacting agents: in the case of Project Isabela a population of wild and invasive goats, native and threatened plants and animals, and the members of conservation groups make up the complex arrangement that plays out across a protected, yet degraded, national park landscape. Although eradication specialist Bruce Coblentz argued in 1991 that "it is clear…that benefits [of invasive species] to humans can easily be exceeded by the costs to biodiversity, and in many cases benefits to humans are either short-term or marginal at best" (Coblentz 1991), more recent campaigns to eradicate invasive animals from islands inhabited by humans have been met with numerous operational challenges, forcing environmental managers to weigh the ecological benefits of eradication against social and economic costs (Bath 1999; Genovesi and Bertolino 2001; Blackburn et al. 2004; Blackburn et al. 2010; Oppel et al. 2011). In addition to social considerations tied to populated islands, the presence of nearby populations of domestic animals risks recolonization of areas that had previously been declared pest-free. The indirect effects of eradications, too, can potentially be devastating to islands (Courchamp et al. 2003; Rayner et al. 2007). As Oppel et al. (2011) write, "[E]ffective biosecurity and quarantine measures must be strict enough to greatly reduce the probability of colonization by animals other than the target species." Because ecosystem interventions are an inherently social endeavor, carefully-planned management interventions that attend to public policy, prioritization, technical feasibility, and cost-effectiveness are vital to the success of their efforts (Zavaleta 2002; Bergstrom et al. 2009).

Methods

Study Site and Background

Isabela's five large shield volcanoes dominate the landscape during travel to the western part of the archipelago. Rising 1,128 m in elevation, Alcedo stands out in the center of the island, with a 7 km wide caldera and steaming fumaroles (Figure 3.1). The volcanic crater is situated along a transition zone between the moist windward (southeast) slope and the dry leeward (northwest) slope of the volcano. At higher elevations, there are three broad vegetation types. The humid forest, or 'Scalesia', zone is comprised of cloud forest-type vegetation and dense shrubs dominated by *Scalesia microcephala* forest, *Zanthoxylum fagara*, mosses and bromeliads, primarily along the volcano's windward crest (Itow 1995). Above the tree line, the summit areas of the Alcedo volcano have been altered from a 'green zone' to a 'pampa' characterized by ferns and sedges due to the grazing activities of feral goats (Desender et al. 1999). A trail leads upward from the eastern coast, passing through sparse *Scalesia* forest before giving way to native *palo santo* trees (*Bursera graveolens*), nettle tree (*Trema micrantha*), and herbs and grasses near the crater's edge. Despite the fact that Alcedo was visited semi-regularly by tourists until the late 1990s, Shimizu noted in 1995 that there were no introduced trees or shrubs found in the area (Shimizu 1997). Vegetation patterns in Galápagos are highly influenced by two primary seasons: summer (January to June), characterized by frequent downpours, and the *garúa* (July to December), or misty, season, dominated by cooler temperatures and low rainfall. As in the archipelago's other highland zones, vegetation across the higher-elevation zones of Alcedo is generally more abundant during the summer, and declines in the *garúa* (Aldaz and Tye 1999).

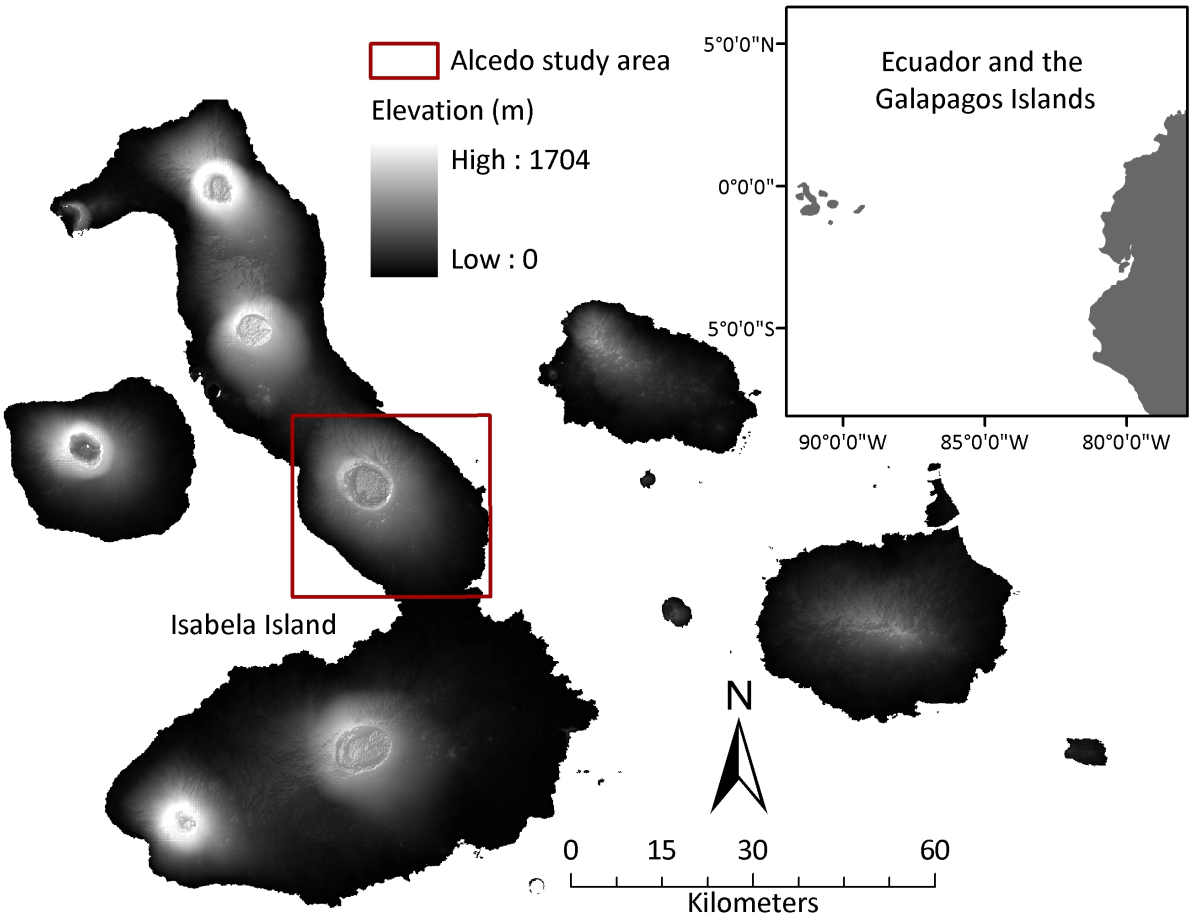

Figure 3.1. The Galápagos Islands and Isabela Island's Alcedo volcano (left center box).

The effects of goats on islands have been well documented (Oliver 1910; Coblentz 1978; Haberle 2003; Lowney et al. 2005). Capable of reproducing up to four times a year, feral goats denude vegetation in the same manner as pigs, destroying foliage that is more than a food source for native animals like land iguanas and giant tortoises – its shade also allows rainwater pools to form (Kaiser 2001). Goats in Galápagos primarily eat five plant species, dominated by the native *Blainvillea dichotoma* (Muñoz 1993). They trample the ground, causing erosion and damaging tortoise nesting sites (Figure 3.2), and habitat degradation by goats affects other native bird, insect and plant species in the Galápagos, as well (CDF 2006b). In the 1950s and 60s it was a common practice for fishermen to deposit pairs of goats on remote islands to ensure a food supply for future expeditions, and by the 1970s there were no less than 20,000 of the hardy, saltwater tolerant animals

in Galápagos. Their rates of reproduction and dispersal were so striking that when he retired in 1974, then-Director of the CDRS Peter Kramer commented, “I found long ago that I cannot live happily without the Galápagos Islands; even if I am not there I need to know that they exist undestroyed by goats or men” (Davies 1974).

Figure 3.2. Feral goat herd inside Alcedo’s crater, and competition with giant tortoises for scarce vegetation along the rim. Photos by Wilson Cabrera (2004).

The GNPS has targeted goats inside GNP boundaries since its establishment, eliminating them from Española, South Plaza, Santa Fe, Marchena and Rabida Islands between 1968 and 1998 (Guo 2006). Those islands’ small size contributed to eradication success, while other efforts took significantly longer. It is believed that goats were introduced to Pinta Island in the 1950s and by 1971 their numbers had grown to 20,000. Goats on Pinta were the target of multiple hunting trips per year between 1971 and 1982 and they were wrongfully declared eradicated twice, in 1985 and again in 1990 (Campbell et al. 2004). Furthermore, while evidence of the recovery of plant species that are appetizing to goats exists in the short-term (Whelan and Hamann 1989; Garcillán et al. 2008), there are few long-term studies of vegetation recovery following goat eradications (Whittaker and Fernández-Palacios 2007; Bellingham et al. 2010).

In the early 1990s Alcedo's giant tortoise population was between 3,000 and 4,000 individuals (Muñoz 1993). Because of growing concerns about the threat that feral goats posed to giant tortoise food and water resources, Alcedo vegetation monitoring of *Scalesia* and Darwin's aster (*Darwiniothamnus tenuifolius*) began in November 1995 with the establishment of 20 permanent plots (Aldaz and Tye 1999). A research team led by Konjev Desender completed a study of vegetation transects along an elevation gradient between 1986 and 1996, noting disappearing *Scalesia* forests, patches of dying tree ferns, and erosion at higher elevations (Desender et al. 1999). When Henderson and Dawson conducted their study in 2009, they found statistically significant NDVI reductions on Alcedo between 1992 and 1996, consistent with concerns over goat population growth. At that time some herds numbered more than 100 strong among Alcedo's grasslands and along hills, and the first ground hunting campaign was carried out on Alcedo between 1996 and 1997, during which over 30,000 animals were killed (CDF 1998).

The conclusion of the hunting campaigns coincided with a second letter from Herrero (1997), which again called for immediate and drastic measures to be taken to eradicate goats on Alcedo. Herrero cited recent successes on small islands in the archipelago, such as Pinta, but Coblentz responded by maintaining that more research and management planning was needed given Alcedo's large size and difficult terrain (Coblentz 1997). Coblentz reminded critics that Isabela Island is more than 10 times the size of Lanai'I Island in the Hawaiian archipelago, which was the site of the largest successful goat eradication project at that time.

In 1982 a strong climatic phenomenon swept the middle Pacific, affecting nearly every aspect of the archipelago's terrestrial and marine systems (Itow and Mueller-Dombois 1988). Followed by an even more severe event in 1997/1998, these two occurrences, known as El Niño, increased the overall vegetation density in Galápagos and specifically along the upper slopes of the islands' volcanoes. The 1997/1998 event also facilitated the germination of introduced plants such as arrowleaf sida (*Sida rhombifolia*) and knobweed (*Hyptis rhomboidea*) in the Alcedo region. Increased biomass as a result of El Niño conditions may have contributed to the dispersal of Alcedo's growing

goat population, alleviating pressure on the southern rim where herds appeared to concentrate, but this also appeared to increase their reproduction (Aldaz and Tye 1999). According to Project Isabela technician Karl Campbell (1999), the El Niño event temporarily slowed the process of vegetation loss on Alcedo, but the presence of goats continued to expand in the region. Members of the Galápagos scientific and conservation community began to discuss the possibility of eradication, with a focus on New Zealand's recent aerial hunting successes.

Satellite Image Collection and Pre-Processing

For the spatial analysis component of this chapter, Moderate Resolution Imaging Spectroradiometer (MODIS) satellite data were obtained from the Earth Science Data Interface at the Global Land Cover Facility. MODIS data products are freely available and span from the time of the sensor's launch in 2000 to the present day. The dataset contained 253 16-day enhanced vegetation index (EVI, Equation 3.1) composites over the Alcedo region of Isabela Island between February 2000 and December 2010, at a spatial resolution of 500 meters. The images had previously been radiometrcially calibrated, and were atmospherically and geometrically corrected. EVI is a standard vegetation index product, with improved sensitivity to canopy structure, background and atmospheric noise when compared to NDVI (Heute et al. 2002). MODIS data also exhibits improved atmospheric and cloud screening over AVHRR products, its predecessor in studies of global vegetation productivity (Zhang et al. 2008).

$$\mathrm{EVI} = \mathrm{G\ x}\ \frac{(\mathrm{NIR} - \mathrm{Red})}{(\mathrm{NIR} + \mathrm{C1\ x\ Red} - \mathrm{C2\ x\ Blue} + \mathrm{L})} \qquad (3.1)$$

Where G is the gain factor, NIR/RED/Blue are atmospherically-corrected (Rayleigh and ozone absorption) surface reflectances, L is the canopy background adjustment, and C1, C2 are the coefficients of the aerosol resistance term, which uses the blue band to correct for aerosol influences in the red band. The coefficients adopted in the MODIS-EVI algorithm are G = 2.5, C1 = 6, C2 = 7.5 and L=1.

Residual cloud cover not removed by the EVI algorithm frequently results in data values being artificially higher or lower than normal. To reduce this artificial cloud noise a Fourier

transformation was applied to the images using a Harmonic Analysis of Time-Series (HANTS) algorithm, which removed cloud-affected pixel values from 16-day intervals and replaced them with interpolated values from images within a close neighborhood and timeframe (Wen et al. 2010). To account for the seasonality of vegetation patterns, pixel-by-pixel annual maximum EVI values were extracted for the summer (12 images per year) and the *garúa* (11 images per year) seasons. Images were co-registered to form two 11-year image time series that span the preparation, execution and aftermath of Alcedo's goat eradication effort.

Goat Density Calculation

GPS points corresponding to goat kill locations were collected by GNPS personnel during ground and aerial hunting phases of Project Isabela, and a subset of the aerial hunting dataset (11,320 points) was acquired following project completion. All of the points acquired were collected between January and May of 2004 and 2005, when over 90% of the aerial hunting at Alcedo took place (Cabrera, personal communication 2009). Although they do not comprise the complete database, the points represent the spatial distribution and density of over 22,000 animals and are used as a proxy for the presence of goats and denuding potential of the large herds that were present by the mid 2000s. Using ArcMap software, a goat density raster was created by building a 2 km buffer around each point, corresponding to Galápagos herd ranges observed by Muñoz (1993). The raster resolution and size of the density surface were matched to the 500 m MODIS EVI dataset, resulting in goat density values for every pixel in the Alcedo study area. Using ENVI image analysis software, an unsupervised Iterative Self-Organizing (ISO) classification was performed on the density raster to group pixels into six goat density zones, based on the total number of goats killed inside each 2 km buffer.

Statistical Analysis

Once the goat density zones were defined, Durbin-Watson testing (Durbin and Watson 1950, 1951) within seasonal datasets was carried out using SAS statistical analysis software to test for

temporal autocorrelation, or heterodescascity. Put simply, temporal autocorrelation implies that the observations in a time sequence are not independent, violating assumptions used to test for statistical significance by most regression models. This is a common problem with data that display a high degree of variability associated with seasonal fluctuations, such as temperature, rainfall, or vegetation growth and die-off, making comparisons between data values collected during different seasons inappropriate. Separating the MODIS EVI datasets by season, however, was successful in eliminating the high level of dependence between summer and *garúa* EVI values at a given pixel. Therefore, two image 'stacks' were generated over the Alcedo study area that contained 11 (annual) EVI values for each 500x500 m pixel. Pixel-based Ordinary Least Squares (OLS) regressions were then performed on the separate summer and *garúa* image time-series. Negative or positive EVI trends over time were isolated at a significance level of $p<0.05$, and significant pixels along with r-square values are reported by goat density zone.

Qualitative Analysis

Open-ended interviews were conducted in Galápagos, on the Ecuadorian mainland and in the United States with 16 members of the project including eight GNPS employees, six ground personnel and two project leaders. Interviewees were identified through a snowball approach, beginning at the main GNPS office in Santa Cruz Island in the department of invasive mammal control. Early informants identified other members of the Project Isabela team who were subsequently contacted and interviewed. This method was chosen because involvement in the project spanned continents and institutions, and its duration led to high turnover in management and staff. Interviews were generally guided by the informants and often concerned their personal experiences in the field. GNPS employees who were involved in ground patrols were asked to describe vegetation patterns prior to, during and following eradication, and detailed information regarding planning and deployment was requested from project leaders.

Vegetation Monitoring

Archival reports and peer-reviewed studies of the invasion and spread of goats on Alcedo, along with *in situ* studies of vegetation patterns, were acquired from the CDRS Library and online sources. The GNPS and Ecuador's Center for Remote Sensing of Natural Resources (CLIRSEN) used NDVI values from 2000 satellite imagery and vegetation survey data collected in 2006 to produce classifications for the entire archipelago. The classified maps covering the Alcedo region were digitized and spatially joined to points that represented significant negative and positive EVI trends to isolate vegetation degradation or recovery zones. Summary statistics were generated based on the number of significant EVI change pixels within each zone. After Project Isabela's ground and aerial hunting campaigns were complete, in June 2007 I visited the Alcedo region of Isabela to observe vegetation regrowth accompanied by two colleagues and three GNPS employees. Twelve GPS points and photos were collected along the edge of the crater, which corresponded to native vegetation and zones of recovery as identified by our guides and GNPS-CLIRSEN classifications.

Results

Project Isabela Deployment

In September 1998, an international workshop was held that included a field excursion to the rim of Alcedo, followed by logistical and financial planning sessions (CDF 1998). Goats had been eradicated from over 120 islands worldwide, and new technology and techniques such as GPS, radio telemetry and 'Judas' goats[12] were being developed to ensure that island size was no longer an insurmountable obstacle. The 16 participants drafted a detailed eradication plan that totaled $8.5 million, bringing together the world's best techniques and tools (Lavoie et al. 2007a). As Johannah Barry recalls, "At the beginning of the workshop…well, we weren't sure. At the end it was agreed

[12]Project Isabela exploited the highly social nature of goats by releasing feral goats that had been fitted with telemetry collars. They differed from 'traditional' Judas goats in that they were previously sterilized and in the case of females, pregnancies were terminated to minimize field births. So named for their Biblical counterpart, the goats sought out other herds and were subsequently tracked, reducing the search time required by ground hunters in the later phases of the project.

that it could be done" (personal communication 2010). In 2000, the Global Environmental Facility approved a six-year, $18 million campaign against invasive species, which would include what by then was simply called 'Project Isabela' (Kaiser 2001).

Project ECU/00/G31, "Control of Invasive Species in the Galápagos Archipelago," was implemented by the United Nations Development Programme and executed by the GNPS, CDRS, INGALA and the Ecuadorian Agriculture and Livestock Sanitation Service. To prepare for a project the size of Alcedo, the GNPS recruited approximately 40 local hunters who were issued AR-15 .223-caliber semiautomatic rifles for aerial hunting, and 12-gauge shotguns and Ruger .223-caliber bolt-action rifles for the ground crews (Cabrera, personal communication 2008; Figure 3.3). Prohunt New Zealand Ltd., a world leader in invasive animal removal, provided technical advice to the GNPS throughout the course of Project Isabela (Campbell, personal communication 2010). Specialized hunting dogs from New Zealand's Department of Conservation were also used to track goats and train Galápagos dogs not to disturb vegetation or native animals.

Figure 3.3. Aerial hunting on Alcedo. Photo by Wilson Cabrera (2004).

Some of the female Judas goats received hormone implants following sterilization to keep them cycling through estrus and attract potential mates (Campbell, personal communication 2010). Known as Mata Haris, they made up a third of the 700 Judas goats that were released across the Alcedo region, based on GPS locations of high numbers of goat kills and the GNP-CLIRSEN vegetation classifications that identified areas of high vegetation cover (Lavoie et al. 2007a). Between Alcedo and Santiago Island, Project Isabela came in under budget at almost $6 million (Barry, personal communication 2010). The aerial hunting component alone cost a total of $1.2 million, or $21 per goat (Lavoie et al. 2007b), but proved to be much more efficient than ground hunting efforts. Because aerial hunting and deployment of Judas goats comprised the majority of the effort at Alcedo, costs per hectare were much lower ($6.56/ha) than on Santiago Island ($93.79/ha) where hunters relied heavily on ground-based techniques (Lavoie et al. 2007b; Figure 3.4).

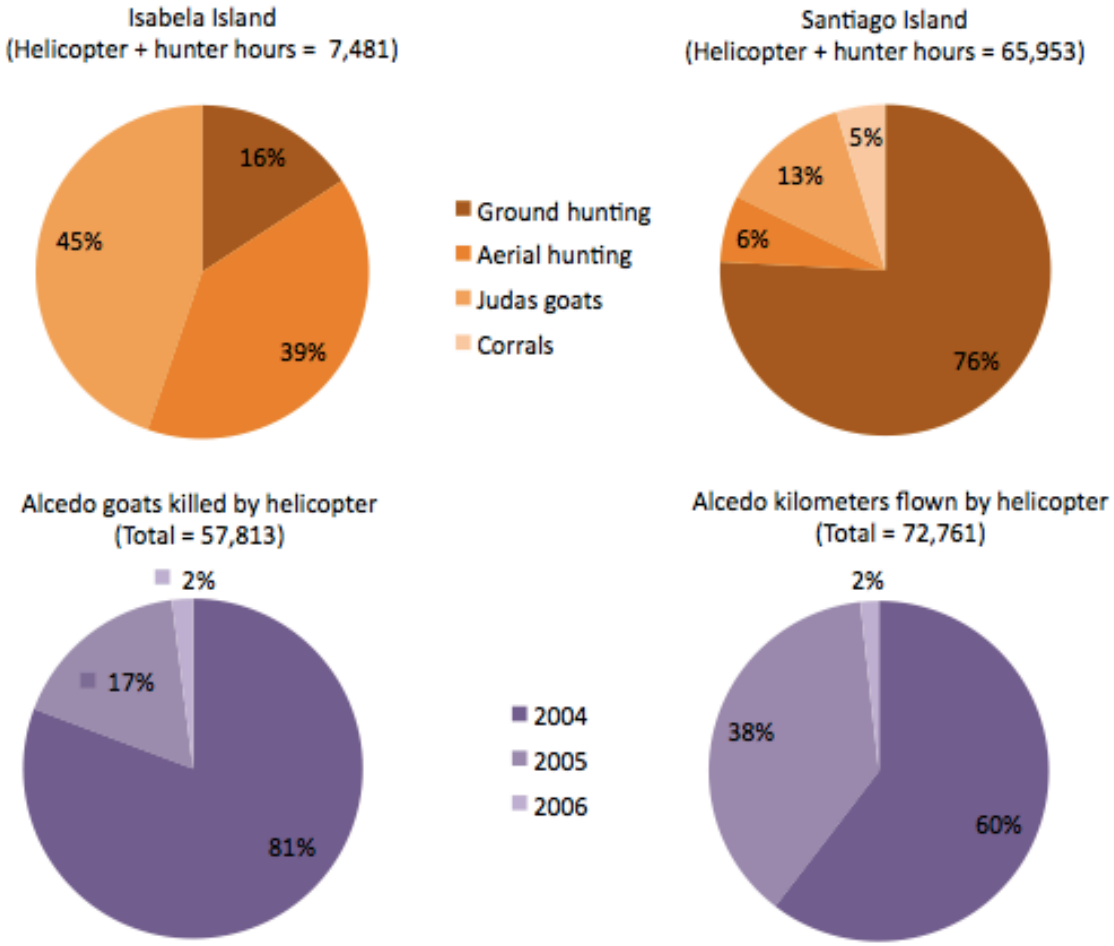

Figure 3.4. Isabela and Santiago labor allocation and Alcedo aerial hunting statistics. Source: Lavoie et al. 2007b.

Temporal Analysis

Because the Alcedo region is difficult to access, remote sensing provides a cost-effective way to evaluate landscape-level vegetation dynamics before, during and after Project Isabela. Figure 2.5 indicates the spatial distribution of goat kill locations and the goat density raster that was produced by unsupervised classification based on the number of goats killed within each buffer area. For the six zones, the range of number of kills within each zone pixel, or 2 km buffer, is indicated. For example, every pixel classified to Zone 1 contained fewer than 12 kills, while all pixels in Zone 6 contained between 95 and 145 kills.

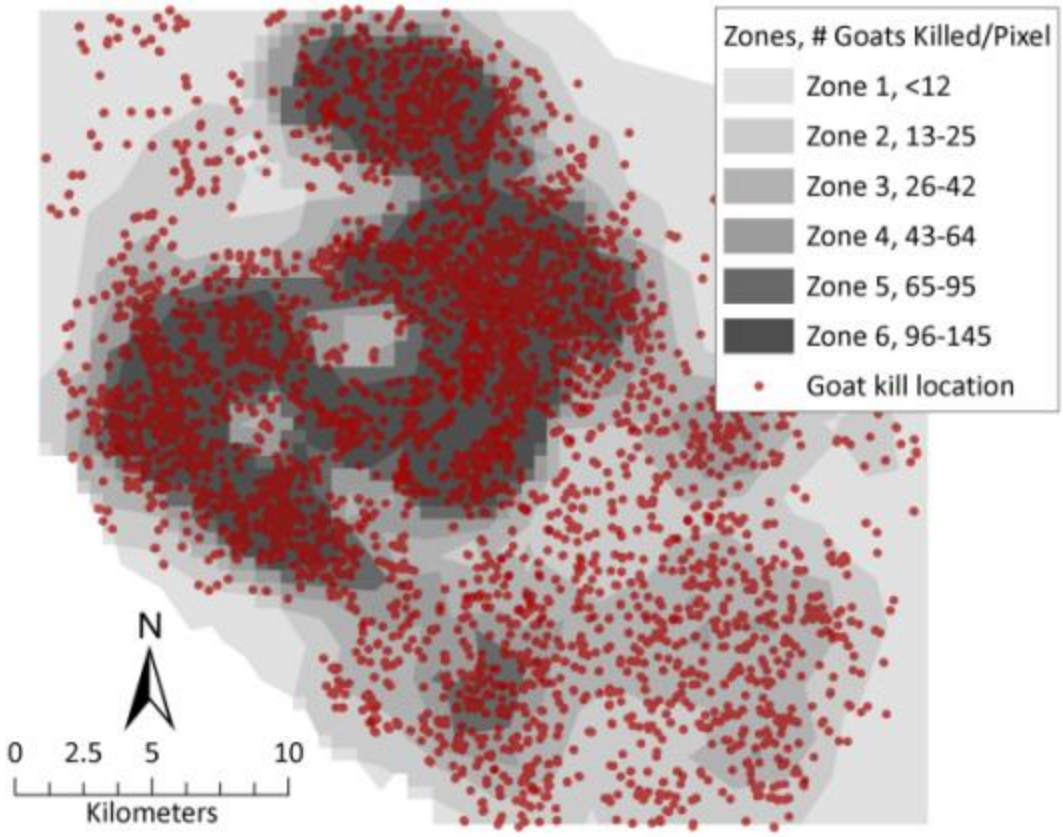

Figure 3.5. The Alcedo study area divided into six goat density zones derived from GPS locations of over 22,000 kills. Zone 1 = lowest goat density, Zone 6 = highest goat density. Each red point represents up to 11 kills.

Maximum seasonal EVI values, ranging from 0 to 1, were extracted from each 11-year seasonal image series (Figure 3.6). Seasonal EVI statistics across the six goat density zones indicate stronger vegetation variability during the summer months, when compared to the *garúa* season that typically receives less rainfall. The highest EVI values correspond to regions of high goat density (Zones 4 – 6), which is not surprising since herds tended to concentrate near areas where moisture and elevation contribute to vegetation productivity. The sharp peak in EVI in 2008 is likely related to increased rainfall during a mild El Niño season that year. Aldaz and Tye (1999) also hypothesize that subsequent La Niña-related droughts trigger Alcedo vegetation reductions, indicated by the trough in 2009.

Figure 3.6. Average maximum EVI values by goat density zone between 2000 and 2010 by season.

Statistical Analysis

Next, seasonal and per-pixel EVI patterns were extracted from the 11-year image time series using OLS Regression. Only statistically significant ($p<0.05$) seasonal trends are shown in Table 3.1. Because aerial and ground hunting on Alcedo were 95% complete by mid-2005, seasonal EVI trends were analyzed separately between 2000-2005 and 2006-2010 to account for vegetation dynamics in the presence and absence of goats. Strong negative trends are observed in the *garúa* seasons before and during eradication (r-square > 0.75 for 27% of study area), and effects increase in zones with higher goat densities (Zones 4 – 6). Herd migration is triggered by *garúa* conditions because of the lack of available food and water (Muñoz 1993), which may contribute to widespread vegetation loss in regions where the goats were not concentrated at the time of eradication (Zones 1 – 3). According to project hunters, the greatest competition between goats and giant tortoises for food also occurred during this season (Cabrera, personal communication 2007).

Table 3.1. Significant (p<0.05) pixel-based negative and positive seasonal EVI trends before/during eradication (2000-2005) and after eradication (2006-2010).

	2000 – 2005[a]		2006 – 2010[a]	
Zone	Summer/-	*Garúa*/-	Summer/+	*Garúa*/+
1	77 (8%[b])	243 (26%)	167 (20%)	69 (7%)
2	63 (8%)	281 (35%)	241 (30%)	76 (10%)
3	63 (9%)	228 (33%)	385 (56%)	109 (16%)
4	17 (5%)	178 (48%)	179 (48%)	32 (9%)
5	11 (4%)	164 (60%)	90 (33%)	20 (7%)
6	23 (4%)	405 (57%)	197 (28%)	37 (5%)
Overall	256 (7%)	1499 (40%)	1279 (34%)	343 (9%)
r-square				
<0.25	1784 (47%)	765 (20%)	667 (18%)	1178 (31%)
0.25-0.50	1180 (31%)	799 (21%)	970 (26%)	1603 (42%)
0.50-0.75	702 (19%)	1196 (32%)	1380 (36%)	851 (23%)
>0.75	125 (3%)	1031 (27%)	774 (20%)	159 (4%)

[a] Fewer than 1% of all pixels exhibited significant positive (2000-2005) or negative (2006-2010) trends and are not displayed.
[b] Percentages are based on zone pixel totals, where values of 0 were excluded from OLS regressions.

There were very few (<10%) pixels that exhibited significant vegetation declines before and during eradication in the summer months, reflecting the abundant rainfall the region receives at that time. Strong positive trends in the summer seasons following eradication indicate vegetation recovery (r-square > 0.75 for 20.4% of study area) and are primarily located within moderate density zones (Zones 2 – 4). These strong negative trends observed during the *garúa* before/during eradication, and positive trends in the summer after eradication, are also likely related to the fact that Alcedo vegetation is more abundant during the summer rainy months (Aldaz and Tye 1999).

Analysis of the entire image series (2000 – 2010), however, shows little significant positive or negative EVI change in either season (Table 3.2). The change that did occur is not dependent on goat density zones, implying it is more likely related to the normal seasonal patterns of vegetation green-up and die-off than to the presence or absence of goats. Rainfall monitoring data is not available for Alcedo, but is needed in order to separate goat impacts from seasonal rainfall in the analysis of vegetation change. Furthermore, while MODIS EVI data shows promise in its application

to future vegetation change detection and analysis, image collection began in 2000 when thousands of feral goats were already present on Alcedo. Extending the EVI dataset using AVHRR imagery from the 1990s would likely reveal more positive vegetation recovery trends overall.

Table 3.2. Significant ($p<0.05$) pixel-based negative and positive seasonal EVI trends over the entire image series (2000-2010).

	2000 - 2010			
Zone	Summer/-	Summer/+	*Garúa*/-	*Garúa*/+
1	17 (2% [a])	17 (2%)	39 (4%)	14 (2%)
2		20 (3%)	17 (2%)	3 (<1%)
3		5 (1%)	1 (<1%)	4 (1%)
4		10 (3%)	1 (<1%)	
5	1 (<1%)	17 (6%)		
6	2 (<1%)	24 (3%)		
Overall	20 (1%)	93 (3%)	58 (2%)	21 (1%)
r-square				
<0.25	3410 (90%)		3538 (93%)	
0.25-0.50	364 (10%)		240 (6%)	
0.50-0.75	17 (1%)		12 (<1%)	
>0.75			1 (<1%)	

[a] Percentages are based on zone pixel totals, where values of 0 were excluded from OLS regressions.

Vegetation Monitoring

While the MODIS EVI data product is useful for revealing large-scale vegetation patterns over the invasion and eradication period, it cannot provide insights into species-level composition on Alcedo. Drawing on endangered plant research in Hawaii and Japan (Mueller-Dombois and Spatz 1975; Shimizu 1995), Campbell and Donlan (2005) speculate that some native seed banks in Galápagos may be inaccessible to feral goat populations, facilitating native species regrowth following eradication. In June 2007 our research team visited the Alcedo region to observe vegetation recovery along the rim. Over the course of three days we covered nearly the entire circumference of the volcano, observing and recording vegetation recovery from the humid south to the arid north of the caldera. Vegetation types included pioneer grasses and residual native plant species including *Scalesia*, Galápagos guava (*Psidium galapageium*) and cat's claw (*Zanthoxylum fagara*), along with

small trees or forests of varying makeup. Our observations corresponded with expected transitions, from tall ferns, trees and grasslands in the south to dry shrubs and ferns in the north. Vegetation inside the crater was made up largely of grasses and dense ferns, with mixed forest toward the south dominated by native and endemic species such as chala (*Croton scouleri*), *Scalesia*, and *palo santo* (*Bursera graveolens*). GPS points collected along the rim confirmed the validity of the 2006 GNPS-CLIRSEN vegetation classifications, indicating that native vegetation was returning in relative abundance to areas that had previously been cleared by goat herds. Tree stumps left by goats were regenerating, although the CDF acknowledges that complete recovery of these areas will take many years (CDF 2006b).

Vegetation patterns from the 2006 survey were linked to significant EVI loss or recovery during the study period. Figure 3.7 shows that EVI reductions prior to and during Project Isabela are stronger in the north and west regions of Alcedo, areas that are typically drier and experience high loss of biomass in the *garúa*. Vegetation regrowth following eradication, on the other hand, is concentrated to the south of Alcedo's crater where rainfall and humidity are highest. Nevertheless, there is little difference between statistically significant EVI loss and recovery by vegetation zone. Between 50 and 60% of change in either direction occurred in the dense dry vegetation zone at middle elevations, which is dominated by native vegetation such as *palo verde* and *palo santo*. Regions containing primarily pioneer vegetation and sparse forest followed, which are primarily made up of grasses, chala, cat's claw and *palo santo*.

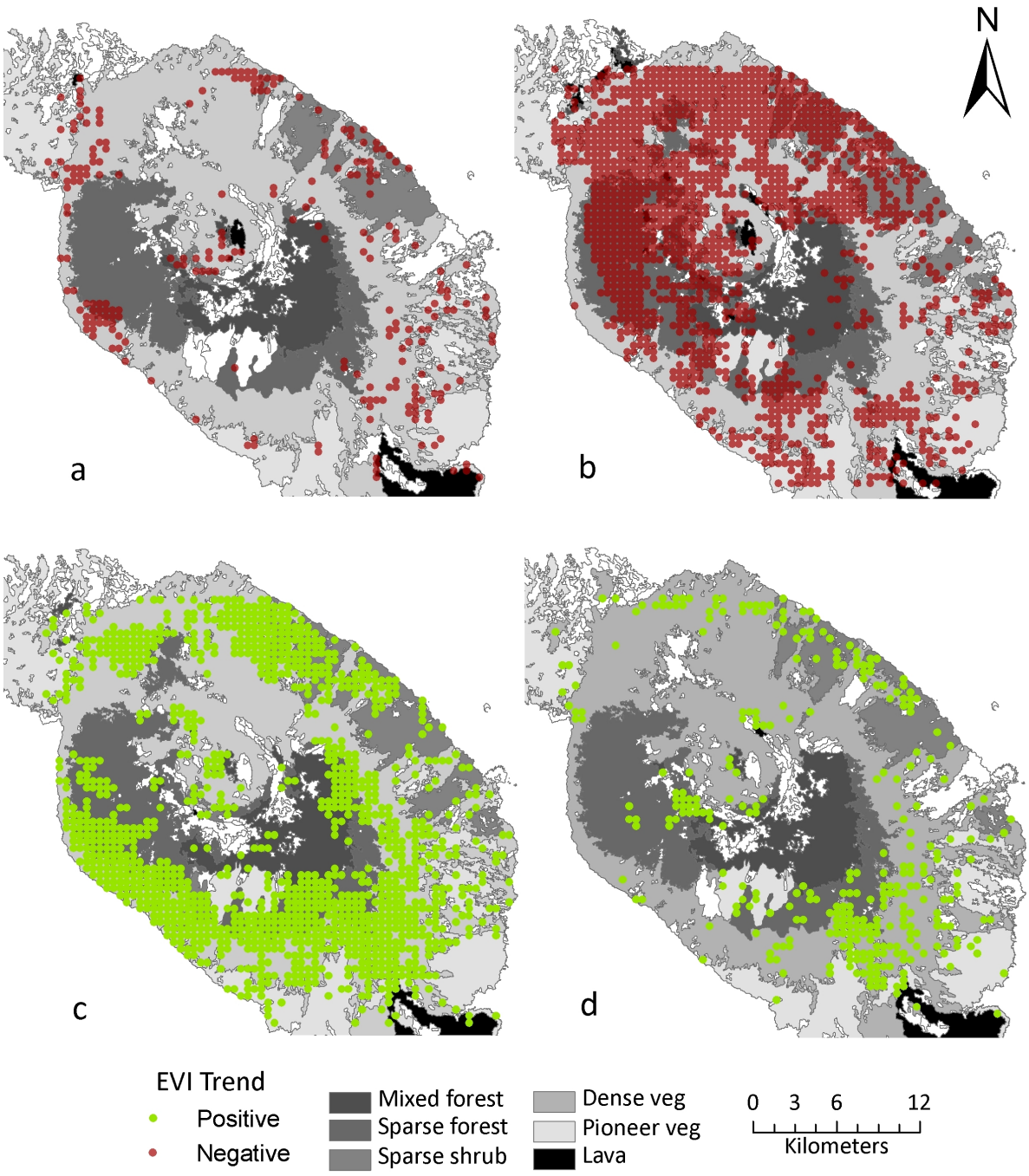

Figure 3.7. Statistically significant ($p<0.05$) EVI trends by season, before/during eradication (a = summer and b = *garúa*), and after eradication (c = summer and d = *garúa*).

Continued monitoring of Alcedo's established vegetation plots will be needed to evaluate the long-term effects of invasion and eradication. Hamann (2004) found that native Galápagos vegetation that was rare at the time of eradication of feral goats from Santa Fe Island was abundant in permanent

monitoring plots 30 years later, promising encouragement for environmental managers. Unfortunately, future *in situ* monitoring on Alcedo will be costly, as trips to the volcano are increasingly challenging. Pete Oxford, a nature photographer and former Galápagos guide, has been to Alcedo many times, but on a trip in 2008 it took him more than twice the normal four hours to reach the rim due to the dense brush (personal communication 2008). When I met one of our GNPS guides at his office in June 2009, he had just returned from Alcedo. The vegetation was thicker than ever, he reported, and soon it will be difficult to access the old trails (Cabrera, personal communication 2009).

Project Opposition and Challenges

Reports and publications about Project Isabela say little about the challenges the team faced from a constellation of stakeholders. Because the backbone of Project Isabela was international donor support, project developers had to be up front about the costs in terms of the numbers of goats that would be killed. Galápagos Conservancy President Johannah Barry explained, "Very few external NGOs wanted to be involved in killing animals. … We were clear with our donors, we were clear in the lectures that I gave – that Linda [Cayot] gave – that this is going to kill animals, and here's why" (personal communication 2010). Barry answered project skeptics with the rationale that it would cost $5,000 per goat to remove them from the islands alive, in addition to the serious hazards that the rough terrain posed to ground crews. As project leader Victor Carrión put it, "Sometimes you have to kill one animal so another can survive," (personal communication 2008).

Similar to eradication efforts on other inhabited islands (Parkes et al. 2002; Chan et al 2007), Project Isabela was met with local opposition from residents who derived economic benefits from goat hunting. "They were killing all those goats from helicopters and leaving them out there when I'm trying to feed my family," said Javier, an Isabela Island resident, in 2007. During the 1990s, Isabela residents were taken to Alcedo by boat, where they could shoot as many goats as they could carry (Murillo, personal communication 2010). But eradication specialist Josh Donlan argues that

compared to isolated hunting campaigns, "eradication is going to be cheaper. It also makes sense from an ethical perspective, because in the end you are actually killing fewer animals" (Marris 2009; cf. Myers et al. 2000; Pascal et al. 2008). Campbell agreed, adding that the thousands of carcasses would be too costly to transport, and a sudden glut in the Galápagos meat market could have put local cattle ranchers out of business. Even if the meat were sold to the mainland, it would barely meet Ecuadorian standards for dog food (personal communication 2010).

Project deployment presented still more problems, particularly during ground hunting campaigns. Hunters were offered $500 per month for up to two years, which attracted some locals who were unfamiliar with or unable to withstand the harsh field conditions. Several of the ground hunters I interviewed described a loss of morale during long field campaigns, especially on Santiago Island where the use of corrals meant herding the animals into a confined space and shooting them point blank, one at a time. Two admitted that when they were alone on field campaigns, they frequently marked the place where goats were found with a GPS point and let them go. “I hated killing those goats,” one said, “but I needed the money.” For quality control reasons, Campbell eventually required his team members to return to camp with the tails of all of the goats they killed that day.

The Reality of Restoration

In 2006 all of northern Isabela was believed to be home to more than 15,000 giant tortoises (CDF 2006b), but although it will be decades before the recovery of Alcedo’s population can be determined Project leader Felipe Cruz reported, “Project Isabela is an example of restoration of ecosystems on a scale never carried out before. … We have achieved, in record time, a reversal of the degradation processes that were occurring on Isabela Island and Santiago, improving by 60% the conservation status of the native and endemic species of Galápagos” (Lavoie et al. 2007b). Feral goats, pigs and donkeys had become “a story for the history books about Santiago and Isabela” (Cruz, personal communication 2009). Donor solicitations for the Galápagos Conservancy continue to cite

Project Isabela as the most successful and "largest ecosystem restoration project ever contemplated," and a "return to nearly pristine conditions." The GNPS issued black t-shirts to project participants, friends and family that read, "R.I.P. *Chivos* [Goats]", and a New Zealand flag still adorns one wall of Limón y Café, a popular bar on Santa Cruz Island, with the signatures of the foreign hunters who became a part of the Galápagos conservation community. Project leaders Linda Cayot and Johannah Barry are still "high on Project Isabela" today (Barry, personal communication 2010). As Lavoie et al. (2007b) write:

> We are rather like a collective Noah, deciding with a biblical coldness which life forms will be able to accompany us on our new journey in the Ark. The world state continues to get worse, but in Galápagos we still have the opportunity to reverse this trend because the human presence is fairly recent; because the impacts of the invasive species are reversible; because here we still maintain 95% of the native and endemic biodiversity; and, because of geographical isolation, we can help to protect the area with strict processes which make the arrive of new invasive species difficult. … Even though the initial [eradication] costs may be high, the final benefits are greater than the investment.

Returning Alcedo and Santiago Island to their pre-human conditions, however, is no longer a realistic goal. Eradication programs are not conservation 'ends' in themselves, but rather reflect a single (human) modification in the ongoing processes of environmental adaptation and change in those areas. Referring to Project Isabela, one Galápagos scientist responded, "The environment of the Galápagos has already been massively impacted by human activities. … The actions there now are in effect creating a simulation of original nature untouched by human hand" (Romero 2007). Ecosystem management and restoration projects are more illusory than real; that is, we do not actually restore or manage ecosystems – they are inherently unmanageable. To this end, eradication efforts do affect ecosystems in significant ways. As the GNPS learned on Pinta Island, eradication is only beneficial if goats never recolonize the area, meaning that continued monitoring for and the extermination of goats will always be necessary. They are still present in great numbers on southern Isabela, and their intentional or accidental reintroduction could mean decades of trying to make up for lost time (Krajick 2005; Campbell, personal communication 2010).

The environmental conditions of Alcedo and Santiago continue to change, and following eradication there have been unexpected interactions that were not anticipated by project developers. The Galápagos rail has recovered somewhat following goat eradications on Santiago and, to a lesser degree, Alcedo (Donlan et al. 2007). Numbers of the Santiago and Alcedo populations of native Galápagos hawks have actually dwindled since goat eradication. As the birds are predators as well as scavengers, the hypothesis is that either their access to ground prey has dropped with increased vegetation cover, or that without a steady supply of carrion meat their reproductive rates have been reduced (PiperNotes 2008). Invasive plants can gain a foothold once feral goats are removed (cf. Bullock et al. 2002), as evidenced by the increased presence of wild raspberry vines in the absence of feral pigs and goats on Santiago Island (Marris 2009).

Conclusions

This chapter assessed landscape-level vegetation changes due to species invasions and their eradication, while critically evaluating attempts by environmental managers to restore environmental systems to a pristine state. In doing so, some conflicting conclusions about how Project Isabela's success can and should be measured were revealed. On the one hand, the project effectively eliminated one major threat to local populations of native giant tortoises and vegetation, and the EVI MODIS data product proved to be a useful and cost-effective way to identify long-term vegetation trends before, during and after the goat eradication, particularly given the difficulty that distance, terrain and access pose for *in situ* monitoring on Alcedo and other similar locations. When linked with information related to a spatially-specific vegetation disturbance, such as feral goat invasion, it is possible to extract estimates of degradation and recovery from large-scale seasonal vegetation trends. The spatial analysis also implies that both invasion and eradication have had significant and distinct geographic effects on vegetation cover on Alcedo.

These results also show that the coarse resolution of MODIS satellite imagery makes long-term *in situ* monitoring necessary to accurately assess vegetation processes at the species level. It will

be many years before the impacts of Project Isabela can be fully appraised in terms of giant tortoises saved. In the absence of such certainty; however, Project Isabela continues to inspire other large-scale eradication projects. A plan is now in place to eradicate goats from the archipelago's three other inhabited islands, totaling over 170,000 ha (Campbell, personal communication 2010), and the Jamaican Goat Islands (52,000 ha) are under negotiations for goat and mongoose eradications that were previously considered impossible (Douglas 2010). A 10-island rat eradication project recently provided the "trip of a lifetime" for eradication contractors John and Bruna Oakes, owners of New Zealand's Central South Island Helicopters (Rae 2011). But the costs of eradicating hundreds and thousands of feral animals cannot always take into account dynamics between environmental managers, species and the landscape that produce unexpected, and sometimes unwanted, environmental outcomes.

During our trip to Alcedo in 2007, we saw dozens of Galápagos hawks and ruby-colored vermillion flycatchers through the wind, rain and fog. Their soaring grace against the gray sky contrasted sharply with the thousands of goat skulls and skeletons at our feet, and one of our guides mimicked shooting them with an imaginary rifle. The ground was littered with glinting bullet casings and I slipped a few in my pocket. Godfrey Merlen's words at the beginning of this chapter capture the dedication of the global environmental community to protecting Alcedo's giant tortoises at any cost, in dollars spent or in lives lost. Project Isabela was scientifically and politically appraised, along with alternatives. Ultimately, however, eradication projects achieve long-term environmental benefits only when the benefits of human inhabitants are tied to environmental gains. Without economic returns, arguments to protect biodiversity for biodiversity's sake gain little traction among the islands' residents, a theme that will be explored in the next chapter. Beyond Project Isabela, conservation politics in the islands have marginalized those who could be important allies, with associated environmental and social effects.

Chapter 4: Highland Production, Island Protection on Isabela and Santa Cruz

Introduction

Patterns of food production and consumption in the Galápagos have changed dramatically over the last 100 years. Around the turn of the twentieth century, large farming areas were established in the highlands of Floreana, San Cristóbal, Isabela and Santa Cruz Islands. The archipelago's isolation necessitated food self-sufficiency, and farms provided ample fruits, vegetables and meat to sustain the few hundred residents (Gordillo 2000). Until the 1970s and 80s farming was a major component of the Galápagos economy, but growth in commercial fishing and more recently, tourism, have caused many of today's Galápagos landowners to diversify their livelihoods or to abandon agriculture altogether.

While early agricultural practices were responsible for many of the introduced plants that are now present in Galápagos, food production in Galápagos is further crippled by the presence of many of those that have since become invasive. The majority of the islands' nearly 900 non-native vascular plants are found in the humid highlands, which are considered to be the most degraded island zones (Tye 2006; Guézou et al. 2010; Trueman 2010). Common guava (*Psidium guajava*) was introduced in the 1800s for cultivation, and its rapid spread across farmland and into the national park was facilitated by birds, cattle, donkeys and pigs. A transformer species, guava shades out other vegetation and alters soil composition, making it a threat to both native species and agricultural crops (Itow 2003: 53). Other top plant invaders, including hill raspberry (*Rubus nivius*, locally known as *mora*), elephant grass (*Pennisetum purpureum*), rose apple (*Syzyguium jambos*) and sauco

(*Citharexylum gentry*) have been present in the highlands for decades and pose challenges to farm cultivation (GNPS 2009).

Today over 20,000 Galápagos residents and nearly 200,000 annual tourists and visitors rely on subsidized food imports via air and sea. According to the GNPS, 83% of new introduced species arrive with imported food products. Many, such as the biting black fly (*Simulium bipunctatum*) and the Mediterranean fruit fly (*Ceratitis capitata Wiedemann*) also affect farm productivity and denude fruit crops (Wiedenfeld et al. 2002; Herrera and Roque-Albelo 2007). The GNPS and the CDRS have attempted to eradicate non-native organisms inside the boundaries of the GNP for decades, but have rarely engaged with local landowners despite evidence that such species often originate within agricultural zones.

The added vulnerability to species introductions by cargo transport also means that issues of biodiversity protection and food production are intimately intertwined in Galápagos (UNESCO 2010). Meanwhile, private land management influences and is influenced by invasive species that are already present. That Galápagos agriculture is both responsible for and suffers from highland plant invasions gave rise to the two central questions that guided the research for this chapter:

1) What factors are causing agricultural decline in Galápagos? And;

2) What policy measures link farm management with biodiversity protection in the broader economy of island food production?

Although the mechanisms by which species invade and spread beyond the islands' agricultural zones have been well-documented (cf. Tye 2006; Guézou et al. 2010; UNESCO 2010), the drivers of change in Galápagos farm production have not. In this chapter, I investigate how invasive species research and control have historically maintained a rigid dichotomy between protected areas and privately-owned land, creating isolated food producers with few individual resources and a growing number of challenges. Invasive species know no such boundaries, however, and ongoing control measures are further undermined by a demand for imports that leaves the islands vulnerable to invasion by new pests.

This chapter also compares landowner attitudes about conservation policies and invasive species between Isabela and Santa Cruz Islands. Highland management programs developed on Santa Cruz frequently do not necessarily apply to more isolated Isabela, with different production patterns and ecosystem structures, while Isabela's distance from more centralized Santa Cruz also prevents landowners from receiving benefits from conservation and tourism programs. On both islands, a prevailing assumption that rural landowners are not environmentally responsible has underwritten their exclusion from GNPS and CDRS interventions, but the confluence of ecological value with a rising demand for food and the potential for new invasions makes incorporating them into conservation planning essential to achieve realistic restoration goals.

Isolation, Invasion and Food

The fields of island biogeography and invasion biology have shown that the high endemism and constrained size of oceanic islands makes them vulnerable to species introductions and extinctions (Simberloff 1995; Ruiz and Carlton 2003; Wetterer and Porter 2003). Since 1600, 75% of all vertebrate extinctions and 36% of all plant extinctions worldwide have been of island species, despite the small contribution that islands make to the total land area of the planet. Island tropical forests and upland zones are particularly vulnerable to invasion by exotic plants (Cox 1999), which in populated islands frequently coincide with local agricultural zones. Agricultural land that is fallow or abandoned provides further opportunities for invasive plants to advance into new territory (Fargione and Tilman 2005).

Adequate financial resources for dealing with introduced species are often unavailable to developing island territories and nations (Barnard and Waage 2004), an issue that is compounded by the fact that many islands also experience a narrow range of exports and rely on imports. Food sovereignty, a measure of local food production relative to imports, is therefore important in remote archipelagos where imported products are costly (Hughes and Lawrence 2005; Bourke and Harwood 2009; Bell et al. 2009; Mertz et al. 2010). Global and local transportation networks are also known

vectors for species introductions to oceanic islands (Poirine and Moyrand 2009), particularly by air and sea cargo (Rodda and Savidge 2007; Russel et al. 2008; Kaluza et al. 2010). In Galápagos, the UNESCO World Heritage Committee recently reported that "the most likely introduction channel for new species is via the shipping of organic produce from the continent to the islands" (UNESCO 2010: 37).

A growing body of literature in conservation research points to the efficacy of land management programs that unite rural economic interests with conservation goals (Perfecto et al. 1996; Vandermeer and Perfecto 1997; Collins and Qualset 1998; McNeely and Scherr 2003; Gangoso et al. 2006; Gøtz and Harvey 2008). As Guerron-Montero (2005) has shown, the role of the state in Latin American environmental politics has often been inadequate, but current institutional restructuring and a more centralized approach to governance in Galápagos may help forge the missing link from the top down. At the same time, new alliances between conservation organizations and members of rural Galápagos society are cultivating what Pejchar and Press (2006) call "creative conservation" from the bottom up. These are especially important along the margins of private property and protected areas (Perfecto and Vandermeer 2008) where invasive species tend to be concentrated. Increased human access to and population growth on island territories worldwide make such initiatives essential to the long-term success of environmental protection efforts in places where global biodiversity concerns are tied to local economic goals.

Methods

Qualitative Data Collection

A combination of fieldwork and secondary data analysis was employed in researching this chapter. Galápagos agricultural communities were first visited in 2008 for preliminary interviews, and Isabela and Santa Cruz Islands were selected as comparative case studies based on their very different colonial and production histories. Landowner interviews and participant observation were later conducted on those islands with a total of 89 participants. Interviews were semi-structured and

addressed the changing nature of agriculture and their perceptions about highland environmental management, while participant observation provided a deeper understanding of social networks and land use practices that were not explicitly discussed in the interviews. In 2010, two focus group discussions were held and recorded on Isabela (n=8) and Santa Cruz (n=11), during which topics centered around political and organizational challenges to production. Interviews generally were not recorded, therefore notes and memory were relied upon to reconstruct the opinions that were shared.

During August and September 2009 I administered a short survey (Appendix I) to the heads of 55 active farming households on Isabela and Santa Cruz. Households met selection criteria if any member of the household owned land and generated some agricultural income through local market sales in the last 12 months. Surveys of farmers' markets and grocery stores (Appendix II) on those islands were carried out to determine the quantities and prices of food imports versus local produce. In 2010 I volunteered with FUNDAR-Galápagos on Santa Cruz, assisting with the foundation's tourist program and documenting organic agricultural techniques on their demonstration farm, *Reserva Pájaro Brujo*. I also conducted and recorded semi-structured interviews on Santa Cruz and Isabela with 15 members of the GNPS and the CDRS who were involved in terrestrial conservation and invasive species control. Topics were organized around the drivers of highland environmental change and policy responses in and around agricultural zones.

Secondary Data Collection

A province-wide living standards survey was carried out in 2009 among 1,334 households by the Ecuadorian Institute of Statistics and the Galápagos Government Council (INEC-CGREG). When the raw data was made publicly available in 2010, it was downloaded from the INEC website to be translated and coded, and using the same criteria as above I selected 134 active farming households from Isabela and Santa Cruz Islands. Peer-reviewed articles, news reports and grey literature on the history of Galápagos agriculture were acquired through online databases and print catalogues; or, in the case of many Spanish-language sources, requests were made to the person(s) who produced them.

Published and unpublished data and reports on introduced species were acquired from the CDRS library. Additional project reports and publications related to agricultural development, challenges to farming and production decline were obtained from the websites or offices of conservation NGOs operating in Galápagos.

Analysis

The interrelationships between social and ecological change in the highland areas were assessed based on interviews and surveys, and participation in day-to-day farming practices. Interview results illustrate how particular individuals and groups respond to the presence of problematic species on farmland or inside the GNP, and highlight different stakeholder perceptions of agriculture's role in island conservation. 'Stories' about agriculture, conservation and invasion were generated in this way, and a theoretical framework was developed to represent the relationships between land use and management policy, and the production and prevention of species invasions. Data from the INEC-CGREG survey and this study were compared using t-tests and Chi-squared statistics to provide measures of demographic and socio-economic difference between island agricultural households.

Results

Owing to the islands' violent origins, Galápagos soil is volcanic and rich in minerals, with a low to neutral pH and depths of up to a meter in the highlands, less so for younger islands such as Isabela (Herrera 2008). While the highland zones are suitable for agriculture, they are vulnerable to erosion, especially during the rainy summer months (Aldaz, personal communication 2010). Only San Cristóbal and Floreana Islands retain surface water in the form of small pools or ponds; on Santa Cruz and Isabela soils and substratum are too porous to accumulate significant surface water or a water table (Chiriboga et al. 2006), although standing water can form during heavy downpours.

The rural zones of the four inhabited islands are made up of individual or family owned agricultural production units, defined as rural land holdings larger than 0.05 ha in size. Rural land

comprises 99% of the human use zones in Galápagos (SICA-MAG 2002), and is completely surrounded by national parkland (Figure 4.1). According to the most recent agricultural census, 604 production units make up 23,426 ha archipelago-wide that are involved in some kind of agriculture, with an average farm size of 50 to 55 ha (SICA-MAG 2002). Highland residents are represented by parochial *juntas*, which along with the municipalities of the coastal towns report to the provincial government. Depending on their labor and financial investments most landowners consider themselves full-time, part-time or weekend/occasional farmers.

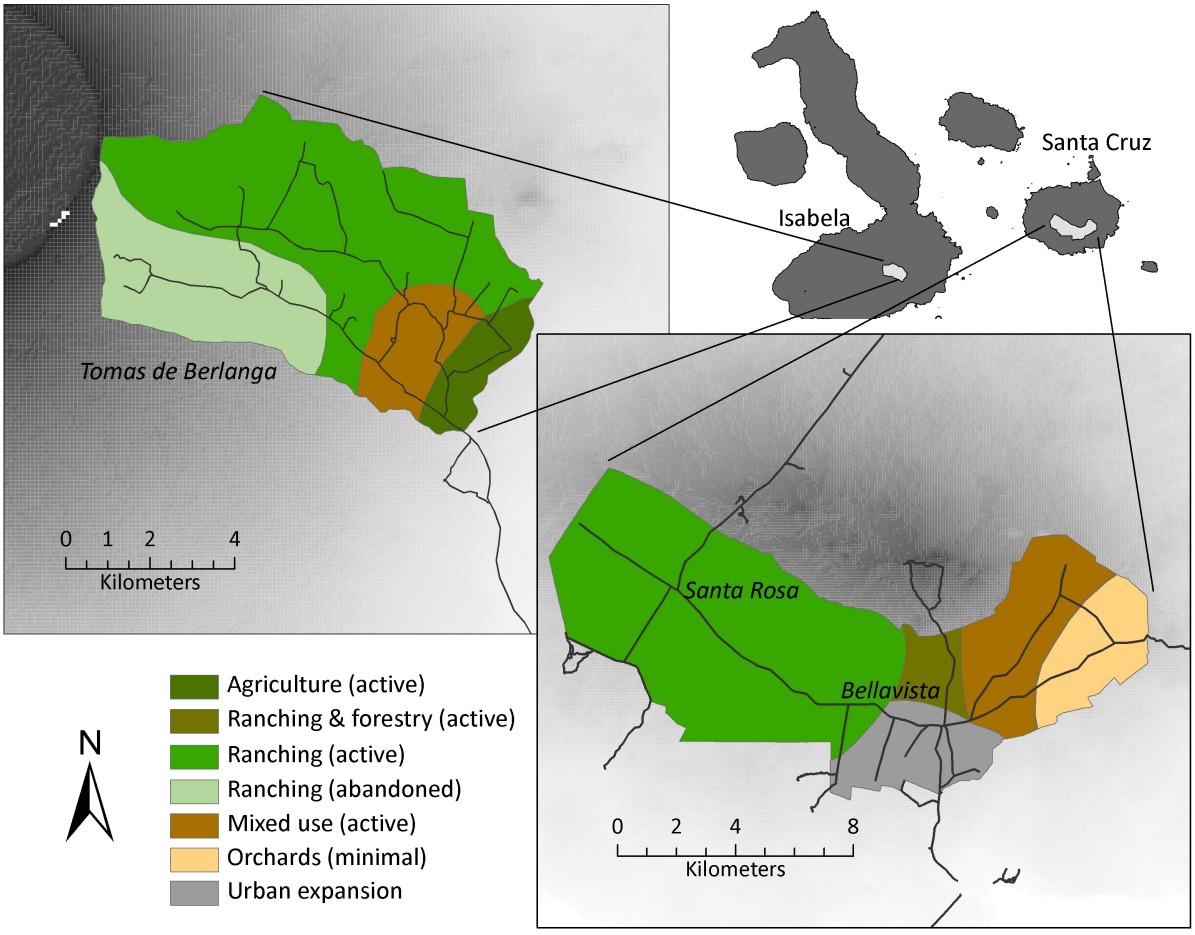

Figure 4.1. The rural-use zones of Isabela and Santa Cruz Islands. Source: Chiriboga et al. 2006.

Isabela Island

First settled by Antonio Gil and a handful of Ecuadorian colonists in the late 1800s, Gil and his successors cultivated fruits and vegetables and raised livestock in the humid highlands (Perry 1984). Mainland prisoners were sent to the island in 1946 where many were put to work in agriculture (Gordillo and Tupiza 1989), and a wave of voluntary rural migration from Ecuador's Sierran provinces occurred in the 1960s and 70s. In 2000 there were 108 privately-owned production units spread out over 5,211 ha in Isabela's highlands (SICA-MAG 2002). Table 4.1 describes the various production zones on the island today. The humid northwest region was formerly used for livestock ranching, but is now largely abandoned. To the east and south ranching, mixed use and general agriculture is still practiced semi-extensively. A small number of farms cultivate shade-grown coffee that is exported to the mainland for processing and sale. There are no certified organic producers, and a farmers' market, started in 2008, now has five to 10 weekly vendors. Over the last five years, however, Isabela has begun to experience considerable change as a consequence of economic development to meet the increased needs of a growing tourism industry. This rapid transition further encourages landowners to leave agricultural production for coastal opportunities, resulting in a rising demand for imported foods.

Table 4.1. General characteristics of Isabela Island's agricultural area, by production zone.

	General agriculture	Mixed use (includes coffee)	Ranching & forestry	Ranching
Neighborhood name	Barrio Loja, Merceditas	Esperanza, Los Tintos	Cerro Grande, Cerro Verde, Los Mellizos, El Papal	Pretoria, El Cura
Area (% of total)	10%	20%	40%	30%
Altitude (m)	175-300	235-400	300-600	400-800
Water	Scarce rainfall	Limited rainfall	Limited to abundant	Abundant rainfall
Population origin	Early migrants (primarily Loja)	Galápagos, early migrants	Galápagos, early migrants	Galápagos, early migrants
Land parcel size (ha)	3-20	2-30	30-110	70-150
Farming intensity	Active	Active	Active	Abandoned
Primary land cover	Grasses, fruit trees	Coffee, plantains, citrus, vegetable products, orchards	Grasses, fruit trees	Guava
Introduced species	---	---	Guava, elephant grass, ferns	Guava, ferns
Future use	Urbanization, abandoned	Large-scale coffee production	Abandoned	Abandoned, tourist use

Source: Chiriboga et al. 2006

Santa Cruz Island

Santa Cruz Island has a much larger agricultural zone than Isabela, which is matched by a developed network of farmers' unions and cooperatives, and a growing constituent of organic producers that cater to high-end restaurants and hotels. Rural lands make up 10,426 ha divided among 268 households (SICA-MAG 2002). Ranching, forestry, and fruit and vegetable farming are practiced extensively throughout its highland townships, ranging from the largest farms in the northwest to smaller, more recently-settled areas in the east (Table 4.2). Cattle graze on pasture that is heavily invaded by elephant grass, which serves as foliage. The growing presence of *mora* and guava, however, is beginning to affect production. A thriving farmers' market now has around 60 vendors on

a given Saturday morning, and large tour operators who commit to buying local produce further inject the agricultural economy with an annual source of income.

Table 4.2. General characteristics of Santa Cruz Island's agricultural area, by production zone.

	Mixed use	Ranching & forestry	Ranching	Orchards	Urban expansion
Neighborhood name	Cascajo, Camote	Media Luna	Occidente, Santa Rosa, Salasaca	El Cascajo	Bellavista
Area (% of total)	10%	8%	65%	10%	7%
Altitude (m)	220-280	250-400	250-500	220-380	120-250
Water	Limited rainfall	Abundant rainfall	Abundant rainfall	Limited rainfall, reservoirs	Scarce to limited rainfall
Population origin	Galápagos, early migrants	Galápagos, early migrants	Galápagos, early migrants	Recent migrants	Migrants, foreigners
Land parcel size (ha)	>20	20-80	50-400	2-20	0.5-10
Farming intensity	Active	Active	Active	Minimal	None
Primary land cover	Grasses, coffee, orchards	Grasses, hardwood trees	Grasses, fruit trees	Orchards, coffee	Households, grasses, corn, yucca
Introduced species	Guava, sauco	Elephant grass	Elephant grass, guava, *mora*	Guava, sauco	Guava, supirrosa
Future use	Abandoned invaded farms, rural tourism	Abandoned	Large-scale ranching, tourism	Land sold, ranching with coffee	Urban area, species invasion

Source: Chiriboga et al. 2006

Archipelago-wide, seasonal variations in rainfall and sunlight make greenhouses and irrigation systems essential for year-round production, but only the wealthiest households can afford them. As opposed to the two seasons normally described in Galápagos, the *garúa* and summer, landowners recognize three seasons in accordance with changing rainfall and suitability for agriculture. During the cool *garúa* season from July to December, temperatures average around 25° C and primary fruit and vegetable products include beans, carrots, lettuce, zucchini, radishes, broccoli,

peppers, avocados and oranges. Between January and March (referred to as the winter) sun- and rain-tolerant cucumber, cantaloupe, watermelon, pineapple and papaya dominate the local market. Drought-tolerant crops such as plantains, corn, yucca and tomatoes are harvested from April through June, which producers call summer. During the winter and summer seasons temperatures are much warmer, around 30° C. Locally-raised poultry, beef and pork are available in Galápagos year-round. Wood from introduced hardwood trees is used in construction, and the only agricultural export is Galápagos shade-grown coffee. Common agricultural products and practices are shown in Figure 4.2.

Figure 4.2. Clockwise from top left: Farmer milking a cow; Vegetable seedlings protected from finches by netting; Papayas ready to be taken to the farmers' market; Pigs in an enclosure; Field under cultivation during the *garúa*. Photos by author (2010) and Nick Zetts (2009).

For several months in 2009 and 2010, I traveled to the highlands of Isabela and Santa Cruz Islands to work on the farms of my informants, primarily in the 'mixed use' agricultural zones. Due to the difference in rainfall between seasons, production intensity also varies and is the highest during

the *garúa*. At the end of the *garúa*, many landowners dedicate several weeks to collecting seeds for storage for the next season, particularly for products that cannot be purchased or are prohibited to bring to the islands. During the hot, dry months of March and April, land is cleared and prepared for the next season's rotation.

The majority of the owners of full-time farms were either born in Galápagos or migrated from the mainland at least 20 years ago. Some of these early migrants shared stories of environmental disasters or financial insecurity that led them to relocate to the islands. One Isabela family lived and farmed in the Ecuadorian province of Tungurahua, next to the active volcano for which the province is named. When it erupted in October 1999, 400 families were left without homes and land due to the ash fallout, and the Suarez family came to Galápagos to join their children. Others were attracted by the comparatively stable economic situation in Galápagos: "Here we can afford to eat meat every day," said Franco, a Santa Cruz landowner. "On the mainland we only had meat on the weekends or during fiestas."

According to the INEC-CGREG survey results shown in Table 4.3, the average age of the 134 heads of rural households on Isabela and Santa Cruz Islands is around 51 years old, while the average age of heads of non-farming households is much younger, at 40 years old. Although there are few female heads of farming households, they are five times more common on Santa Cruz. On average, farm sizes on Santa Cruz are smaller than on Isabela, but property values are more than twice as high. Rental values between the two islands are fairly even. While landowners generally agree that they experience an 'average' quality of life in Galápagos, Table 4.3 also reveals socio-economic stratification by island, particularly in fruit and vegetable sales, reflecting the decrease in on-farm agricultural production that Isabela is experiencing. Producers on Isabela experience lower revenue from animal sales report statistically significantly negative opinions about their current economic situation and the dollar-based economy in general when compared with landowners from Santa Cruz.

Table 4.3. Responses to demographic, socio-economic and quality of life measures among active farming households on Santa Cruz and Isabela.

Survey Measure	Isabela (n=62)	Santa Cruz (n=72)	p-value
Average age of household head	51	52	0.639
Percent of female heads of household	2 (3%)	11 (15%)	0.019
Average size of land owned (in ha)	20.92	16.32	0.385
Total property sale value	$71,274	$163,863	0.013
Annual property rental value	$4,678	$5,776	0.653
Average fruit/vegetable sales last year	$930	$2,773	0.030
Average animal sales last month	$1,286	$2,027	0.148
Quality of life:			0.127
Good	9 (15%)	18 (25%)	
Average	46 (74%)	51 (71%)	
Poor	7 (11%)	3 (4%)	
Current economic situation:			0.003
Able to save money	7 (11%)	13 (18%)	
Balance earnings and spending	31 (50%)	51 (71%)	
Forced to spend savings	9 (15%)	3 (4%)	
Forced into debt	15 (24%)	5 (7%)	
You consider yourself poor	30 (48%)	24 (33%)	0.077
Economy is better with the dollar	20 (32%)	35 (49%)	0.055
Estimated monthly household income needed to 'live well'	$1,273.39	$1,733.33	0.013
Noise level outside your home:			0.916
Loud	8 (13%)	8 (11%)	
Average	19 (31%)	21 (29%)	
Low	35 (56%)	43 (60%)	
Cleanliness outside your home:			0.956
Good	33 (53%)	40 (56%)	
Average	26 (42%)	29 (40%)	
Poor	3 (5%)	3 (4%)	

In part, Isabela's distance from the center of Galápagos tourism (Santa Cruz) and small population provide few outlets for food products such as restaurants and stores. Access to local and external markets is limited, technical assistance and machinery are rarely available to landowners, and the lack of a consistent water supply makes year-round production impossible for those who do not possess greenhouses. Furthermore, the invasion of farmland by guava and in some areas, *mora*, is so

extensive that manual labor may no longer be a sufficient control option. As indicated above, 24% of the survey respondents from Isabela feel that they are forced into debt, seeking bank and government loans in order to maintain production levels.

The economic uncertainty expressed by Isabela landowners is one of many factors contributing to an overall decline in agricultural production. Even on Santa Cruz, production obstacles such as introduced species and drought are compounded by a shortage of affordable labor and limited financial resources. Many are choosing to stop farming altogether to capitalize on the coastal tourist industry, and destabilized food production systems lead to a dependence on imports. To characterize the challenges landowners face in continued agricultural production today, the schematic outlined in Figure 4.3 illustrates the linkages between conservation policy, labor, introduced species and food sovereignty in Galápagos. The following sections address these relations in turn, based on surveys, interviews and observations conducted on Isabela and Santa Cruz Islands.

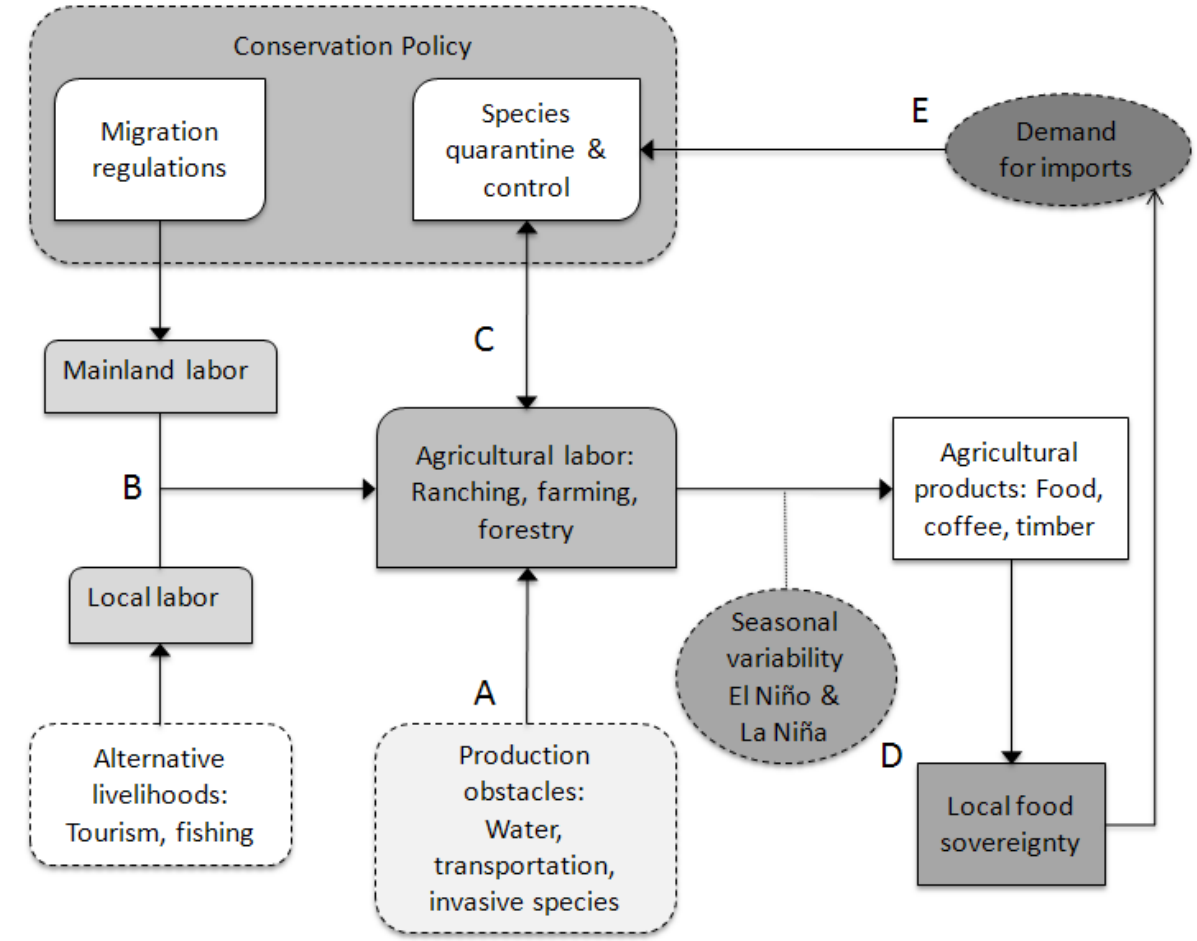

Figure 4.3. The relationships between conservation policy and agricultural production in Galápagos.

Production Obstacles (A)

Based on data from the INEC-CGREG survey, out of 198 agricultural households archipelago-wide, 22% of them had abandoned part of their property because of invasive plants. Most (84%) considered introduced species to be a threat to agricultural production. Because the survey form did not capture other indicators of agricultural production challenges, I asked landowners to rank eight obstacles to agricultural production that were identified by preliminary interviews conducted in 2008 (Table 4.4). They reported that water (either a shortage or an excess), pests (both endemic and introduced) and a lack of available labor pose the greatest challenges to production. The endemic finches of Galápagos can destroy up to 50% of vegetable crops by picking stems and eating

blossoms, and some of my informants openly admitted to poisoning them during the dry summer months. In the 1980s, Santa Cruz landowners nearly exterminated the native Galápagos hawk, which preys on free-range chicks. On both islands, introduced plants were ranked comparatively low next to these seemingly more complex issues.

Table 4.4. Presence of invasive plants on abandoned Isabela and Santa Cruz farmland, and median rankings of common obstacles to agricultural production.

Information about Invasive Plants[a]	Isabela (n=62)	Santa Cruz (n=72)
Number of invaded and abandoned lots	9	10
Total area abandoned (ha)	71	691
Top plant invaders	Guava, *mora,* rose apple	*Mora*, guava, sauco
Production Obstacle[b]	**Isabela (n=23)**	**Santa Cruz (n=32)**
Water	1	2
Insects and worms	2	1
Birds	3	3
Manual labor shortage	4	4
Transportation difficulty	5	7
Unstable markets	6	8
Rats and mice	7	5
Invasive plants	8	6

[a] Source: INEC-CGREG 2010
[b] Source: Household survey, Brewington 2009

Markets and Manual Labor (B)

The ranking exercise also implies that agricultural decline is a response to factors that extend beyond individual farm boundaries. Under pressure to compete with the less expensive, subsidized meat products imported from the mainland, local ranchers lower their prices until the profit margin is barely subsistence-level. In a similar manner, Isabela's coffee producers, without the machinery to prepare a commercial product for sale on the island, are forced to accept a lower price from mainland buyers. For Isabela landowners who are able to produce a variety of products year-round, though, the seasonal fluctuation of local markets present little problem. They are also more willing to go 'door-to-

door' to sell their products directly to buyers, rather than wait for the farmers' market at the end of the week.

Only four (7%) of the landowners I surveyed own farm machinery such as tillers and tractors, something that others, like Romero of Isabela Island believe "is the only way out of the precarious conditions we are in, in addition to allowing us to produce more." Instead, they rely on manual labor, and, as Santiago from Santa Cruz maintains, "In Galápagos, it doesn't exist. The workers that are here want to charge too much, and they don't do good work. We need workers for particular seasons or harvests." It is possible to contract workers from the mainland who, due to the depressed mainland economy, charge a low wage ($5-10 per day, much less than local labor which can cost up to $35 per day). One Isabela farm hired two mainland workers as temporary residents for $200 per month, plus room and board. The same farm had recently paid a local worker for a short-term project at $600 per month. I asked the owner why he and his wife didn't hire another temporary worker to cut down on labor costs. "We would," he replied, "but we can't afford to pay INGALA another year for the permit."

Migration regulations, intended to reduce population growth and impact in the islands, make hiring affordable labor from the mainland increasingly difficult by requiring that employers pay a monthly stipend (a proportion of employee wage) and a one-time guarantee that the worker will return to the mainland upon contract completion. Therefore, many landowners hire mainland workers for three-month intervals (the length of a free tourist visa) or seek local help only for the most labor-intensive projects, including clearing land of invasive plants. It can take up to a month for one person to clear a hectare of guava or *mora* by machete and with local labor could cost over $700. In contrast, tractor rental costs $90 per hour and takes only five hours to clear a hectare, but damages the soil and leaves behind seeds and seedlings of invasive plants to germinate.

Finally, rural out-migration as a result of more attractive economic alternatives in the islands' coastal towns (public and private institutions, fisheries, and tourism) has been occurring since the 1970s. Other social and political factors, such as the lack of polices geared towards rural maintenance

and production, have further contributed to rural-urban migration. The pull of higher-value basic services that are available at the coast, including 24-hour electricity, internet, communications, education, health facilities, markets, banks and shops drive the shift in population dynamics (Chiriboga et al. 2006). In a 2000 survey, Fundación Natura found that less than 1% of Galápagos men and women still participated in some kind of agricultural activity (Table 4.5).

Table 4.5. Percentage distribution by employment sector and gender in 2000.

Employment Category	Men	Women	Total
Commercial business	11%	32%	21.5%
Tourism	21%	11%	16%
Public and legal administration	12%	12%	12%
Health services	4%	16%	10%
Education	7%	13%	10%
Other business or productive activities	12%	7%	9.5%
Fisheries	13%	3%	8%
Transportation and communication	8%	3%	5.5%
Construction	7%	1%	4%
Conservation	4%	3%	3.5%
Agriculture	1%	0%	0.5%

Source: Fundación Natura (2001: 33)

Invasive Species Control (C)

Without adequate labor many landowners find it physically or financially impossible to clear hectares of highly invasive plants like guava and *mora*, despite being legally required to do so under the 1998 Special Law. Furthermore, while the use of agricultural chemicals is controlled by the GNPS (cf. Rentería et al. 2006), regulations are rarely observed and there are no barriers to the import or clandestine transport of prohibited products. Said Santa Cruz resident Steve Devine in 2000, "I didn't realize how bad it could get. I had no idea. For the first couple of years, I was reluctant to use herbicides, and then the *mora* just exploded. Now there's no alternative. It's either use the Roundup or go under," (D'Orso 2001: 234). As she sprayed her green beans with herbicide in 2010, Teresa

from Santa Cruz commented, "I'm from the Sierra, and this is how we dealt with weeds on our farm there. Are they paying us to do it any differently here?"

The agricultural division of the Ecuadorian Ministry of Livestock, Agriculture and Fisheries (MAGAP) is aware of the problems that invasive species pose for landowners, but currently does not assist them in control or eradication. It is coordinating efforts with the GNPS and foresters on Santa Cruz to encourage landowners to reforest land cleared of invasive plants with non-invasive, and economically valuable, hardwoods, such as *Triplaris cumingiana*, the tree locally known as Fernán Sánchez. According to MAGAP's Galápagos Director, the organization plans to use data collected during the most recent agricultural survey (2010) to identify target locations for future invasive interventions in the islands' highland zones (Bravo, personal communication 2010).

On Isabela, attitudes towards the GNPS are particularly negative. Many were embittered by the high cost expended for Project Isabela when they receive little to no assistance with invaders on their own land. Out of a list of six local institutions that interact with highland landowners (municipalities, parochial *juntas*, agricultural cooperatives, INGALA, the CDRS and the GNPS), Isabela landowners ranked the GNPS last based on benefits received through public works or policy.[13] Seeing the institution as being concerned only with the park gives them little incentive to comply with regulations. "Besides," said one, "if they get rid of all the problems, then where will they get more money?" A local GNPS employee agreed that park-only policies have historically alienated the island's landowners. When he described a project in 2008 and 2009 to assist them in controlling *mora* on their land, he explained that many were afraid to grant GNPS employees access to their property, fearing fines for other regulatory infractions.

Seasonal Variability and Food Sovereignty (D)

Every few years, the warm, summer season in Galápagos is more intense and prolonged than usual. Sea surface temperatures off the Pacific coast of South America rise a few degrees Celsius

[13]Santa Cruz producers ranked the CDRS last, after the GNPS.

above normal, exercising a strong influence over the waters surrounding Galápagos. El Niños have most frequently been associated with decreases in populations of charismatic Galápagos flora and fauna, including *Scalesia* forests (Itow and Mueller-Dumbois 1988), penguins (Vargas et al. 2007) and blue-footed boobies (Gibbs et al. 1987), but they affect aspects of human life in the islands, as well.

Characterized by sudden, heavy downpours, El Niño events and the droughts that follow them directly impact agricultural activity in the archipelago's highlands. Landowners on Santa Cruz Island described unsalvageable losses due to El Niño-related flooding in 1997, as a whole season's crop remained covered by water for weeks at a time. Because Isabela's soils are more porous than those on Santa Cruz, the primary threat is erosion. In 2010, a mild El Niño destabilized entire farm buildings on Isabela as rains washed away greenhouses, sheds and stables. Despite warnings from the National Oceanic and Atmospheric Administration (NOAA) as early as September 2009 and a CDRS monitoring program for the marine reserve, landowners were not aware of the coming event and sustained severe economic losses.

Even during normal years, the decline in island agriculture and growth in population and tourism means that the islands are unable to provide a consistent supply of staple foods, creating a seasonal dependence on imported fruits and vegetables. Grains and most dairy products are also among the food and other items imported via cargo ship (Table 4.6). Santa Cruz currently receives two ships a week and one continues on to Isabela before returning to the mainland. Stores and other venders pay $1.17 per 100 pounds of vegetables, fruit and grains that make the two and a half day voyage. Cold storage facilities, on the other hand, cost $0.14 per pound, and the higher cost is borne by consumers – frequently the same mainland product sells at double its price at the farmers' market. Due to the extra travel time, Isabela consumers pay up to twice as much as consumers on Santa Cruz for imported goods. Prices skyrocket if a cargo ship is delayed due to mechanical issues or quarantine failure, leading to food insecurity among the poor (El Colono 2009: 12).

Table 4.6. Percent of food imports averaged across 10 Santa Cruz and Isabela stores.

Food Product	Jan – March ('winter')	April – June ('summer')	July – Dec (*garúa*)
Grains	100%	100%	100%
Eggs	90%	90%	90%
Milk	69%	75%	69%
Cheese	44%	56%	41%
Beef	63%	85%	63%
Vegetables	53%	80%	10%
Fruits	30%	69%	8%

Source: Store survey, Brewington 2009-2010

Invasions via Imports (E)

Decreased food production is related to species introductions at the coast, as well, in what one GNP official calls "a vicious cycle of invasion." In 2008 I accompanied Agrocalidad Director David Arana on a routine inspection of two ships docked in Pelican Bay, Santa Cruz. In addition to receiving 5% of the $100 foreign visitor entrance fee, nearly a fifth of Agrocalidad's $1.5 million budget is collected through inspection fees (around $0.025 per kilogram) that are levied on shipping companies for entry into the lucrative Galápagos shipping market (UNESCO 2010). The first cargo ship we visited, the *Angelina II*, had just been added to the fleet and possessed the largest refrigerated containment unit. *Angelina's* captain, a Galápagos resident, and Arana went over the cargo manifest containing food product lists and the origin and destination for all items, as well as the ship's disinfection certificates. Arana then verified that food quality met regulations and that insect traps next to the ship's lights contained no dangerous invertebrates before we boarded a dingy to take us to the second ship, the *Montserrat*.

All ships departing for Galápagos are required to undergo hull inspections to avoid introducing crustaceans into the marine reserve. As we climbed on board the *Montserrat*, however, inches of barnacles, mollusks and algae coated the lower half of the hull. On deck, the ship's gentle rocking spilled potatoes, tomatoes and heads of lettuce from burlap sacks as spiders and cockroaches scuttled by. Below, leaking water formed stagnant pools around crates of beer, pallets of bottled

water, a speedboat and a bus. When the crew collected insect traps for inspection, they appeared to have just been unwrapped. The economic cost of losing up to 100 tons of produce due to a failed inspection is enormous, making deceiving an inspector, as Arana puts it, "well worth the risk" (personal communication 2008).[14]

Arana estimated that in 2009 cargo shipments transported over 54,000 tons of commodities to Galápagos, and 75% of all food products arrive in this manner. Potatoes, rice, sugar and corn for poultry feed alone comprise over 2,500 tons of shipping cargo per year. Organic cargo is a known vector for plant diseases and soil nematodes, along with insects such as fire ants and fruit flies that are also attracted to ships' external lights during nighttime travel. Two mosquito species (*Aedes aegypti* and *Culex quinquefasciatus*) were recently introduced to the islands via cargo ship and are also vectors for introduced pathogens that cause serious harm to humans and animals. The fact that airline compliance with legal regulations to fumigate passenger craft is low increases the likelihood that diseases like West Nile virus and avian malaria, to which native bird populations have little or no immunity, will arrive to the Galápagos in the coming years (UNESCO 2006).

Galápagos Landowners: Conservation Allies or Enemies?

Attitudes that landowners on Isabela and Santa Cruz Islands have towards conservation were expressed to me in a variety of ways during my fieldwork. Many agree with Felipe from Santa Cruz who gestured toward his large and orderly rows of crops, "Agriculture is the best form of conservation – imagine if all of the highlands in Galápagos were being farmed like this." But everyday farm activities do not always conform to environmental regulations. In addition to poisoned finches and the use of illegal pesticides and herbicides, I observed the clandestine import of organisms, plants and seeds. Several farms utilize commercial bacteria and fungi that have not been evaluated for environmental safety as primary decomposers for composting. The introduction of

[14]In 2009, the *Montserrat* was suspended from the Galápagos fleet along with two other ships, and in 2010 one of the three loading docks in Guayaquil was closed due to unsanitary conditions. Negotiations are currently underway to consolidate the remaining loading docks and create a central off-loading port for all marine cargo on Baltra Island.

flowers is prohibited, yet some, like the marigolds in Figure 4.4, provide non-chemical pest control by deterring insects and nematodes that live in the soil (Zetts, personal communication 2009). Stems and bulbs of roses and lilies from the mainland are carefully wrapped and concealed in luggage, to be tended out of sight in back yards. Finally, landowners who neglect or are unable to control introduced species on their own properties compromise the ability of their neighbors to carry out agricultural activities, while farms that abut parkland facilitate the continued transfer of such species into protected areas. Without focused highland management initiatives on the part of conservation organizations, UNESCO maintains, "controlling introduced species in the park lands of inhabited islands will always be akin to bailing out a leaking ship" (UNESCO 2006).

Figure 4.4. The seeds of marigolds, planted to ward off insects, are also eaten by birds and can be transported long distances into protected areas. Photo by Nick Zetts (2009).

The case of Spanish cedar (*Cedrela odorata*) on Santa Cruz Island illustrates another aspect of the complex relationship between environmental politics and agricultural productivity. In 2008 the harvesting of Spanish cedar, a vulnerable tree species in Latin America, was prohibited on the Ecuadorian mainland, launching a lucrative market for its export from Galápagos where the tree is invasive. The local furniture industry had relied on cedar for years: Said Alberto Calderón, President of the Santa Cruz master carpenter's guild, "It's a limited resource – we don't have large forests here, nor are we allowed to plant more of it" (personal communication 2009). The remaining suitable hardwoods in the islands are protected by the GNPS, which turned a blind eye to the illegal export of timber. Without local cedar woodworkers import high-cost, treated wood that leaches chemicals into soil and groundwater, prompting one to ask bitterly, "What kind of conservation are they [the GNPS] talking about?"

When asked what they valued most, long-term, out of 1) Household food security; 2) Economic productivity; 3) Island agricultural development; and 4) Environmental protection, nearly all of the landowners I surveyed (52, 95%) placed economic productivity first. Isabela farmers expressed a strong desire for more agricultural development, echoing the sentiments of Carlos who argues, "The biggest problem here in Isabela is that agriculture is the last wheel on the cart. There's no support – what is missing is a state policy, a policy to strengthen the agricultural sector." The sense that they have been abandoned by the government is matched by a frustration with government-funded workshops and short courses that landowners don't feel "lead to any kind of concrete support," said Romero.

During the focus group discussion on Isabela, the lack of state support and organization among local producers emerged as a central theme. Currently there are three producers' organizations (the Centro Agrícola, the Asociación de Ganaderos, and Unidos Venceremos), all of which have weak participation from their members. During the debate, participants expressed a need for leadership and representation among Isabela society, as well as in the broader political arena:

> Romero: "But we don't have money to start our own projects, we need direct support from the state. We don't need workshops and we're not asking for donations – what we need is credit."
>
> Carlos: "I agree. There needs to be a committee or a single organization to represent *all* of the agricultural sectors, in order to serve the interests of the industry and help us apply for support."
>
> Victor: "You know, the other problem is that we don't have the labor we need for projects to work. The irrigation hoses [part of a 2008 Peace Corps project grant], how many of you are using them? For me they are useless unless I have the kind of manual labor needed to make the system function."
>
> Lauro: "In that case we should have a real agricultural technician to teach us good practices, have higher quality production and so we'll know how to deal with insects and disease without chemicals."
>
> Carlos: "What we ought to propose is creating a single agricultural committee to bring our interests and the needs of the town together – this is something that the municipality doesn't consider, and neither do other institutions like the park. It can't be political, too many of the problems we have trying to work together as producers already come from politics…"

Among landowners on Santa Cruz, focus group discussions revealed that there is less of a sense that agricultural producers have been abandoned by the local state and conservation authorities, but they still express the desire for a more even stake in markets and resource use:

> Felipe: "It seems the biggest problem we have is uneven access to markets, for example Hernan [a neighbor] has a contract with Metropolitan [Touring] and he makes all the money off of that but my wife and I, none of us, see the first cent."
>
> Teresa: "Yes I agree, but we still need the local institutions to take greater account of our agricultural sector and allow us an equitable use of the resources."

Highland residents desire responsible rural development, having seen the changes during the urbanization of Bellavista. The fear of hoof and mouth disease is high following a false alarm in the early 2000s when several hundred cattle had to be destroyed, while avian flu and other diseases common among livestock are what one CDRS researcher believes will be "the next big epidemic" in Galápagos (Blake, personal communication 2009).

In spite of having a diverse and precarious stake in the local food economy, many Galápagos landowners are finding ways to align agricultural production with conservation priorities. Maria Elena Guerra and Scott Henderson are conservation advocates who rehabilitated an abandoned farm on

Santa Cruz and now produce organic coffee. Their 'Lava Java' label describes a vision of agriculture and conservation that is distinct to Galápagos, bridging old divides to span stakeholder interests:

> In restoring our own farm, we are able to provide seedlings of rare and endangered native plants and coffee to other farmers who choose to join us in the effort to restore abandoned land back to a healthy Galápagos ecosystem where native species thrive. We see every new farmer committed to this as a conservation ally. [Lava Java] captures the essence of the Galápagos we hope to create: a unique place where people learn to live in harmony with nature, conserving it as part of their everyday lives.

Responding to the need to support conservation through land use, FUNDAR-Galápagos has initiated rural assistance programs and provides opportunities for residents to participate in sustainable farming alternatives. Martín Espinosa, project coordinator, elaborates, "We want the community to be involved in conservation. There are people here who say the Galápagos Islands would be better off without people. FUNDAR does not believe that" (personal communication 2010). The NGO uses its 84 ha demonstration farm to educate landowners in responsible land management techniques. Taking advantage of the heavy regulation of agro-chemicals, FUNDAR recently published a guide to organic farming in Galápagos that includes instructions for making natural fertilizers and insecticides (Herrera 2008).

Galápagos shade-grown coffee production also illustrates the financial benefits of responsible resource use by exploiting an important link between cultivation and conservation. Coffee trees are non-invasive, help prevent soil erosion, and retain nutrients for later crop rotations (Perfecto et al. 1996), resulting in a product that caters primarily to eco-conscious American and European consumers. A project financed by the Inter-American Development Bank assists landowners in planting native and endemic trees for shade on Santa Cruz, enabling some to obtain organic certification – and sale prices up to 20% higher.

Despite such promise, organic agriculture has yet to catch on outside of Santa Cruz. Certification is an additional expense of time and labor that most Galápagos landowners aren't willing to risk. Especially on isolated Isabela Island, few have the capital needed to invest in organic farming, and the necessary economic incentives for planting native and endemic plants simply aren't

there. As Vicente says, “Why would I plant something that I can’t sell?” As an alternative, some have begun ‘selling’ native plant and animal tourism. At *El Chato* farm on Santa Cruz visitors walk through cavern-like lava tunnels, watch giant tortoises as they feed on native vegetation, and sample juices and jams made from native fruits. Another farm operates an eco-tourism program that recruits volunteers for work in ecological restoration and food self-sufficiency. On several small Isabela farms, a new agro-tourism program invites visitors to learn traditional farming techniques while promoting highland restoration.

In terms of practical politics, the relationship between food sovereignty and introduced species should make land management training and the subsidization of local agriculture priority interventions by the Ecuadorian government and associated conservation institutions, especially the GNSP and the CDRS. With over 400 employees, a large budget and a strategic location within science and policy, the GNPS possesses the economic and political power to effect real change among Galápagos rural society. New programs to establish conservation easements and train landowners in invasive species removal are two ways the GNPS is shedding its old image as a park-only protection agency. The CDRS has begun to incorporate landowner economic needs into ecological rehabilitation projects, and with the help of Isabela’s resident plant expert Jacinto Gordillo published a gardening guide that highlights the conservation and economic benefits of native planting (Atkinson et al. 2009).

Conclusions

With the recent study by Chiriboga et al. in 2006 and UNESCO’s reports highlighting the dangers of invasion by cargo ship, concern for the future of food in Galápagos has directed much-needed attention to the islands’ populated highlands. This chapter sought to describe the diversity of challenges that landowners face in producing food for increasing numbers of island residents and tourists, including introduced species, seasonal and market fluctuations, and park-only policies that marginalize private landowners. A $15 million endowment fund for Galápagos invasive species

control is planned to ensure the long-term success of eradication and control measures, archipelago-wide (UNESCO 2010). As this chapter has shown, the physical boundary between the GNP and privately owned land is easily breached by introduced species whose presence undermines environmental protection and production. Furthermore, migration regulations, weak markets, climate variability and a dependence on imports are other important barriers to local agriculture that extend well beyond Isabela and Santa Cruz farm boundaries.

I also situated contemporary agricultural practices within the broader politics of biodiversity protection, showing how food producers simultaneously violate conservation regulations even as they contribute to a reduction in the threat of introduced species via cargo ship. In a commendable overhaul of past policies that have made landowners both enemies and allies of conservation, the rural residents of Galápagos are being incorporated into environmental planning. Unfortunately, these shifts in management policy focus from the protected areas to the inhabited zones are primarily taking place on Santa Cruz Island. The CDRS has also recently initiated Project Floreana, a restoration plan for the archipelago's first (and least) populated island that integrates community environmental stewardship. On Isabela Island, this chapter demonstrated that in addition to conservation protocols from the top-down, local action and activism are essential to confronting the problems of introduced species at their sources. Where state support for such measures is lacking, growing grassroots agricultural engagements are beginning to find ways to align sustainable food production with conservation priorities.

Finally, this chapter revealed particular challenges for the future of food production on both Santa Cruz and Isabela Islands. With one of the fastest growing tourism economies in the world, there is an archipelago-wide transition out of traditional subsistence activities and into coastal business and recreation, resulting in an increasingly abandoned highland landscape. Promoting responsible land use will also have to overcome the bitterness and mistrust that landowners, particularly those on more isolated Isabela, frequently direct towards policy interventions. This is reflected in the fact that between Isabela and Santa Cruz, awareness of and perceptions about invasive species – and

landscapes in general – differ markedly between conservation officials and landowners, the implications of which are the focus of the next chapter.

Chapter 5: Participatory Mapping of Invasion in the Isabela Island Highlands

Introduction

In June 2007, Pedro Ramón, an employee of the Isabela Island office of the GNPS led me on horseback to a region of the island's highlands called Buenaño, southwest of the Sierra Negra volcano. We were inside the GNP to record the presence of invasive guava trees (*Psidium guajava*). As we rode Ramón indicated patches of new guava growth since the volcano's last eruption in 2005. "When I first came to Isabela this was all grasses and ferns," he said. "Since then, the *guayaba* has covered everything between here and Cerro Azul [a volcano to the west of Sierra Negra]" (Ramón, personal communication 2007). Guava was present throughout the national park in one stage or another, but we were going to an area that was settled by early colonists and still remained guava-free. According to Ramón, Buenaño had been heavily grazed by livestock before being abandoned for land closer to the coast, and the grasses that remained prevented guava seedlings from sprouting. From our vantage point at the crater, however, it seemed that the guava was marching relentlessly across Isabela's southern highlands (Figure 5.1).

Figure 5.1. The view from the 10 km wide crater of Sierra Negra volcano with grasses and guava (inset) in the foreground. Photos by author (2008).

The upper elevation slopes of Sierra Negra are high enough to push moisture-bearing air masses upward, bringing significant precipitation to upland areas (Perry 1984). In these zones, the mineral rich volcanic soil makes the region favorable for agriculture, as well as invasive guava growth. Common guava is a small fruit-bearing tree (3-10 m) that was brought to the Galápagos in the 1800s for cultivation (Binggeli 2001). Known locally as *guayaba*, its fruit contains vitamin C, fiber and calcium that made it a desirable crop for early colonists when few nutrition sources were available. In 1970, Itow found the plant abundant in Isabela's agricultural zone, which is surrounded by the GNP (Hamann 1981). Called the archipelago's "most widespread intruder" (Schofield 1989), Walsh et al. (2008) estimate that guava now covers more than 40,000 ha of southern Isabela's private and protected lands, the same figure that Stone et al. (1988) estimated two decades earlier for the total area invaded by guava archipelago-wide. Because of guava's widespread presence on Isabela, control, rather than eradication, is the most feasible management option.

In the agricultural zone, microclimates further differentiate the production capabilities of farms. As described in the previous chapter, privately-owned land in the Isabela highlands comprises just over 5,000 ha, and the approximately 100 Isabela landowners are primarily ranchers and fruit and vegetable farmers who live at the coast and return to their farms on the weekends. Farms range in size from 0.5 to 200 hectares, many of which belonged to original settlers and have since been subdivided among children and grandchildren. Those located along the southern, windward slope of Sierra Negra experience a wetter, cooler climate and are generally much larger (50 – 200 ha) than farms to the southern and eastern regions of the zone. Invasive plant species are particularly prevalent on land used for livestock ranching, where many landowners are original island inhabitants or early migrants who have other economic engagements at the coast. As ranchlands often border the national park, keeping them productive and avoiding land abandonment is essential to preventing extensive spread of these pests. The lower elevation farms tend to be smaller and more intensively cultivated, and the region's comparatively arid climate facilitates a wide variety of food crops, primarily sugar cane, papaya, oranges, melons, beans, tomatoes and greens. The households in this zone are primarily recent migrants who rely on their own full-time labor, and Chiriboga et al. (2006) and others fear that rural out-migration to the islands' urban centers will contribute to an expansion of the limited numbers of invasive plants already present.

In the previous chapter, it was also shown how park-only policies of biodiversity protection have contributed to a reduction in agriculture on Isabela and Santa Cruz Islands, resulting in increased dependence on imports and the potential for new invasions. Furthermore, while the restoration of highland national parkland has been high on the agenda of environmental managers, the maintenance of highland agricultural landscapes has not. Although guava has been studied and targeted for control inside Isabela's protected areas for over 30 years (Eckhardt 1972; de Vries and Black 1983; Schofield 1989, Binggeli 2001), little effort has been made to control its presence in the agricultural zone where animals eat the fruit and spread the seeds into the surrounding national park.

The focus of this chapter is to understand how landscape cover and change on Isabela Island are experienced by different stakeholder groups, through an evaluation of the impact of guava's invasion. I first address the question:

1) How do different stakeholder groups 'see' landscape cover and change in the Isabela highlands?

Interviews and observations suggest that perceptions of environmental change due to invasive species vary between landowners and the GNPS. Using a participatory classification technique, competing maps of land cover in Isabela's highlands are created to illustrate two local points of view and highlight areas of 'shared' guava coverage. Despite agreement in some types of land cover, other highland areas that landowners view as productive are 'seen' as degraded by conservation practitioners, suggesting that they converge or diverge based on particular uses and knowledge of the landscape. This leads to the second question guiding the research for this chapter:

2) What do competing conceptions of the landscape mean in terms of land management and the future of farming on Isabela?

By comparing and contrasting different perceptions of land cover, land change and land use, the 'good' and 'bad' nature of introduced plants can be addressed in terms of economic, environmental and political goals. Spatial differences that are articulated via comparative analysis of each viewpoint are quantitatively analyzed, and the meaning of competing land cover classifications is assessed qualitatively in terms of land management planning and practice. The significance of enrolling private landowners in measures to combat invasive types of land cover that was emphasized in the previous chapter is revisited with a focus on guava and its relevance to both biodiversity protection and agricultural production.

Mapping in Human-Environment Studies

Worldwide, satellite systems have been relied on to gather spatial information about environmental change, particularly where assessments of land cover on the ground can be hindered due to private property rights, remote locations and difficult terrain (Messina and Walsh 2001; Evans

and Kelley 2004; Walsh et al. 2006). Assessments of land use and land cover change frequently incorporate population patterns across space-time scales to settle contentious debates about human impacts on local and global ecosystems (Meyer and Turner 1994; Gutman et al. 2004; Malanson et al. 2006; Walsh et al. 2008) This trend has been accompanied by the acceptance of such 'objective' classifications of landscape-level change as hard fact.

The creation, reading and interpretation of maps of land cover change, however, are typically in the hands of bureaucrats, environmental managers, NGOs and applied research groups. Categories are fixed and patterns are described according to the perceived urgency of a particular environmental issue: as political ecologist Paul Robbins points out, "[O]ne must identify forest in order to map deforestation" (2001). Collectively, the complementary tools of political ecology and land change science provide the methodological underpinnings for this type of study of human-environment interactions (Turner and Robbins 2008). One of the benefits of conducting an empirical study of landscape use is the ability to distinguish trends of ecological change and its differential impacts on particular stakeholder groups. The incorporation of local knowledge can offer fresh insights into the causes and consequences of landscape change (Rochelau 1995), and participatory mapping (also called countermapping) has been noted for its explicit assumption of conflict and struggle between local and 'expert' scientific knowledge about a landscape (Peluso 1995; Zurayk et al. 2001). By creating competing accounts of the land, struggles over boundaries and territories (Walker and Peters 2001), natural resource control (Nevins 2004) and protected areas (Taylor 2009) gain legitimacy among traditionally disempowered populations.

Remote sensing analysis of land change can also reveal additional stories and a broader understanding of the social aspects of the landscape once synthesized with qualitative research (Jiang 2003; Matthews et al. 2001). Robbins (2003) cautions, though, that the use of maps to illustrate the geographical imaginaries of land use according to a particular social group must be supplemented by information about how those categories are produced. Few studies quantitatively compare local knowledge-derived land cover classifications by separate stakeholder groups, where they diverge and

why (Robbins 2001). This chapter contributes to this growing body of literature through the use of participatory mapping to qualitatively and quantitatively evaluate different stakeholder perceptions of land cover, and the changing nature of the Isabela highlands.

Methods

Qualitative Data Collection

Field research was carried out on Isabela Island during 2009 and 2010, and activities were designed to elicit information regarding highland environmental management techniques and guava control. Interviews and a participatory classification exercise were conducted with six personnel of Isabela's GNPS office who have been working on Isabela for a minimum of five years, and who routinely carry out monitoring and/or control and eradication programs for invasive plants in the highlands. One of them is also a landowner, and he provided excellent insight into the challenges of private land management in a landscape that is increasingly fragmented due to land abandonment. To observe control and eradication procedures, I accompanied three GNPS employees on patrols of the park perimeter and assisted in the identification and removal of invasive plant species.

Of the 23 Isabela landowners who were surveyed in the data collection described in the previous chapter, 15 of them were selected for the participatory classification exercise for this chapter. These self-identified full-time landowners were chosen based on their above average household income and length of land tenure, which served as a proxy for knowledge of the highland landscape and awareness of different types of vegetative cover. During our discussions information was solicited about land management history, alternate economic activities, biophysical challenges to agricultural practice and their perceptions of policies deployed by the GNPS to deal with invasive species in and around the agricultural zone. These activities also clarified contrasting views and actions between the members of these stakeholder groups.

Ground truth sites to be used for participatory classification were selected from 80 GPS locations taken during fieldwork conducted in July and August 2008, based on their location within

the spatial footprint of two satellite images over the study area. The 35 selected sites were not spatially stratified, but represent a diverse set of land cover types found in the highland zone. At the end of our interviews, photographs taken at each site during fieldwork were shown to the 15 landowners and six GNPS employees, and they were asked to identify the land cover shown in the photograph. Responses were assigned to a more general set of six land cover classes, from which the majority response for each group was selected. This resulted in two classification sets per site.

Satellite Image Collection and Pre-processing

A landscape-level assessment of invasive vegetation in Isabela's highlands using satellite remote sensing was carried out by Walsh et al. (2008), who found that fine spatial resolution (3 m pixels or less) imagery was suitable for identifying patches of guava or large individual trees. Two 2.4 m resolution satellite images, QuickBird and WorldView-2, were identified over the study area that have collection dates almost exactly six years apart (October 22, 2004 and October 23, 2010, respectively; Figure 5.2). QuickBird and WorldView-2 sensors are linear array, push-broom designs, and each has a single panchromatic band with a pixel resolution of 0.6 m, and multiple multi-spectral bands with pixel resolutions of 2.44 m. Both of the selected images were collected during the *garúa* season, characterized by high cloud cover, low rainfall and high agricultural productivity. They were geographically referenced to each other, clipped to the same spatial footprint and stacked to produce one image with 12 multi-spectral 'bands', four from the QuickBird scene and eight corresponding to the WorldView-2 image. Because the training samples for classification were extracted from the images to be classified, atmospheric correction was unnecessary (Song et al. 2001; Jensen 2007). Clouds and associated shadows covered a significant portion of the 2004 image and a small portion of the area of the 2010 image. These were digitized using ENVI image processing software, and a mask was created to exclude them from the analysis.

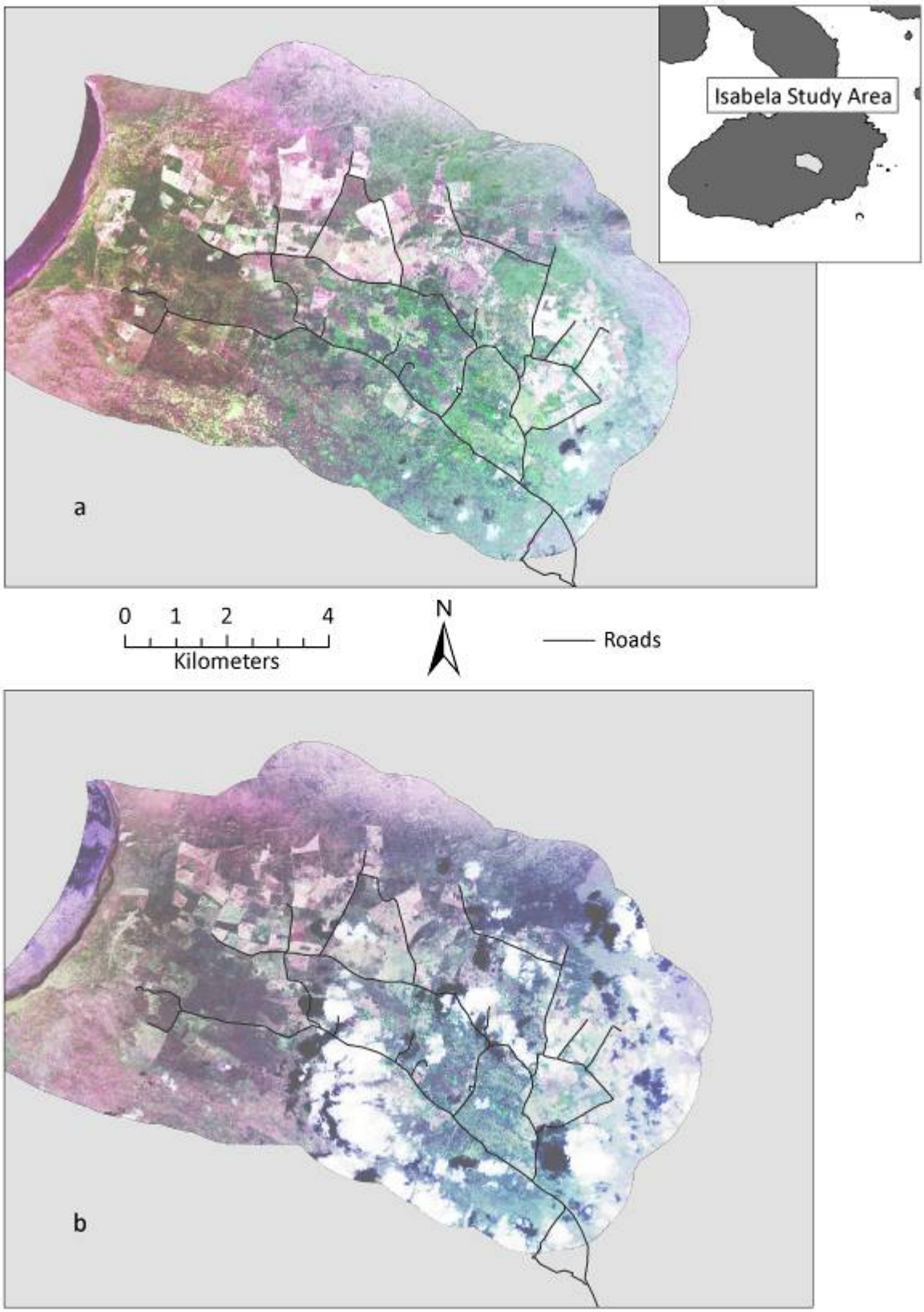

Figure 5.2. True color composites for the a) 2010 WorldView-2 and b) 2004 QuickBird satellite images acquired for the Isabela Island highlands.

Image Classification and Analysis

Because of the time difference between field and image dates, the two satellite images were compared to aerial photographs collected over the region in 2007, closer to the time that study sites were photographed in 2008. Land cover patches containing study sites were more easily identified in the 2010 image, although three sites were removed due to major land cover change between 2008 and 2010. The remaining 32 study sites were digitized into polygons that corresponded to reflectance values within the 2010 image, which was then processed using a Maximum Likelihood supervised classification algorithm that assumed equal prior probability of all classes. Only the multi-spectral bands 2, 3, 5 and 7 were used in the classification of the 2010 WorldView-2 image, as these wavelengths correspond to bands 1 – 4 (Blue, Green, Red and Near-Infrared) of the QuickBird image. The supervised classification procedure identifies land cover classes for every 'unknown' pixel in the image based on the attributes for the 'known' pixels as classified by study participants. The image was then classified twice, producing two output images; one representing the opinions of the 15 landowners, and one representing those of the six GNPS respondents.

The resulting classifications were characterized by a lack of spatial coherency, and contained numerous one-pixel patches of land cover types inside larger patches. When compared with aerial photographs it appeared that these were misclassified pixels that should be members of the surrounding patches. To smooth the images, a set of procedures was run in ENVI. First, a sieve procedure scanned all neighboring pixels to determine if isolated pixels should be grouped with nearby pixels of the same class. A clump procedure then applied morphological operators to further group neighboring pixels of the same class together. Finally, a 3x3 majority/minority filter reclassified each pixel to the majority surrounding land cover class. This commonly-used set of procedures was successful in reducing the speckled nature of the images.

The areal coverage of each class was evaluated for the resulting classified images, and these were cross-tabulated against one another to derive kappa indices that reflect the level of spatial agreement between corresponding categories. The kappa index approaches 1.00, for example, when

GNPS-defined land cover categories, extrapolated across the entire image, are similar to landowner-defined land cover categories. The above steps were repeated for the 2004 image to facilitate comparative, quantitative evaluation of the change in spatial coverage and location of land cover types between 2004 and 2010. Because it is theorized that patterns of landscape change are tied to management practices on either side of the boundary, GIS coverage of the GNP/agricultural zone divide also facilitated spatially-differentiated land cover assessment.

Results

Divergent Perceptions of Land Cover

When I conducted the classification exercise in 2009, I carried a copy of the 2004 satellite image with me to help explain the nature of the project. Participants who viewed the satellite image and photographs interpreted this 'hard data' about the landscape very differently – landowners saw a fragmented landscape, not by vegetation types but the boundaries of territories that represented theirs or their neighbors' farms. GNPS personnel instead recognized where certain types of vegetation were dominant over others, and hypothesized why or for how long.

The classification exercise was a two stage process, as I was interested to see how groups of categories emerged through classification, but aware of the need to reduce the number of classes to a manageable set. First, participants were encouraged to assign a land cover type that they felt 'best' represented each photograph they viewed from a broad list of types commonly found in the region (Table 5.1). Then, based on their responses and my knowledge of the highland zone, I derived a final set of six general land cover classes. The photos in which respondents identified trees and forest, for example, were assigned to the cropland category because they constitute a small part of agricultural use or income and are sometimes used to mark farm boundaries. Guava was frequently singled out in the photographs even when interspersed with other types of vegetation, and was assigned its own category apart from other introduced vegetation. Non-specific vegetation types, including grasses and shrubs, were assigned to a general 'other vegetation' category while individual species or vegetation

types that are known to be invasive were assigned to the category 'other introduced vegetation'. Other categories were pooled together because they were too infrequently cited to meet the criteria for the maximum likelihood algorithm used to perform supervised classifications.

Table 5.1. Summary of land cover classes selected for classification.

Initial Category Assigned	English meaning	Final Land Cover Class
Lava, rocas, afloramientos rocosos	Lava, rock	Lava
Suelos	Soil	Bare soil
Infraestructura, caminos	Infrastructure and roads	
Cultivos	Cultivars	Cropland
Arboles,bosque, arbórea	Trees, forest	
Herbácea	Herbaceous vegetation	Other vegetation (OV)
Arbustiva	Shrubs	
Pastos	Grasses	
Guayaba	Guava	Guava
Helechos	Ferns	Other introduced vegetation (OIV)
Plaga	General pest	
Especies introducidas	Introduced species	

The classification exercise generated two unique sets of perceptions about highland land cover. Classification results for the 2010 image are shown in Figure 5.3. Changes in land cover area are analyzed between stakeholder groups, and interpreted according to particular trends in agriculture and conservation management in the highlands.

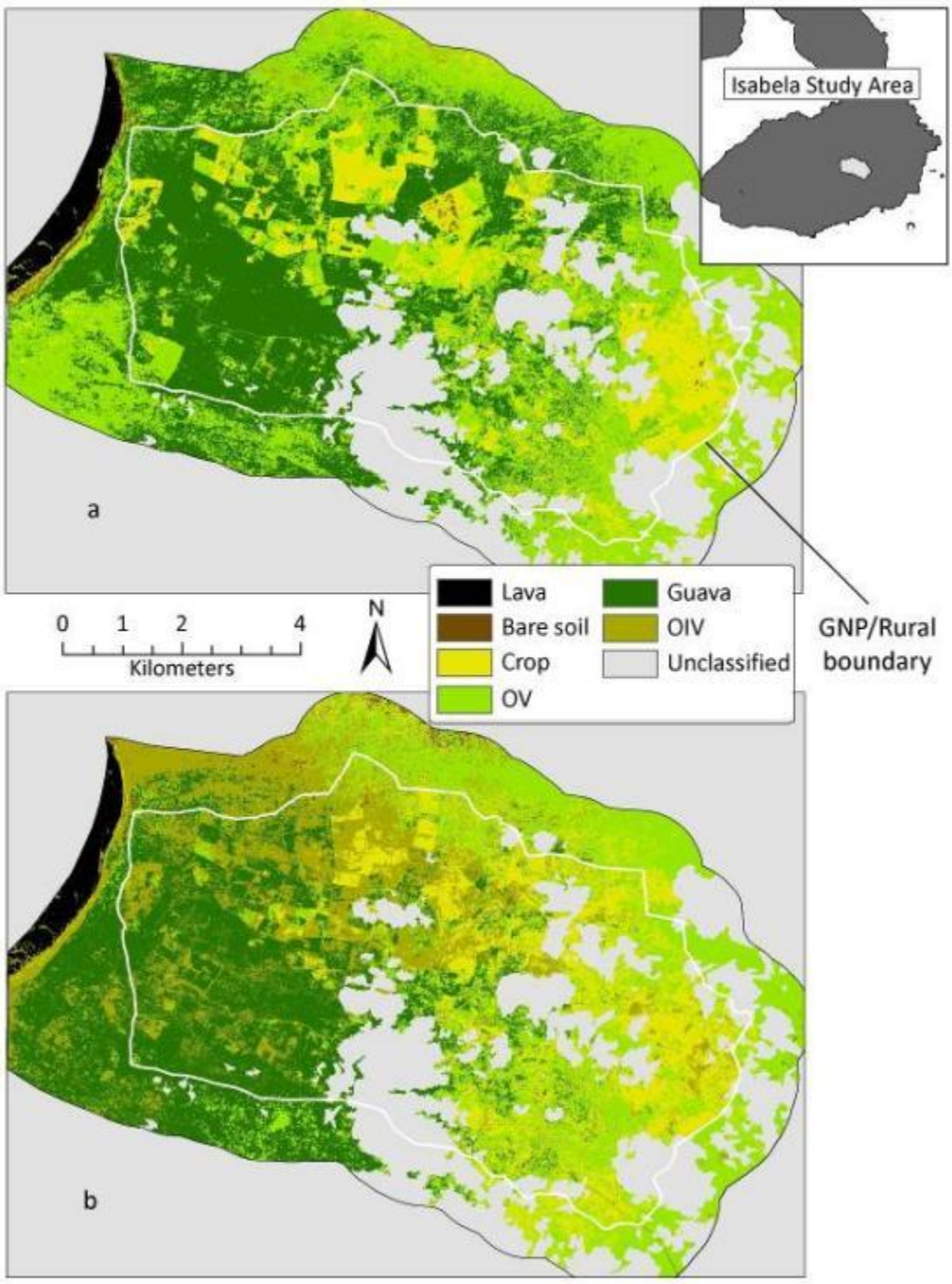

Figure 5.3. Land cover classifications of the October 2010 satellite image of the Isabela highlands, by a) landowners and b) GNPS employees.

Responses between the two groups differed greatly, while within-group responses were highly uniform. During the exercise, landowners and GNPS employees identified nearly matching

guava photos, and the spatial coverages of cropland and guava match reasonably well (Table 5.2). Agreement over what constitutes bare soil, other vegetation (OV) and other introduced vegetation (OIV) was significantly poorer, however. GNPS employees 'saw' far more OIV than do landowners, who instead identified this vegetation as OV. Overall, there is a high level of disagreement between the two classifications (Kappa = 0.39).

Table 5.2. Comparison of coverage agreement (in hectares) for the 2010 image.

Category	Landowner coverage	GNPS coverage	Difference (Landowner-GNPS)
Lava	166.55 (2%)	153.61 (2%)	12.94 (8%)
Bare soil	85.69 (1%)	46.43 (1%)	39.27 (85%)
Cropland	1068.87 (15%)	1252.93 (18%)	-184.06 (-15%)
OV	3016.18 (42%)	1651.19 (23%)	1364.99 (83%)
Guava	2715.62 (38%)	2192.46 (31%)	523.16 (24%)
OIV	39.97 (1%)	1796.27 (25%)	-1756.30 (-98%)
Total	7119.79	7119.79	

Figure 5.4 shows the spatial agreement and disagreement of guava pixels in the landowner and GNPS classifications. The central-west portion of the image is dominated by vegetation that both landowners and GNPS employees would identify as guava. This 'shared' coverage is almost entirely contained within the high western elevations of the agricultural zone, a cooler area that is suitable for guava growth. This region contains a vast forest of guava trees between 3-4 m tall that form a dense, closed canopy. At the mid-northern edge of this dense coverage near the farm/GNP boundary, numerous seedlings are found, indicating that the invasive 'front' is proceeding. The farms in this region are used primarily for livestock grazing, where landowners tend to allow trees to mature and shade out surrounding seedlings, or plant surrounding grasses to limit growth.

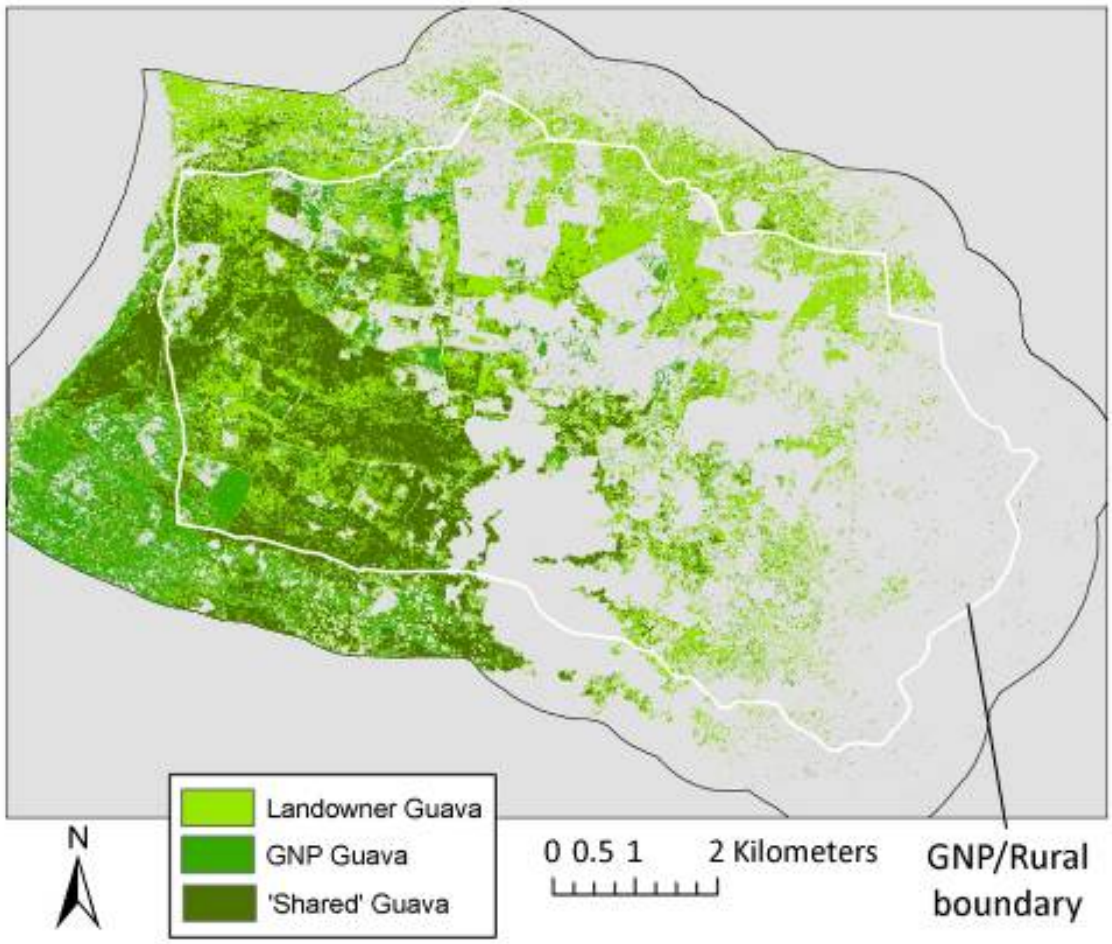

Figure 5.4. Landowner and GNPS perceptions of guava coverage.

In the more intensive agricultural zone toward the center of the image, landowners identify guava in patches that GNPS employees do not. The patchy nature of guava in these areas is attributed to seed dispersal by birds and both domestic and feral animals, but is also likely due to processes of land abandonment and guava succession that began in the 1970s and 80s with the arrival of the more lucrative fishing and tourism industries. Both young and old guava in this region is also interspersed with crops. The southeastern portion of the agricultural zone, because of its lower elevation and shelter from the prevailing winds, experiences a dry climate that is less favorable for guava growth. This area is also more intensely cultivated, containing a higher proportion of landowners who live in the highlands full-time and operate commercial or subsistence farms.

In both classifications, areas of the GNP that are adjacent to the agricultural zone contain more guava than areas that are further away. The GNPS classifications contain more guava in the protected area surrounding the agricultural zone than those of landowners. While landowners tended to classify only photographs that contained mature trees and young growth as guava, GNPS employees also identified photographs that contained small seedlings among other shrubs and ferns as guava. Of the total guava coverage in the GNPS classification, 54% is found inside the national park, compared to only 30% in the landowner classification. On a hike to the crater's northeastern edge in 2009, a GNPS employee gestured toward the mix of short, scrubby vegetation that surrounded us. Twenty years ago, he explained, the area was all grasses. Tourism, especially on horseback, to the crater has increased significantly since that time, and as the horses are contracted directly from local landowners they are capable of spreading the seeds of invasive plants from farmland along the trail's edge that leads through the GNP to the crater's rim. As in the agricultural zone, large areas of the GNP that have not been recently cut or treated are heavily invaded by guava.

The unsupervised classification conducted by Walsh et al. (2008) analyzed a subset of the QuickBird 2004 image that was used in the research for this chapter. They too found that guava was distributed throughout the scene, "with a large area of invasion in the southwest corner of the study area, scattered patches of invasion across the agricultural zone, and dispersed, smaller patches of invasion along the transition zone located along the border of the Park." The dense, continuous 'shared' guava patches that were identified by GNPS employees and landowners in this classification correspond to regions that Walsh et al. considered well-defined areas of older guava growth and invasion. Smaller, dispersed patches within the agricultural zone that landowners in this analysis considered guava are visible in the Walsh et al. classification as well, suggesting that field knowledge and recognition of guava is especially high among highland landowners.

Divergent Perceptions of Land Change

Of the 23 Isabela Island landowners interviewed for the previous chapter, it has become common in recent years for many of them (83%) to live and work in the coastal village of Puerto Villamil during the week, reserving farm work for the weekend. A little more than half (55%) hire temporary workers from the mainland to maintain the farm while they are away. For most, only two or three hectares are kept under cultivation at any time of the year. Agricultural activity in the highlands has decreased in the last decade, which as the previous chapter showed is due to a constellation of economic and ecological factors, including off-farm employment opportunities, unstable local food markets, and challenges to production such as inadequate water supply, labor, mechanization and the spread of introduced species. It is hypothesized that 'crop' cover would decrease during that time, and the amount of guava and OIV would increase between 2004 and 2010. The classification exercise, however, reveals conflicting perceptions of land cover change among participants (Table 5.3).

Table 5.3. Classified land cover change between 2004 and 2010 (in hectares).

	Landowner area			GNPS area		
Category	2004	2010	2010 - 2004	2004	2010	2010 - 2004
Lava[15]	532.89	166.55	-366.34	377.31	153.61	-223.70
Bare soil	184.45	85.69	-98.76	137.16	46.43	-90.73
Cropland	1872.03	1068.87	-803.16	554.70	1252.93	698.23
OV	1434.04	3016.18	1582.14	1362.76	1651.19	288.43
Guava	3014.23	2715.62	-298.61	1665.48	2192.46	526.98
OIV	56.10	39.97	-16.13	2994.57	1796.27	-1198.30

As expected, the amount of cropland decreased by almost half when viewed from the landowners' perspective, while OIV more than doubled. The loss of cropland perceived by landowners is balanced by an increase on the part of GNPS employees, perhaps because what the

[15]The decrease in lava coverage in both sets of classifications is likely due to the fact that, although the adjacent volcano recently erupted in 2005, older lava and rock visible in the 2004 image have since been reclaimed by pioneer vegetation such as ferns and grasses.

GNPS would call *bosque*, or forest (which was combined with the 'crop' category), in the region has actually expanded since 2004. GNPS employees classified stands of trees, some of which were native and others that were introduced, as forest, while landowners instead tended to classify those photographs as general herbaceous vegetation (OV). Forestry on Isabela is a marginal industry compared to its economic stake on other inhabited islands; therefore, local landowners see little value in the presence of trees among other types of ground cover (Segarra, personal communication 2009). But the GNPS, according to one study participant, considers that "the presence of forest is an indicator of how we are doing our job. Trees play an important role in preventing invasive species growth" (personal communication 2009). Former farmland acquired in 2007 by the GNPS highlights native forests and hosts a tree nursery, although invasive rose apple trees contest the welcome sign's claim that all introduced plant species have been removed from the site (Figure 5.5).

Figure 5.5. Welcome sign for La Cueva de Sucre, now part of the GNP (left); invasive rose apple trees growing within the 'native' forest (right). Photos by Amy McCleary (2008).

Conversely, from the landowners' point of view guava coverage in 2010 actually decreased from 2004, while GNPS employees perceive it to have increased. Spatially differentiated, those land cover reductions occurred primarily in the agricultural zone according to landowners. According to the GNPS, on the other hand, guava emerged in the national park and the southwestern agricultural

zone. If these agricultural and invasive land covers are truly in transition, then what land cover types have come to replace (or reconstitute) them?

As seen in Table 5.4, the transition that landowners perceived *from* cropland and guava *to* other classes is matched by GNPS-perceived transitions *to* cropland and guava from other classes. In fact, only 17% of cropland from 2004 was present in the 2010 landowner image, and it transitioned largely into OV (45%) and guava (32%). This is consistent with observed vegetation transitions on abandoned or fallow land, as grasses, shrubs and guava seedlings often make up pioneer vegetation. The GNPS classifications show a similar (15%) stability of the crop class, but the 'new' cropland is mainly comprised of former OV and guava. This unexpected transition is likely due to the fact the 2008 photographs containing young trees, which were used to classify the 2010 image as 'crop' according to GNPS input, also contained a variety of shrubs and, to a lesser extent, guava, which may have dominated the spectral signal in those same regions of the 2004 image.

Table 5.4. Land cover change matrices for 'Crop' and 'Guava' categories (in hectares). Stable land cover between time periods is indicated in bold.

	Landowner area (2004 to 2010)		GNPS area (2004 to 2010)	
To/From Category	From Crop	From Guava	To Crop	To Guava
Lava	12.19 (1%)	22.67 (1%)	41.53 (3%)	0.50 (<1%)
Bare soil	16.90 (1%)	37.96 (1%)	36.51 (3%)	14.03 (1%)
Cropland	**316.33 (17%)**	235.77 (8%)	**187.78 (15%)**	50.20 (2%)
OV	917.22 (49%)	1006.05 (33%)	442.49 (35%)	120.54 (6%)
Guava	601.27 (32%)	**1692.67 (56%)**	323.96 (26%)	**765.16 (35%)**
OIV	8.11 (<1%)	19.11 (1%)	220.38 (18%)	1241.54 (57%)
Total	1872.03	3014.23	1252.93	2192.46

Over half (56%) of the guava in the landowner classifications remained stable, while the remaining majority (33%) also transitioned into OV. This shift in crop-to-guava and guava-to-OV reflects anticipated land cover changes in areas that have been abandoned, are no longer under cultivation, or were cleared of guava and succeeded by pioneer vegetation (OV). The spread of guava, as Walsh et al. (2008) found, "is likely affected by age of establishment of the guava source areas,

and land management strategies implemented on the farm and on adjacent farms." Landowner-defined guava actually decreased by 19% inside the GNP, but appeared more widely dispersed within the agricultural zone in 2010. Compared to the landowner classifications, only 35% of GNPS-defined guava remained stable, while 57% of its coverage in 2010 was derived from land cover previously classified as OIV. Furthermore, the majority (62%) of the GNPS-defined guava growth occurred in the national park. The reasons for these divergent understandings of species and the landscape are complex, but they stem from the differing perceptions of land use and what environmental management means in the Isabela Island highlands.

Divergent Perceptions of Land Use

While there was a high overall level of agreement between stakeholder groups in the case of guava, the almost complementary classification of OV versus OIV calls attention to a divergence in views about native and introduced species. Landowners and GNPS employees 'saw' different vegetative makeup in photos that contained a variety of vegetation types. Where introduced ferns or grasses were present, GNPS employees singled them out as individual introduced species, often citing the plant's common name, whereas landowners were more likely to identify them to a more general category of 'grasses' or herbaceous vegetation. Guava was the exception to this rule in that both landowners and GNPS employees identified it in photographs, even when other species or land cover types were present. These results imply that the kinds of land cover that the GNPS considers degraded are seen by landowners as productive, and point to a critical disconnect between land use regulation and actual land *use*. In other words, protecting native highland biodiversity may be the ultimate goal of the GNPS and other conservation institutions, but it is not always shared by landowners who have economic interests in the region.

Other introduced, invasive plants such as avocado trees, elephant grass and citrus trees further illustrate this distinction. Elephant grass, for example, is preferred by landowners as livestock fodder because it is drought-tolerant and adapts well to poor soils, but its rapid growth makes it a threat to

the national park on the other side of the boundary. Even the presence of guava is sometimes considered positive because it provides shade and fruit for livestock, although it quickly invades open pastures. Other plant invaders are perceived as strictly negative by landowners, including most ferns, *mora* and rose apple. Odd numbered entries in Table 5.5 highlight cases where conservation officials consider an introduced plant to have a negative impact while landowners believe it has a positive use. Even numbered entries exhibit shared perceptions of the plants' negative impacts.

Table 5.5. Shared and divergent views of introduced plants present on Isabela Island among GNPS employees and highland landowners.

Plant Name	GNPS Impact	Landowner Impact
1) Guava (*Psidium guajava*)	Invades and replaces native vegetation	Invades pasture and difficult to eradicate; provides shade, food for livestock
2) *Mora* (*Rubus niveus*)	Chokes out native vegetation	Forms dense thickets and chokes out cultivated plants
3) Avocado (*Persea americana*)	Invades native vegetation	Provides shade, food for livestock; a seasonal cash crop
4) Ferns (*Pteridium sp.*)	Invade zones of the national park	Form dense stands in pasture
5) Citrus trees (*Citrus sp.*)	Invades zones of the national park	Provides shade, a seasonal cash crop
6) Rose apple (*Syzygium jambos*)	Forms dense forests, shades out native plants	Forms dense forests; prevents livestock grazing
7) Passion fruit (*Passiflora edulis*)	Chokes out native vegetation	Chokes out cultivars; food for livestock
8) Mother of thousands (*Bryophyllum pinnatum*)	Replaces native vegetation	Competes with grasses and cultivars for soil nutrients
9) Elephant grass (*Pennisetum purpureum*)	Competes with native vegetation, especially *Scalesia*	Assists in control of guava and *mora*; important food for livestock

Several of my landowner informants had difficulty understanding the distinction drawn between introduced plants and their native counterparts. Mother of thousands (*Bryophyllum pinnatum*), everyone agreed, was a *plaga*, or weed, but they were uncertain of how it had arrived or

why that was even relevant. This reflects the fact that awareness of the threat of introduced species among Isabela landowners is low (79%), compared to 94% archipelago-wide (INEC-CGREG 2010). After all, the concept of 'nativeness' did not appear in the literature until the mid-nineteenth century, and invasion biology as a field has only emerged in the last 50 years (Davis et al. 2011).

Put another way, in the GNPS context, ecosystem threats are introduced species that have the potential to impact the range, distribution and survival of native species. In landowner terms, an environmental threat could be any organism, regardless of origin, as long as it somehow diminishes the productive potential or economic value of agricultural land or agricultural products in the region. *Plaga* status for landowners does not imply alienness, nor is it excused by nativeness. The presence of GNPS-defined 'forest' comprised of native and non-native plant species also implies that overall 'ecosystem health' is a subjective notion and not necessarily an ecological one. Even native species are quite capable of facilitating ecosystem and economic destruction, as in the unique case of endemic Galápagos finches that both spread *mora* seeds and denude crop productivity.

Returning to the presence of guava, however, landowners and GNPS employees agree on its potential to destroy highland biodiversity and agricultural livelihoods, even if it does provide some minor benefits. Unfortunately the last three decades of guava management on Isabela Island have alienated rural community members instead of recruiting them as active participants in conservation. This again highlights the detrimental environmental effects of park-only policies that fail to enroll private landowners in the control of invasive species.

Inside the boundaries of the national park, for example, the GNPS has spent thousands of dollars exploring alternatives to the point application of metasulfuron and picloram herbicides, which is effective but must be applied directly to individual tree trunks or cut stumps (Rentería et al. 2006). Covering seedlings with large mats and cutting mature trees proved too expensive and labor intensive, and the use of biological controls could pose threats to the native guava variety (*Psidium galapageium*; Tye 2001). Referring to the chemical method of control, "It's not an ideal solution, but it's what made sense," said one GNPS employee out on patrol in 2009. Controls are most effective in

isolated patches and areas of young growth where the trees have not set fruit, making the 'front' of guava that is proceeding at the boundary of park and private land a high-priority area for the GNPS and highland landowners to jointly intervene. On private land, the Isabela GNPS office provided assistance to landowners in the control of *mora* for several years in the early 2000s; but the control of guava is, as another employee simply put it, "their problem. We're a conservation organization," he maintained. "What the farmers do is none of our business" (Ramirez, personal communication 2009).

Without financial and labor assistance from the GNPS, many landowners resort to the use of banned herbicides and, in some cases, burning, to rid their land of guava. In 2009 I talked with a man whose farm had recently been destroyed by a fire he started to burn the guava on his field. Although prohibited, burning is a common practice in Isabela's highlands, both to promote regeneration and as a form of weed control. The fire he started rapidly grew out of control and spread to neighboring farms and homes, ultimately consuming over 150 ha of farmland. He gestured across the charred remains of fields where he used to graze his cattle. "I would have done things differently, but there's no other choice for us, up here. They [the GNPS] don't care about us. It's every man for himself."

Fire can actually contribute to the regeneration of guava seedlings, as Shimizu discovered during a vegetation survey conducted in 1997. Following an intense 1994 fire that burned thousands of hectares in Alemania, a formerly colonized but now uninhabited region of Isabela's highlands, new guava shoots were sprouting from the base of burned trees and dead trunks. Where guava did not recover in the most severely damaged areas, dense thickets of ferns had formed as pioneer vegetation (Shimizu 1997). As a control measure, landowners often follow prescribed burning by planting elephant grass, another highly invasive (but useful) species, to serve as livestock fodder and prevent the recovery of guava.

Many Isabela landowners have found creative solutions and even uses for guava without institutional support. By keeping their land cleared and under production, full-time farmers avoid the problems with guava reported by landowners who only farm part of the year. Some clear guava and plant shade-producing coffee trees that would naturally prevent the seedlings from sprouting beneath

them. Others cut guava trees and seedlings several times a year, composting the weeds and planting a non-invasive species of hardwood tree to provide the farm with wood in coming years. Clearing it by hand, however, is time-consuming at best, and some of the large land holders argue that it's a losing battle: "If we keep cutting the guava like this, by hand, every year, we'll be dead and only the guava will be left!" said Fernando, a farmer who is originally from the mainland province of Loja. As another implied in a 2009 interview, the future of Isabela's farmland depends on production today: "I cut guava and plant trees to shade out seedlings, but that's all I can do. I'm only one man. … I still believe, you know – we have a future, and we're working for the future."

Two landowners use the wood from mature trees to make charcoal, which they sell by the *quintal* (100 lb) for $30 (Figure 5.6). I asked one of them if his charcoal was in high demand, and he replied in his usual good humor: "*¡Están llorando por carbón!*" [They're crying for charcoal!]. With coastal tourism on the rise, restaurants in Puerto Villamil have begun offering buffet-style barbecues, and the locally-sourced charcoal burns longer, cleaner and at a lower price than mainland imports. When I mentioned this conversion of an invasive pest into an economic resource to one of my GNPS informants, he responded that even if the funding existed for additional manpower and ovens for high-volume pyrolysis, the park would be unprepared to sell or export the final product. "Sure, Juan [Chavez, the previous Isabela GNPS Director] was interested in the process," he concluded, "but the park isn't in the charcoal-making business" (Alvarez, personal communication 2009).

Figure 5.6. Farmers building a charcoal oven using the wood from guava trees. Photo by Nick Zetts (2008).

Finally, misconceptions about local farm practices continue to distance Isabela's landowners from invasive interventions. The owners of abandoned farmland, primarily in the northwest regions of the agricultural zone, are being held responsible for the continued spread of guava seeds into the surrounding national park, and ranchers are accused of allowing their livestock to graze across the border. "Regardless of how it's happening, the border between the park and the agricultural zone has been breached," said a CDRS botanist in 2008, "and the guava is going to keep spreading." In the meantime, for the few households who still participate in full- or part-time agricultural production, economic security is more important than restoration goals that are handed down to them from Santa Cruz. Isabela landowners do not have the agricultural infrastructure enjoyed by their Santa Cruz or

San Cristóbal counterparts, nor do they have the attention of politicians and institutions. As another scientist commented in 2009, "Well, perhaps it's just time for farming to be over on Isabela."

Conclusions

In this chapter, I used participatory remote sensing to show how different stakeholder groups 'see' the Isabela highland landscape, focusing on the perceived presence of introduced vegetation and more specifically, invasive guava trees. In particular, this analysis found that remotely sensed imagery can be a powerful tool with which to render competing landscape knowledges and uses clear, as landowners perceive more guava than GNPS employees overall, but find less of it in the national park. Nevertheless, the 'front' of guava that is proceeding at the edges of privately owned land and the national park was noted by both stakeholder groups in this analysis. Comparison of the results of this analysis with an evaluation of guava's presence conducted by Walsh et al. in 2008 further suggests that field knowledge of guava among highland stakeholders is high, particularly in the regions identified as 'shared' guava coverage. As Walsh et al. found, large, contiguous patches of guava "create a negative feedback on the landscape as animal dispersal of seed and the emergence of new seedlings serves to 'choke' the landscape and further debilitate the farm." Where it is a hindrance to agricultural livelihoods, it may be that a species known to complicate crop production and resist traditional methods of control will be singled out among other vegetation types in participatory classification, including other introduced plants. The GNPS, on the other hand, identifies all introduced vegetation regardless of its utility, with the surprising exception of trees. It seems that to Isabela's national park employees both native and introduced tree species contribute to an inherited image of highland productivity from Santa Cruz, where forests (and forestry) are more common.

Furthermore, this chapter expands upon the analysis of the previous chapter to consider the implications of divergent perceptions of land cover, change and use in the Isabela Island highlands. In a landscape where productivity and degradation co-exist, only one of these competing conceptions about what the highlands are and 'ought' to be will gain legitimacy behind the desks of policy makers. While the impacts of invasive plants such as guava on the future of Isabela's food production

remain uncertain, the lack of local institutional support will likely influence future land management decisions by landowners. In other words, where it is the goal of conservation practitioners to restore the island's highland zones, the evaluation, nature and timing of restoration schemes must incorporate those decisions. Practices based solely on the grounds of belonging should be modified to reflect how ecosystem interactions differ in their application to agricultural practice than to environmental management, making it more likely that environmental management schemes will be accepted and carried out by rural community members in the long term.

Chapter 6: The Double Bind of Tourism in Galápagos Society

No existe desarrollo sostenible [There's no such thing as sustainable development].
Isabela Island hotel owner, 2008

Poaching remains a serious threat and eco-tourism an even more serious threat. The Galápagos are being destroyed by both poachers and eco-tourism.
Sea Shepherds Captain Paul Watson, 2011

Introduction

"This is not what it means to be *galapagueño*."[16] As my GNPS companion made his sad proclamation, we were standing in front of the desiccated carcasses of three giant tortoises whose flesh from their torsos and feet had been scraped away. It was June 2009, and I had accompanied three Isabela Island GNPS employees on foot to the isolated beaches of Barahona and Quinta Playa, located several kilometers from the town of Puerto Villamil, important nesting sites for green sea turtles that migrate throughout Pacific and Caribbean waters. On this day, however, it was not sea turtles but giant tortoises that had been dead for over three months. The tortoises had been placed in tree branches at eye-level, and the faded numbers painted on their shells indicated that they were born and raised at the island's breeding center only a few miles away. The guards were convinced that this was the work of one of Isabela's oldest families who were thought to be responsible for 16 such deaths the previous year.

Acts such as this are less common than they were a decade ago, when high profile conflicts between the fishing sector and policy makers erupted into violent demonstrations. Illegal activity is prevalent today, though, not only on Isabela Island, but archipelago-wide. Clandestine, illicit behavior

[16]In this chapter the term '*galapagueño*' refers to a permanent resident of the islands, but in colloquial use is often reserved for descendents of the original colonists. In general, 'resident' will be used to distinguish legal permanent residents from temporary and illegal migrants.

in Galápagos is paralleled by the present of a clandestine, illicit population of workers and visitors who overstay their permits, thereby becoming illegal guests of the islands. The first of these twin human 'invasions' is driven by resistance to measures that limit local development, while the second is fueled by the economic logic of development itself. Tourism, as the driving force of today's Galápagos economy, has become what Environmental Minister Marcela Aguiñaga called "one of the main threats to the health and integrity of Galápagos" in her opening speech at the Sustainable Galápagos Tourism Summit held in 2010. Although it is often called ecotourism, conflicting notions about how tourism in unique and fragile environments should be realized have brought the industry under recent scrutiny. Accelerating introductions of new species, migration and illegal activity have come in the wake of the tourism boom, questioning how 'eco' Galápagos tourism really is.

Indeed, ecotourism should, according to Martha Honey (2008), be environmentally sound and small-scale, providing equal benefits to conservation as it empowers and enriches the lives of local residents, but the sudden growth and expansion of the industry in Galápagos has transformed this economic activity into a threat to conservation and social practices. And as the previous chapters have shown, uneven and restrictive measures to protect island biodiversity perpetuate old tensions between those who benefit from regulations and those who do not. Legal prohibitions designed to control the human population impact further constrain certain groups. Galápagos society, therefore, is caught in a double bind: 1) To pursue economic success; and 2) To do so in an environmentally responsible and legal manner. Across the archipelago people are struggling to come to terms with these two, often contradictory, demands that privilege some and marginalize others in the shadow of the tourism boom.

As one of the fastest growing economies in the world (Taylor et al. 2006), obvious questions can be raised about the impacts of the Galápagos tourism industry on local society. These include:

1) How do residents perceive conservation and tourism-related development, and to what extent are they participating in and benefiting from them?

2) What is the role of the migrant population in the Galápagos tourism economy? And;

3) Who owns and controls tourism facilities and infrastructure?

Answers to these questions should clarify whether Galápagos 'eco'tourism is contributing to responsible development by promoting economic success among local populations and ensuring environmental sustainability and social accountability.

This chapter evaluates the impacts of the rapidly-growing ecotourism industry on Galápagos society by focusing on the questions above. It identifies particular socio-economic and demographic characteristics among the resident population that are conducive to supporting particular types of development or conservation, and investigates illicit environmental behavior in the context of environmental restrictions and economic need. Then, the presence of a temporarily legal and illegal population of migrants is used to further contextualize tourism's impact on the local culture and environment. Finally, the chapter concludes with an examination of the benefits and costs of the current tourism model and considers proposed alternatives that could contribute positively to the long-term environmental management and economic development of the archipelago.

Development, Sustainability, and Legality

Since the early 1990s, industry-driven growth has dramatically altered the social, political and environmental realities of Galápagos. The demand for food and goods alongside population growth outpaced disjointed environmental regulations, whose implementation was stalled because there was no clear leadership entity. Commercial fishing of sea cucumbers, in particular, divided the resident population as well as the Ecuadorian government. Against regulations were local *pepineros* (sea cucumber fishermen), fishermen from the Ecuadorian coast and the Ministry of Industry and Fisheries; while scientists and the Ministry of Agriculture expressed their strong support. Attempts to control the fishery were, as Honey writes, "disastrous. … On the morning of January 3, 1995, a group of *pepineros*, some masked and wielding machetes and clubs, blockaded the road to the national park headquarters and research station outside Puerto Ayora [on Santa Cruz Island]" (Honey 2008: 134).

On other occasions disgruntled fishermen set fire to thousands of acres of land and threatened to kill giant tortoises held as 'hostages' (Honey and Littlejohn 1994; Snell 1996; MacDonald 1997).

At the same time, tensions were growing between local tour operators and mainland agencies, which controlled the Galápagos tourism market. This assumed the nature of a battle between residents and 'outsiders', as naturalist guide Mathias Espinosa recalls (personal communication 2008). The pushback from residents was met with resistance by the Ecuadorian government when the issuance of *cupos* (passenger/berth quotas) for local tour operators was suspended at the same time that the local fishing sector was restricted, resulting in explosive riots and demonstrations. "If the government wanted to economically strangle the Galápagos population," said Christophe Grenier, head of social science at the CDF, "it would not have done anything differently: all of the islands' productive sectors were smothered under the pretext of protecting the ecology" (1996: 421).

Troubling levels of violence led to the development of the 1998 Special Law for Galápagos, a complex set of articles designed to control population growth, eliminate commercial fishing inside the Galápagos Marine Reserve, and promote responsible tourism development. A significant portion of the Law was created by Galápagos residents to protect their economic interests and cultural integrity. Following its passage, trade unions and civil society organizations became important sites within local industry for residents to influence political decision making when according to anthropologist Pablo Ospina, "it became necessary to oppose the hold that environmentalism had on the province" (2001: 21). Galápagos identity became associated with a geographic territory, and permanent Galápagos residency was established, granting locals rights to employment and wages 75% higher than on the mainland. Incoming migrants are restricted to renewable, one-year temporary residency and 90-day visitors' visas. Residency is monitored via an electronic system that tracks ID cards issued to all residents and visitors.

Implementation of the Special Law with respect to the tourism industry, however, has been weak. Tourism continues to bring about considerable change in the urban and rural landscapes of Galápagos, and little has been done to encourage responsible development. Economics have dictated

decision-making more than sustainability criteria, resulting in a 9% annual increase in visitation and 150% growth in the number of island hotels (Epler 2007), while only 45 individuals and corporations own the 80 luxury, standard and day-tour vessels operating in the islands (Epler and Proaño 2008). At the same time, conservation measures in Galápagos have been uneven and restrictive to the local population. Research on conservation psychology and political ecology has shown how illicit environmental behavior can arise out of marginalization and resentment (Neumann 1998; Kaplan 2000; Robbins et al. 2006; Khan and Haque 2010), demonstrated by continued acts of resistance when the needs and desires of Galápagos residents conflict with conservation mandates.

The strong growth in tourism also fueled migration from the mainland, as skilled and unskilled migrants often fill employment needs that cannot be met by members of the resident population (Grenier 2007; Watkins and Cruz 2007). In this way, tourism supports the maintenance of a segmented labor force that requires migrants taking advantage of wage differentials between Galápagos and the mainland (cf. Massey 1999). Unfortunately, this has also given rise to one of the few cases of domestic illegal migration in the world. When their temporary visas expire, many migrants transition into illegal status, of which there are an estimated 3,000 to 3,500 in the islands today (Sotomayor, personal communication 2010).

Beyond reports produced by institutions operating in Galápagos, in the literature on modern Galápagos society a heavy emphasis has been placed on the now-waning fishing sector (Honey and Littlejohn 1994; Andrade 1995; Moreno et al. 2000; Ospina 2005). Other scholarship tends to focus on the construction of a local *galapagueño* identity (Ospina 2001; Borja 2003; Ospina 2003; Ospina 2006) and migrant demographics (Bremner and Perez 2002a, 2002b; Kerr et al. 2004). Studies of Galápagos tourism have been economic (Taylor et al. 2006; Epler 2007; Epler and Proaño 2008) rather than social. The overall goal of this chapter is to dismantle stereotypes that characterize members of Galápagos society as ‘good’ or ‘bad’, ‘legal’ or ‘illegal’, through an exploration of the pressures of tourism-related development and conservation regulations.

Methods

To encourage residents to support specific measures, conservation practitioners must understand what such measures actually mean in relation to resident interests. Because Galápagos residents have diverse goals, ways of knowing the islands, and everyday economic engagements, this requires a focus on how different groups view island conservation and development. To examine what combinations of conservation/development attitudes arose most frequently among Galápagos permanent residents, a cluster analysis was performed. Based on existing household survey data, the aim of the clustering exercise is to develop a resident typology based on attitudes about conservation and development. The purpose is to characterize the diverse motivations, expectations and circumstances that encourage or obstruct their engagement in island conservation.

The 2009 INEC-CGREG survey was conducted to obtain current measures of the quality of life, health, education and economic well-being of the permanent resident population. Using proportional, single-stage random sampling investigators selected 1,336 households from the 72 census sectors in the province, which included the populated islands of Santa Cruz, Baltra, San Cristóbal, Floreana and Isabela. Of those, 1,242 households were selected for this analysis based on completed forms for the head of the household. Archipelago-wide, the average age of the household head was 43, and males comprised 82% of the respondents.

The survey form asked respondents to indicate their opinions about particular indicators associated with beliefs about the environment and growth in the tourism industry. Fifteen variables were chosen as surrogates for attitudes about development and conservation (Table 6.1). Using SAS statistical analysis software, a cluster analysis was performed on these nominal, anominal and ordinal variables, and four clear typologies emerged from the data. The clustering algorithm analyzes means for each measure, grouping the data by minimizing the within-group response variance and maximizing between-group variance (Kaufman and Rousseeuw 2005). This facilitates group comparisons of the roles of other variables that were not included in the clustering algorithm, such as amenities and expenditures, quality of life, education and migration information. Pair-wise testing for

differences in mean values and frequencies for these interval and ordinal variables was conducted at the 0.05 significance level.

Table 6.1. Summary of 15 variables selected for cluster analysis.

Survey Measure	Responses		
Collect trash at tourist sites			
Believe introduced species are a threat			
Number of tourists should grow	Yes	No	
Should live '*isleño*' lifestyle[17]			
Should conserve island nature long-term			
Quality of life in a World Heritage Site is:	Good	Average	Poor
Boat-based (cruise ship, multi-day trips) tourism should:			
Land-based (hotel stays, day trips) tourism should:			
Fishing should:			
Land transport should:	Increase	Stay the same	Decrease
Mainland marine transport should:			
Island marine transport should:			
Island air transport should:			
Mainland air transport should:			
Construction should:			

Cluster interpretation is based on cluster means, past and present trends of conservation and tourism development in Galápagos, and the economic and geographic contexts in which residents engage with the tourist industry. Explanation of the cluster groupings is discussed through interviews conducted in 2009 and 2010 with residents, policy makers and representatives of conservation organizations.

Once clear typologies are established, the second goal of this chapter is to investigate compliance with conservation regulations or illicit environmental behavior among resident groups.

[17]An *isleño*, or island-based, lifestyle is promoted by conservation institutions and emphasizes low imports, less motorized transport, responsible development, etc.

Despite much of the environmental stewardship rhetoric surrounding communities living near protected areas, efforts to maintain and enforce regulations are resisted by some (Ferraro and Kiss 2002; Adams et al. 2004; Romero and Andrade 2004), and in Galápagos such actions are driven both by need and frustration. To assist in drawing this distinction, a brief opinion survey (Appendix III) was carried out among a sample of Isabela (n=30) and Santa Cruz (n=42) Island residents. Information was requested about their opinions of and engagement in current policies related to ecological degradation, tourism and migration to the islands.

There are no reliable data available regarding the origin and number of illegal migrants present in Galápagos, and while information regarding temporary migrant motivations exists in some literature, census estimates of population growth cannot differentiate between in-migration, out-migration and natural population increase. For up-to-date estimates of the numbers of temporary and illegal migrants in the islands, interviews with six members of Migration Control offices (formerly part of INGALA) and four police officers on Santa Cruz, San Cristóbal and Isabela Islands were carried out in early 2010. Additional interviews concerning tourism growth and population pressures were conducted with ten business owners, tour operators and representatives of local Chambers of Tourism. These interviews were recorded and transcribed, and hand-written notes were taken during the discussion to highlight particular topics or responses.

Finally, informal conversations with 15 members of the migrant populations of Isabela and Santa Cruz were conducted to understanding migration motivations and everyday experiences. The sample was not intended to target illegal residents, and while I requested basic demographic and socioeconomic information from participants, I did not solicit information that would divulge an informant's legal status. Because this was still sometimes revealed during our discussions, names as well as locations have been changed to conceal the identity of my informants. Where appropriate, archival documents such as international and local newspaper articles are used to provide a more complete description of a particular conflict or issue.

Results

Permanent Resident Typologies

The clustering exercise revealed that overall, Galápagos residents agree with the need for conservation in the islands (n=1,215, 98%) and the preservation of an *isleño* lifestyle (n=1,140, 92%; Figure 6.1). This represents a practical understanding of Galápagos as a source of their livelihoods and cultural legitimacy (Ospina 2006: 52). In this respect, many of my informants expressed a profound pride in their province while at the same time making clear their desire for greater mainland access and everyday comforts. Three-quarters of respondents live in the coastal urban centers where they engage in the growing private and public sectors rather than traditional activities such as farming and fishing. A new housing development in Puerto Ayora is the result of a recent land swap between the municipality and the GNP that will almost double the town's spatial footprint. So far 1,130 lots have been assigned to the 70 ha site, "a dream come true" for residents (El Colono 2010a: 9), but conservation representatives fear it will be "just like any other slum you'd find on the mainland" (Barry, personal communication 2010).

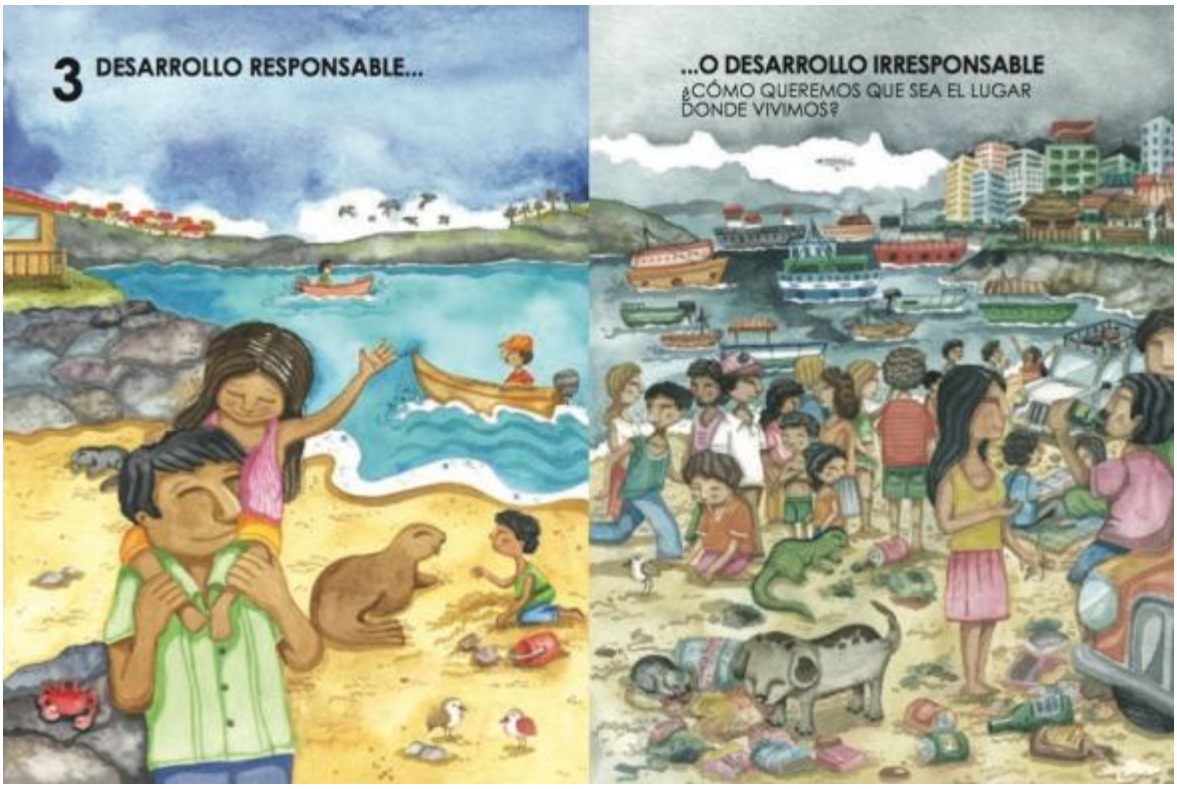

Figure 6.1. Images from a 2008 GNP publication for children that emphasize the difference between *isleño* (left) and mainland-based (right) lifestyles.

The clustering algorithm condensed the 15 variables concerning attitudes about development and conservation into four clusters (Figure 6.2). Based on group responses to questions included in the algorithm, a development typology was assigned to each cluster. Expansionist: The first cluster comprises over half (n=673) of the survey respondents included in this analysis and describes a strong motivation for development, through mainland and island transportation, tourism and construction. Isolationist: The second cluster (n=310) is characterized by a desire for moderate tourism development, high construction and a lower opinion of life in a World Heritage Site. Moderate: The third group (n=102) is the smallest cluster, and expresses low to moderate interest in tourism and local development. Conservationist: The fourth group (n=157) seeks stabilization or decrease in most aspects of island growth.

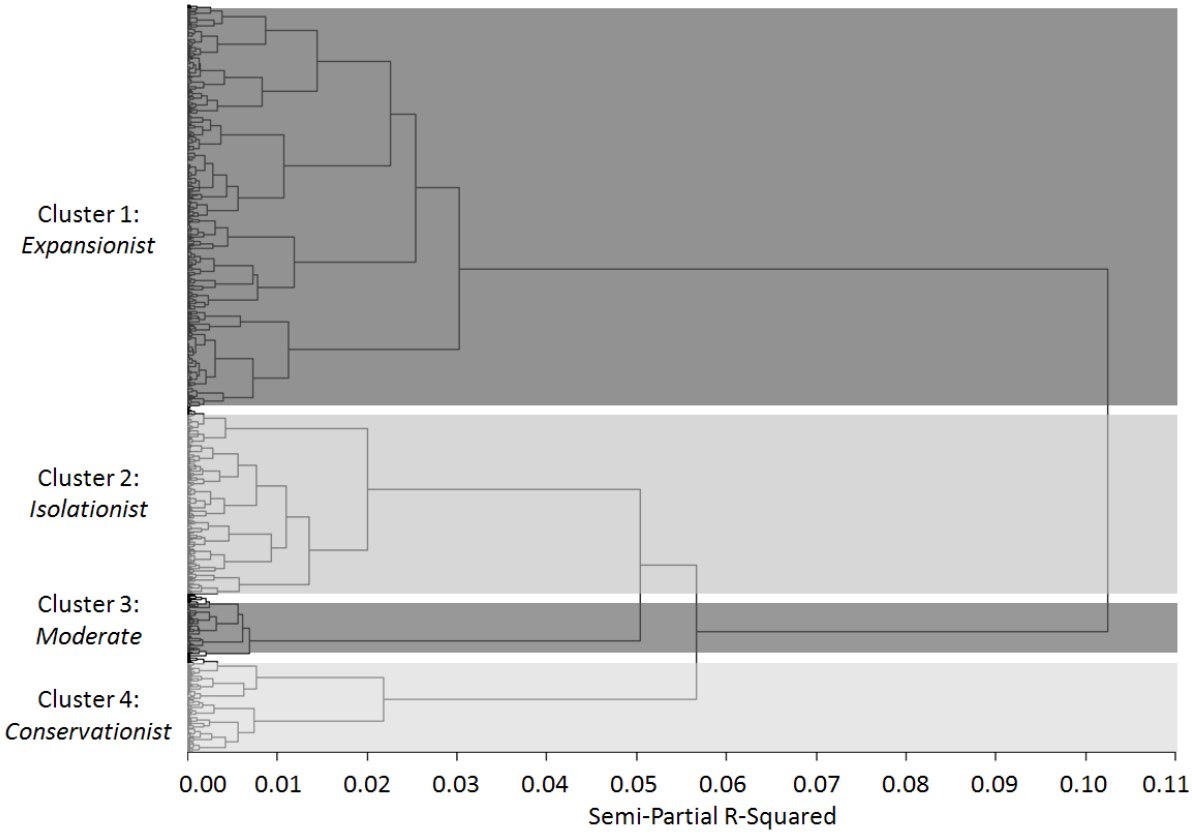

Figure 6.2. Dendrogram produced by the clustering algorithm. The four development typologies are indicated by alternating shades of gray.

Now that general typologies have been formed, the factors shaping permanent resident attitudes about conservation and island economic growth can be considered. Analysis of the clusters on variables not included in the clustering process provided interesting insights, and facilitated further description of distinct resident types as identifiable categories (Table 6.2).

Table 6.2. Survey information on household characteristics, education, amenities, and health.

Survey Measure	Expansionist (n=673)	Isolationist (n=310)	Moderate (n=102)	Conservationist (n=157)	Signif.[a]
Household Characteristics					
Current Residence					E,I - M,C
Santa Cruz/Baltra	277 (41%)	136 (44%)	64 (63%)	99 (63%)	
San Cristóbal	219 (33%)	126 (41%)	21 (21%)	42 (27%)	
Isabela	155 (23%)	44 (14%)	14 (14%)	15 (10%)	
Floreana	22 (3%)	4 (1%)	3 (3%)	1 (1%)	
Household type					C - E,I,M
House	442 (64%)	197 (64%)	62 (61%)	120 (76%)	
Apartment	87 (13%)	38 (12%)	13 (13%)	23 (15%)	
Rented room	67 (10%)	38 (12%)	17 (17%)	9 (6%)	
Shack	68 (10%)	32 (10%)	9 (9%)	5 (3%)	
Other	9 (1%)	5 (2%)	1 (1%)		
Origin					
Galápagos	178 (26%)	74 (24%)	16 (16%)	36 (23%)	M - E,I
Sierra	273 (41%)	136 (44%)	40 (39%)	68 (43%)	
Coast	215 (32%)	96 (31%)	43 (42%)	51 (32%)	
Amazon	7 (1%)	4 (1%)	2 (2%)	2 (1%)	
Foreign Country	4 (1%)	5 (2%)	1 (1%)	7 (4%)	
Years lived in Galápagos	24.5	24.7	19.7	21.6	M - E,I
Education & Employment					
Highest education attained					C - E,I,M
None	10 (1%)	6 (2%)	2 (2%)	13 (8%)	
Primary	34 (5%)	10 (3%)	2 (2%)	4 (3%)	
Secondary	244 (37%)	118 (38%)	41 (40%)	29 (18%)	
Post-secondary	281 (42%)	122 (39%)	43 (42%)	50 (32%)	
College and above	104 (15%)	54 (18%)	14 (14%)	61 (39%)	
Job Location					C - E
Local business	309 (48%)	126 (43%)	51 (53%)	86 (58%)	
Construction site	47 (7%)	30 (3%)	11 (11%)	7 (5%)	
Various sites	121 (19%)	41 (14%)	11 (11%)	22 (15%)	
Kiosk/street work	7 (1%)	5 (2%)	2 (2%)		
Local or rental property	54 (8%)	34 (12%)	8 (8%)	13 (8%)	
Domestic work	25 (4%)	22 (7%)	4 (4%)	9 (6%)	
Farm/ranch	86 (13%)	36 (12%)	10(10%)	12 (8%)	

[a] Only variables with significant differences ($p<0.05$) in pair-wise testing are displayed (E for Expansionist, I for Isolationist, and so on).

Table 6.2. Continued.

Survey Measure	Expansionist (n=673)	Isolationist (n=310)	Moderate (n=102)	Conservationist (n=157)	Signif.[a]
Spending & Amenities					
Monthly income needed to live well	$1,654	$1,659	$1,640	$2,301	C - E,I,M
Trouble paying for food during last 2 weeks	189 (28%)	62 (20%)	31 (30%)	28 (18%)	C - E, M
Household Amenities					C - E,I,M
Many amenities	489 (73%)	235 (76%)	74 (72%)	132 (84%)	
Average amenities	168 (25%)	73 (23%)	27 (28%)	24 (16%)	
Few amenities	16 (2%)	2 (1%)			
Quality of life					C - E,M
Good	92 (14%)	62 (20%)	18 (18%)	44 (28%)	
Average	531 (79%)	228 (74%)	78 (76%)	106 (68%)	
Poor	50 (7%)	20 (6%)	6 (6%)	7 (4%)	
Current economic situation					C - E,I,M
Able to save money	79 (12%)	43 (14%)	13 (13%)	36 (23%)	
Equal save/spend	344 (51%)	177 (57%)	62 (61%)	84 (54%)	
Forced to spend savings	80 (12%)	29 (9%)	8 (8%)	15 (10%)	
Forced into debt	170 (25%)	61 (20%)	19 (19%)	22 (14%)	
Consider self poor	306 (45%)	122 (39%)	43 (42%)	34 (22%)	C - E,I,M
Play sports in last month	302 (45%)	140 (45%)	50 (49%)	91 (58%)	C - E,I,M
Internet access in last week	121 (18%)	59 (19%)	27 (26%)	74 (47%)	C - E,I,M
Amount spent on transportation last week	$186	$168	$193	$284	C - E,I,M
Health					
Sick last month	286 (43%)	136 (44%)	44 (43%)	88 (56%)	C - E,I,M
Has health insurance	97 (14%)	43 (14%)	16 (16%)	45 (29%)	C - E,I,M
Amount spent on health last 3 months	$108	$122	$131	$195	C - E,I,M
Amount spent on health last 12 months	$243	$255	$135	$494	C - M

[a] Only variables with significant differences ($p<0.05$) in pair-wise testing are displayed (E for Expansionist, I for Isolationist, and so on).

• **Expansionist**: The socio-economic characteristics found in the first cluster are conducive for encouraging the most positive attitudes toward development. When cluster members were compared by residence it was found that Expansionists were the most highly dispersed across the urban and rural areas of the inhabited islands, with a higher concentration of 'original' (Galápagos-born)

residents than other groups. Pair-wise analysis of the frequency distribution was significant, suggesting that geographic distribution is associated with the respondents' attitudes about conservation. This is due in part to the strong representation of Isabela Island residents, where in spite of UNESCO recommendations, a new airport and dock were recently completed under the mantra of previous municipal administration, "*Isabela crece por ti*" [Isabela is growing for you]. This group is also characterized by the most ethnic diversity, the lowest overall quality of life, and is the most frequently forced into debt. Few (14%) have health insurance, and little household income is spent on health-related issues.

• **Isolationist**: Members of the second-largest cluster are concentrated on Santa Cruz and San Cristóbal Islands, and the group is predominately located in urban areas. Like Expansionists, they have a higher makeup of Galápagos-born residents than the other two clusters, and exhibit the lowest attained education levels. They are characterized by a lower desire for tourism-related development than the Expansionist cluster, but express strong support for increased construction and transportation. This group has the lowest opinion of life in a World Heritage Site, and only 6% of respondents indicated that they collect trash at tourist sites. Households tend to have few amenities and non health-related spending is also the lowest in this cluster, but they experience greater job security than the other clusters.

• **Moderate**: The third cluster is the smallest and contains the highest proportion of members originating from the mainland (85%), the majority of which come from the coast. They migrated more recently than the first two clusters (average 19.7 years ago), and are more highly educated overall. However, they exhibit comparatively low awareness of the threats posed by introduced species, characteristic of those who migrated to Galápagos during the period of expansion in the 1990s (Heslinga 2003). The group is concentrated on Santa Cruz Island (63%) where they engage primarily in skilled labor and subsistence economic activities and experience the highest job security. Households have a moderate number of amenities, but report higher spending on health care and transportation, and experience a low overall quality of life. They are characterized by a desire for

some transportation improvements and boat-based tourism development, while most (68%) believe that land-based tourism should neither increase or decrease.

• **Conservationist**: The final cluster exhibits striking and statistically significant differences in development attitudes and socio-economic characteristics from the other three. This group chiefly originates from Galápagos or the Sierra region of the mainland, but has the largest constituent from foreign countries (4%). Many more are descended from foreign families and speak both Spanish and English. The cluster is predominantly urban and concentrated on Santa Cruz Island. High home ownership, very high education levels, low food insecurity, high savings and spending trends, and the most household amenities contribute to these respondents' experiencing the highest quality of life of any cluster. They are also the most likely to collect trash at tourist sites and express a strong desire for stable or decreased development, transportation and boat-based tourism.

With the exception of the first cluster, survey respondents were in favor of stabilization or a decrease in the local fishing sector. Following the ban on industrial fishing in 1998, the sea cucumber and lobster fisheries virtually collapsed, leaving residents dependent on the less regulated, and less profitable, *pesca blanca* (whitefish) fishery. The coordination of fish sales to tour operators and sport fishing have been explored as alternatives to traditional fisheries that have met with limited success, particularly on Isabela Island. To this end, Expansionists reported the highest participation in fisheries in the last 12 months of any cluster (8%), although this is still low compared to fisheries activities a decade ago.

Given the disproportionately large share of the tourism economy that mainland tour operators hold (Taylor et al. 2006) and the fact that the majority of visitors to the islands still live on board cruise ships instead of staying in island-based hotels (Table 6.3), it is not surprising that most residents are in favor of increased land-based tour development. Although Galápagos tourism is among one of the fastest growing economies in the world, only a fraction of total revenue (36%) remains in the islands (Taylor et al. 2006). The remainder is collected by large mainland touring companies who operate high-end cruises and own or rent passenger *cupos* (Epler 2007: 47). The

Special Law granted permanent residents exclusive rights to obtain new tourism *cupos*, but this requires that they own a large boat that meets environmental regulations. Instead, locally-owned pensions and hostels contract with fishermen and small boat-owners for day tours (Honey 2008: 131). Even a third of Conservationists, with significantly higher relative wealth than the other resident clusters, seek increases in land-based tourism.

Table 6.3. Distribution of local residence by 173,296 foreign visitors to the islands in 2010.

Housing Type	Number of Visitors
Boat	79,657 (46%)
Hotel	75,888 (44%)
Residence	12,839 (7%)
Pension	2,953 (2%)
Other	1,959 (1%)
Total	173,296

Source: GNPS 2011

Much of the tourism-related infrastructure and development does not directly benefit residents, however. This reflects the fact that public services, particularly sanitary drinking and tap water, health care and electricity have been largely ignored during this period of growth.

Although President Correa's administration has invested millions of dollars in mainland health care, marginal funding has been allocated to Galápagos. Limited access to sanitary water and sewer facilities frequently results in gastrointestinal and skin infections, especially among women, children and the elderly (Walsh et al. 2010). None of the populated islands are prepared for serious viral outbreaks such as dengue fever (in 2005 and again in 2010) and H1N1 (in 2009), both of which arrived via tourists and visitors. In the case of H1N1, poorly-enforced curfews and the closure of schools, restaurants and bars did little to stop the spread of the virus. Only after it claimed the lives of several residents did one airline agree to provide emergency flights for sick patients to mainland hospitals. In contrast, during the eruption of Isabela's Cerro Azul volcano in 2008, onlookers watched

as Navy helicopters air lifted giant tortoises away from the flow of lava. “This would never happen if it were us up there,” commented one.

Humans are not the only species whose care is secondary to that of native animals. In spite of registration requirements and leash ordinances, stray pets are frequently found in and around the populated areas. “With people come cats,” says Fernando Ortiz of Conservation International, “and with cats come threats to other animals found nowhere else in the world” (Romero 2009). In 2000 canine distemper was introduced to Galápagos, likely through the illegal transport of an infected dog, which swiftly led to the mortality of nearly 90% if the archipelago’s canine population. A second outbreak in 2007 was limited to Isabela Island, to which the GNPS veterinarian Marilyn Cruz responded that the government-backed ban on island pet vaccinations must be overturned, particularly given the fact that the disease is transmittable to sea lions (Hilbean and Ehrensperger 2007). Additionally, because only Santa Cruz and San Cristóbal have staffed veterinary clinics to sterilize and treat domestic animals, the GNP and local municipalities have resorted to the use of Compound 1080, a highly toxic, slow-acting poison, to eliminate strays. Annual campaigns by Animal Balance, a group of volunteer veterinarians, are critical to controlling the feral population in a humane way and assisting residents in caring for sick pets. Although it is unlawful to bring domestic animals other than live chicks to Galápagos, in recent years purebred dogs such as huskies, cocker spaniels, and pugs have appeared in island neighborhoods, smuggled in on cargo ships (Emko, personal communication 2008).

Growing problems such as crime and household waste are also attributed to the resident population. During the first five months of 2010, more than three quarters (83%) of reported crimes in Puerto Ayora were committed by residents (Zapata, personal communication 2010). Santa Cruz Island alone generates 12 tons of waste per day, and although an estimated 35% of waste is recycled, the majority of is stored in a landfill until it is incinerated (Hardter, personal communication 2010). Despite the ubiquitous presence of trash canisters and recycling bins, littering persists in the islands’ small towns. In a scathing editorial titled *The National Garbage*, American-born resident Jack Nelson

writes, “This garbage doesn’t come from offshore or Peru. It is not the kind of trash that falls from the hands of unthinking tourists. It is native, authentic island trash, lovingly Galápagos” (Nelson 2010: 4).

In light of increasing development and concerns about human impacts, the resident population has been the target of accusations that it is not capable of accepting the responsibility that comes with life in a World Heritage Site. Nelson has also attacked awareness campaigns by the GNPS and CDRS, claiming that their portrayal of the *isleño* lifestyle is too abstract. Instead, he argues, residents must be told in no uncertain terms that what they’re doing is environmentally unacceptable. Although social science has become an important component of CDRS and GNPS protocols, biodiversity goals rarely incorporate information from locals and regulations are handed down as mandates. It is not uncommon to hear sentiments like one Santa Cruz resident who says, “They make us feel like we don’t belong here – like the life of a giant tortoise is worth more than human life.”

Creating Sustainable Citizens

In response to livelihood restrictions and marginalization by conservation authorities perceived as external and illegitimate, unlawful environmental behaviors are acts of resistance by some. Such actions can be driven by need, while as Robbins et al. (2006) explain, “[S]ome is more overtly political.” In part, authorities argue that increased surveillance and sanctions would stem unlawful activities, as the enforcement of environmental regulations in Galápagos has historically been minimal. For example, conviction of killing a giant tortoise carries a 20-year prison sentence in Ecuador – the same as the sexual assault of a minor – but authorities must first catch perpetrators in the act. The established penalty for engaging in illegal fishing includes a prison sentence ranging from three months to three years, plus confiscation of the vessel and a fine that is usually insufficient to deter future illegal activities. For example, seizure of $10,000 worth of shark fins may result in a fine of $2,000, only a fraction of the value of one day’s catch. Organizations like the Sea Shepherds,

which assists in patrols of the marine reserve, routinely push for greater application of the laws but are denied by the GNPS. A revision of the Ecuadorian Constitution in 2008 included a novel set of articles granting a unique set of rights to nature (Ec. Const. art. 71), which the Sea Shepherds urgently wish to apply to stop the poaching of endemic and native species that are protected by law (Emko, personal communication 2009). An exploration of illegal activity, however, necessitates an understanding of why residents would care for the environment in the first place.

Because reasons for environmental stewardship were not captured in the INEC-CGREG survey, I carried out a small opinion survey among Santa Cruz and Isabela Island residents in 2010. Participants were asked to select one response out of four to the question, "Why would you participant in environmental protection?" and the results shown in Table 6.4 are paired with quotes from my informants to further clarify the personal meaning of each statement. Those who responded "It's unique in the world" or "Preserve it for future generations" adopt a view of the intrinsic value of Galápagos, likely represented by members of the Conservationist cluster. Campaigns to reduce vehicular traffic and groups like Ambiente Independiente who raise public awareness among residents of their connection to the Galápagos environment are examples of the kind of stewardship encouraged by conservation initiatives. As one resident put it, "It's a privilege for us to live here, and it's our responsibility to protect it."

Table 6.4. Residents' reasons for participating in conservation measures.

Survey Response	Frequency	Quotes
1) It's unique in the world	10 (14%)	"What we have in Galápagos, we don't have anywhere else"
2) Preserve it for future generations	12 (17%)	"In the future we want to see Galápagos like it has been, always"
3) The environment is the source of our well-being	26 (36%)	"*Galapagueños* have a very special identity. We care for our resources because we live from them"
4) Good quality of life here	24 (33%)	"Here I can still let my children go out to play without worrying"

Source: Opinion survey, Brewington 2010

Members of the Expansionist and Isolationist clusters are more likely to agree with the majority (69%) of these respondents who chose a more utilitarian view of the islands as a source of income or quality of life (responses 3 and 4). These clusters are comprised of more original families and the oldest migrants, a characteristic that Barber and Ospina (2008) also found to be related to a resistance to environmental regulation. The Hernandez family has lived on Santa Cruz for over 100 years. In the early days, as one descendent explained, "We ate the birds, the tortoises, the fish. … Nothing was prohibited – no police and we didn't need them. The land I have today is my family's land. They worked hard, you know? But that's why we survived." His words express the pride in Galápagos that many residents share, intertwined with a sense of entitlement to the land.

It is that sense of entitlement combined with hostility toward authority, however, that authorities fear is driving some residents to engage in unlawful environmental activities. In particular, there is an attitude among the 'original' or 'native' residents that they should not be subject to external regulations that are more concerned with plants and animals than people. As one Isabela fisherman told me in 2010, for example, "The fish [populations] aren't a problem for us, for us the laws are the problem. To the conservationists everything we do is wrong." The IMA/PMB co-management scheme implemented through the Special Law was designed to facilitate the participation of fishermen in environmental decision-making, but its success has been tempered by a perceived lack of rights and access (Heylings and Bravo 2007). Protests and riots still comprise 'negotiations' with the authorities, and violations of fishing regulations continue to be discovered by tour operators and GNPS officials who encounter illegal encampments along the coast.

In contrast to clandestine camps and fishing operations, highly-visible infractions like the killing of giant tortoises are not fueled by a desire for or dependence on the use of protected resources. The reasons for resentment may include the rigid boundaries of the national park or the marine reserve, infringements on resource use rights, and perceptions of corruption among environmental managers or other environmental beneficiaries (i.e. tourism operators; Quiroga 2009). The exposure of one illegal fishing circuit in the 1990s resulted in the massacre of 81 giant tortoises

on Isabela Island (Frazier, personal communication 2009), and in 2000 the Isabela GNPS office was burned down (Quiroga 2009). Other acts are seemingly unprovoked: in 2008, 53 sea lions were discovered on Pinta Island with their skulls shattered, but conservation officials suspect that only fishermen have the capability to travel such long distances by sea (Moscoso, personal communication 2008).

Although fisheries-related conflicts remain at the forefront of concerns about environmental infractions, Galápagos communities are not homogenous and there are many reasons why residents would choose to support (or subvert, resist and oppose) conservation regulations. The bitterness and disdain expressed by some of my informants stems from the awareness that international funding destined for conservation projects will never benefit them. Measures that privilege the flora and fauna of protected areas over the needs and interests of their human counterparts generate further hostility among those poised to be conservation's greatest allies. In a final blow, the current model of development reinforces migrant flows from the mainland, a source of frustration for residents who argue that their interests were meant to be served by the Special Law.

"They Like the Easy Life"

While social and environmental irresponsibility is frequently associated with the resident population in conservation discourse, residents see migrants as the source of the problem, perpetuating old inside/outside divides (Table 6.5). Residents tend to believe that unemployment due to the migrant influx is decreasing over time, but still express a strong agreement to the statement that migrants erode their *galapagueño* culture, reflecting the sense of place described by each cluster above. It is interesting to note that they increasingly do not support restrictions against family members who wish to migrate.

Table 6.5. Changing resident attitudes toward migrants between 2006 and 2010.

Survey Response	2010 [a]	2008[b]	2006[c]
1) Accept migration restrictions for family members	42%	47%	43%
2) Migrants result in environmental damage	78%	82%	82%
3) Migration increases local crime	80%	81%	82%
4) Migration increases local unemployment	72%	75%	83%
5) Migrants erode *galapagueño* culture	89%	NA	NA

[a] Source: Opinion survey, Brewington 2010 (n=72)
[b] Source: Barber and Ospina (2008, n=302)
[c] Source: Barber and Ospina (2007, n=295)

The existence of different legal identities, as well as social ones, is part of the reason why residents harbor hostility toward the migrant population. In spite of the fact that residents are by law given preference for local jobs, tourism-related job opportunities frequently cannot be filled by local labor, whose levels of education and training are often inferior to migrants' (Kerr et al. 2004). At any given time there are around 2,600 temporary residents (Sotomayor, personal communication 2010) whose year-long contracts must be solicited by employers. Because obtaining temporary residency requires an established work contract and a significant financial commitment, however, potentially half of Ecuadorians who travel to Galápagos enter as tourists but engage illegally in paid work, ranging from informal, 'under the table' arrangements (day laborers, construction workers) to professionals (teachers, scientists).

The presence of a temporarily legal resident population complicates the effectiveness of population controls in the islands when migrants overstay their permits. As is the case in other locations with temporary migrant populations, the odds that they will find other employment remain high even as they transition into illegal status (cf. Epstein et al. 1999). Employers like construction manager Vincent Candel of Santa Cruz argue that they have no incentive to pay a guarantee and round-trip airfare to hire a temporary resident when there are "any number of 'irregular' migrants who can build a swimming pool, and for a lot less money, too" (personal communication 2009). But other business owners express frustration at the number of job applications they get from migrants

without papers: “At least six people came by this week – not one of them showed me the correct documentation,” said one (Herrera, personal communication 2010).

Motivations for working and living in Galápagos illegally are as diverse as the migrants themselves, but it is rarely the case that “they like the easy life,” as the Santa Cruz Coordinator of Migration Control Erick Sotomayor believes. Infant mortality in Galápagos is a third of what it is on the mainland, while violent crime and poverty levels of up to 60% in continental Ecuador make the much lower rates in the islands attractive (Kerr et al. 2004). German, a builder from the Sierra, took his first airplane flight in 2009 to the Galápagos where he worked for a hotel owner earning $400 a month. The following year he returned, and he plans to continue doing so. “The time I spend apart from my family is very hard, but I make more in three months than I would in a year [on the mainland],” he reasoned.

Still others stay beyond their permits to continue projects started during their legal stays. In 2010 a software technician from the coast was eventually forced to live in an abandoned house in order to complete a training course. Frustrated, she said, “I’m here trying to help the economy, and I’m being treated like I’m in a foreign country.” Another described the vulnerability associated with everyday life after her work contract with a local tour agency expired: “I’m afraid to leave my house, I can’t concentrate on anything – the police could arrest me if I even walk to the store.” As migration scholar Susan Coutin explains, “Much of the time [illegal migrants] are undifferentiated from those around them, but suddenly…legal reality is superimposed on daily life” (2000: 20). In order to avoid detection, many formerly legal visitors and workers find employment in less-visible sectors as housekeepers, waiters or construction workers (Martínez personal communication 2010).

Using data from the electronic tracking system, the local newspaper frequently publishes a list of the names of hundreds of illegal migrants, while local radio stations broadcast 10 to 15 names per day. When found, they are given 48 hours to leave the islands, after which they cannot return to Galápagos for one year (Sotomayor, personal communication 2010). Migration control through

deportation, therefore, creates the appearance of a decisive government taking action in favor of the resident population (cf. Andreas 2000).

By October 2009 over 1,000 Ecuadorians had been deported to their own country that year (Romero 2009), and during March 2010 a group of 22 migrants were rounded up and deported, bringing the year's total to nearly 200 (Sotomayor, personal communication 2010). Many feel they are being punished while Ecuador enjoys the multi-million dollar earnings from the tourism industry: "It seems that Ecuadorian citizens are not worth as much to Correa's administration as the animals," said one in 2010.

Perhaps migrant illegality is experienced most poignantly by indigenous Ecuadorians. According to José María Caizabanda, President of the Salasacan Community, a growing population of Salasacan Indians (between 1,500 and 2,000) exists on Santa Cruz, comprised of migrants from the province of Tungurahua (personal communication 2010). They speak Quichua, an indigenous language, and are concentrated in the impoverished Puerto Ayora neighborhood of La Cascada. "We built this province with our own hands, so yes, it pains us to see our countrymen deported like animals," said resident Margarita Masaquiza in 2009, "After all, we are indigenous Ecuadoreans, how can we be illegal in our own country?" (Romero 2009). As Caizabanda says, "We Salasacans have come to serve and to work humbly, it hurts when other people say that they belong here, that they own the Galápagos. This land is also Ecuador, it is all of ours" (personal communication 2010).

In the face of increasingly efficient controls, migrants are finding new ways to enter (and reenter) the islands, largely by sea. According to Sotomayor, the Port Captain is not involved in marine patrols of human intruders, nor are the GNPS and Agrocalidad (personal communication 2010). During a visit to one of the shipping docks in Guayaquil, I met a man waiting to ride to Galápagos aboard the cargo ship the *Montserrat*. He had been deported that January, he explained, but "made arrangements" with the ship's captain to secure his clandestine passage.

Recently even residency itself has become something of a commodity. In 2009, there was a noticeable increase in the number of marriages in Galápagos, which could reflect a growing trend of

foreigners and nationals marrying locals to obtain permanent residency (Ortíz, personal communication 2010). Marriage 'proposals' include offers of thousands of dollars and, in the case of foreigners, promises of residency in the United States or elsewhere. To address this loophole, proposed revisions to the Special Law demand that couples remain married and living together in Galápagos for 10 years before a spouse can gain residency, while permanent residents can lose their right to live in the islands if they spend more than three consecutive years outside the province.

Finally, the enforcement of migration restrictions and deportations among a community of one's peers proves to be too much for some Galápagos migration police (cf. Nevins 2002; Van der Leun 2006). Following a 2008 interview with the Santa Cruz Migration Control office, one young employee found me outside the office to explain that his friends no longer trusted him because of his job, actively avoiding him at social gatherings. "It's hard," he said of his predicament, "It's very hard." When we met again in 2010 he had changed departments.

'Eco'tourism: The Benefits and the Costs

The current system of environmental management imposes legal restrictions on residents and migrants, while perpetuating the conditions that facilitate unregulated tourism growth. In order to quell accusations that mainland-based tourist agencies benefit from (but do not contribute to) the islands' welfare, some mainland-based tourist agencies offer services to the islands' human inhabitants. Recognizing the difficulty and expense of medical transport to the mainland, for example, Celebrity Xpeditions instituted a program in 2010 to bring foreign specialists to the Santa Cruz Island health center for week-long volunteer campaigns. Red Mangrove Galápagos and Ecuador Lodges, with hotels on three of the four populated islands, is developing family health and dental care programs and assists the Galápagos Ministry of Agriculture with large-animal veterinary care on Isabela and Floreana Islands. Fundación Galápagos, an Ecuadorian for-profit organization founded by Metropolitan Touring, has promoted solutions in solid waste management for over 12 years.

Other organizations have attempted to address the fact that few local families are able to afford to explore the islands around them, meaning that the archipelago's future leaders will scarcely know them. "There are 5,000 children growing up in these towns who will never set foot on another island," says the CDRS Director of Technical Assistance, Felipe Cruz (personal communication 2010). By 2009 Lindblad Expeditions and Metropolitan Touring had offered over 500 children the opportunity to tour the islands on their cruises, a strategy that has boosted sales among foreigners, many of whom had no idea that up to half of the residents of Galápagos have never visited another island.

Tourism has also provided an alternate source of income for residents who formerly engaged in illegal activity. Franklin, a former fisherman who came to Galápagos in the 1990s, guides day tours of Academy Bay on Santa Cruz. For three years he lived on Isabela, participating illegally in shark fin, sea cucumber and lobster fisheries, and he openly admitted that he helped stage riots against the local GNPS office. "I was making 1,000 a day when my friends on the mainland were watching their money disappear. Of course I was going to keep doing it." Now he works in tourism and he's happy with the change. "It's just not worth it. This is easier and I don't have to be looking over my shoulder" (personal communication 2010).

As mentioned above, to be an autonomous boat tour operator requires obtaining the right kind of boat and a *cupo*. Although the issuance of new *cupos* would promote community-based management and create a larger number of beneficiaries of tourism (Epler 2007: 48), a 2009 'competition' for the release of 72 new *cupos* resulted in fewer than 20 proposals begin approved (El Colono 2010b:11). The process is particularly contentious on Isabela. While the current *cupo* system includes approximately 1,800 berths, they are exclusively owned by residents of Santa Cruz and San Cristóbal Islands. Espinosa elaborates:

> The settlers from Santa Cruz years ago who presented a project and asked for a permit for a live-aboard boat or a day trip boat to visit the park, the park gave them those permits in the 70s and 80s. Same on San Cristóbal. But the people from Isabela never got any kind of tourism permit. So the speedboat that goes out to Los Tuneles

> or that goes out to Tortuga [Island] has still not got an official permit, and the current competition won't change that (personal communication 2009).

The presence of non-licensed tour operators also occasionally manifests in tragedy, as it did in early 2010 when two poorly equipped Isabela boats flipped over while attempting to navigate the rocky entrance to Los Tuneles, resulting in serious passenger injuries on an island with only basic medical facilities.

The questionable legality of another tourism activity becoming popular among the islands' fishermen has generated recent conflict. Although *pesca deportiva*, or sport fishing, was prohibited by law in 2005 (Registro Oficial No. 564), operators claim that the GNPS and the Port Authority support sport fishing as a catch-and-release activity, a component of artisan fishing that is promoted as an alternative to commercial fishing. Proponents, including the San Cristóbal Mayor, who declared his municipality as the "sports fishing capital of the world" in 2006 (UNESCO 2006), argue that it provides local fishermen with a tourist-based, sustainable alternative to traditional commercial fishing, with reduced pressure on local species. Skeptics wonder, however, if this is the kind of tourism that should be promoted in a place like Galápagos (Reck, personal communication 2010).

Although small operations by residents are expanding in the islands, the vast majority of tourism revenues and infrastructure remain in the hands of a few individuals and corporations (Epler and Proaño 2008). Large tourism operations have a seemingly limitless supply of lawyers and funding with which to defend their interests in the islands, while island-based operators, subject to the same conditions and requirements, are caught up in bureaucratic state control. The President of Metropolitan Touring, Roque Sevilla, is among the highest ranked executives in Ecuador, but has been accused of diverting jobs from residents in the operation of his high-end Santa Cruz Island hotel, The Finch Bay, which employs primarily migrant workers (Zapata 2009: 2).[18]

[18]Despite the fact that Finch Bay operates its own shuttle service and on-site farm, Sevilla recently argued that "licensed operators should be prohibited from vertical integration. In other words, tour operators should not be able to have their own on-land passenger transport service or be direct producers of food for tourists. This will allow more citizens to benefit from tourism as suppliers, even if they are not direct tourism service providers" (Sevilla 2008: 26).

The limited release of new *cupos* in 2009 further angered residents who see Quito-based operators like Metropolitan Touring with enough to support several yachts with over 100 passengers each (El Colono 2010c: 5). According to the Mayor of San Cristóbal, "Double talk doesn't work in Galápagos. … It's obvious that [Mr. Sevilla] has his interests. He represents a group that has economic interests, that's who he is. I defend the public interest. … Corruption can't be seen as something normal." (Zapata 2009: 2). The new high-end 'Iguana Crossing' hotel on Isabela Island generated similar opposition among residents when its mainland owner received permission from the Environmental Minister to build on top of a marine iguana nesting site. "This project was approved by the government," said Gardenia Flor, President of Isabela's Chamber of Tourism, "but it violates the desire of the community" (personal communication 2009).

Former GNPS Director Raquel Molina refers to the network of large Galápagos tourism operators as the tourism 'mafia'. In March 2007, Molina was attacked by members of the Ecuadorian Navy and Air Force as she and two park guards attempted to shut down an illegal kayaking operation on Baltra.[19] When asked about the conflict Molina responded, "They're corrupt, all of them. The tourism mafia is in bed with WWF, CDF, Conservation International, Fundación Galápagos. They don't care about conservation in Galápagos – they care about making money. … One day, eight major tour operators filed complaints about me at the municipality. I was just always in their way" (personal communication 2010).

The tourism industry itself has had its share of negative environmental impacts. As early as 1978 Silberglied noted that insects travel between populated islands and to distant sites on tour boats, a trend that has continued to transfer pests and diseases with daily inter-island ferry transport. In 2001 an Ecuadorian tanker carrying diesel fuel, as well as bunker fuel that was destined for a luxury yacht owned by a mainland tour operator, ran aground off the coast of San Cristóbal Island. Over 234,000 gallons of fuel were spilled into the waters that surround the archipelago's capital, Puerto Baquerizo

[19]The attack on Molina was followed by her 2008 dismissal from the GNP by the Environmental Minister for insubordination, due to her refusal to grant additional *cupos* to Sevilla.

Moreno, much of which was directed offshore by strong winds and currents (Fundación Natura and WWF 2001). In 2009 an Ecuadorian Navy training ship ran aground near Santa Cruz carrying 225,000 gallons of fuel, but was safely towed free (Arana, personal communication 2009).

These issues raise critical questions about what kind of tourism model can best meet the islands' environmental and economic needs. Tourists themselves also exert pressure on already-strained local resources. If 100,000 visitors remain in the islands for an average of seven days over the course of a year, for example, they are the functional equivalent of an additional 2,000 residents requiring food, water and other commodities, in addition to the waste they generate. Many argue that this is a new kind of tourist, demanding amenities that can be found in the Caribbean or in Mexico: fine cuisine, discos and luxury hotels. A writer for Surfer Magazine asked in 1998, "[O]n one of the great eco-tourism pilgrimages of all time, blessed with more intellectual raw data than perhaps anywhere on Earth: why are these clowns just doing the same bullshit they do at home?" (cf. Larson 2001: 234). That the naturalist guide pool has been increasingly 'watered down' by new and lower-qualified guides, many of whom speak only Spanish, is another indicator of the educational quality that today's international tourists are seeking (Honey 2008: 157).

During the 2010 Sustainable Tourism Summit, workshop participants emphasized that the local culture is diverse and adapts to both internal and external forces, all clearly identified in Galápagos society, particularly as a result of the tourism boom of the past decade. As CDF Director Gabriel Lopez noted, "It's a major challenge to develop a shared vision for the common good among such a diverse community, but this is essential if we are to achieve a sustainable Galápagos." Proposals to double or triple the foreign entry fee to the GNP (currently $100), initiate a lottery system or limit visitors to one trip in a lifetime are some of the ways policy makers are considering to control the exponential growth in visitor numbers, which UNESCO estimates will reach 400,000 per year by 2021 (Patel 2009). Paradoxically, as word spreads of the 'crisis' in the islands, more people are compelled to visit them before it is too late (Neil 2008; Becker 2009; Bluestone 2009).

Meanwhile, Grenier proposed an increase in the amount of time tourists remain in the islands. "Currently tourists don't know about the problems in the islands," he said, "Right now there's a disconnect between tourists and the population, because tourists stay on boats and in hotels where it's easy to acquire whatever service they want. If they stayed longer, living conditions for residents would have to be improved, and tourists would also learn more about Galápagos" (El Colono 2010d: 15). Local tour operators agreed, reminding participants that the 90-day limit set by the Special Law was in response to residents who desired more land-based tourism. Planned revisions to the Law currently reduce the length of a tourist visa to 30 days, however, a change that will also affect workers who arrive as visitors. "Under the rule of the bureaucrats," said Patricio, the owner of a Puerto Ayora dive shop, "*galapagueños* are losing another part of our economic heritage" (personal communication 2010).

Conclusions

The goal of this chapter was to draw attention to a failed tourism model that has trapped Galápagos society in a double bind of development, conservation, and legality. Identified as a conservation 'problem', a large constituent of residents reject and resist initiatives that they feel are imposed upon them and restrict their economic success. On the other hand, a small and affluent minority, aware of their dependence on tourism, have begun to "utilize the main symbols of science and conservation to further their particular cause," as Quiroga writes (2009). It is critically important to recognize the trade-off between ensuring local benefits through development and ensuring that biodiversity goals are being met. According to former CDF Director Graham Watkins, "Conservation can only work if the biodiversity in the archipelago is owned in the hearts and minds of those that live there. If the local community doesn't benefit economically from tourism, it's not going to support conservation" (personal communication 2008).

It is equally important to understand that while the large number of people in Galápagos solidifies the fear that the human presence will negatively impact island diversity and habitat,

targeting the migrant population does not address the underlying economy that draws them. As is the case in migrant sending and receiving locations worldwide (Massey 1999; Andreas 2000), the stream of migrants provided by temporary and illegal workers is structurally central to the Galápagos tourism economy; but many migrants feel (as do residents) that they have no alternative to becoming illegal in the search for economic success. Rather than attempting to control the tourism industry, which brings in substantial revenue and bolsters the Ecuadorian economy, institutions have chosen to enact increasingly strict migration laws, which adversely affects the country's citizens. It does, however, signal to international funding agencies and conservation organizations that the government is taking decisive action to control population growth.

During the final day of the CDF-sponsored 2009 Galápagos Science Symposium, an afternoon plenary discussion concerned development and the future of management in an increasingly globalized and accessible archipelago. Felipe Cruz addressed the attendees: "We have been allowing this unregulated development for years, and somehow Galápagos is still comparatively pristine…but for how long? The new constitution has changed to theoretically protect the islands, but in Galápagos we still don't know where we're going, and we might end up there." In response, a man stood and introduced himself as a resident of Santa Cruz. "If we are here now," he said, "then we're all to blame."

Chapter 7: Conclusions

In this dissertation I have moved among places, people and perspectives, tracking the processes of invasion, writ large, back and forth across the physical, conceptual and territorial boundaries that today divide the Galápagos Islands. What began as a series of very grounded case studies of invasion gradually widened into a critical evaluation of the local, regional and international politics that govern everyday life in a protected area. I attempted to dismantle the naturalized assumptions that are held by individuals or groups about certain people, plants, and animals that are either designated to belong to, or necessitate removal from, the archipelago. The behavior of these agents, which I gather under the term 'invasion', is made possible by certain attitudes about the relationships between humans and the environment that make up the modern geographical imaginary of protected areas as bounded, pristine spaces. Those attitudes turn on ideas of naturalness and the purity of nature that have translated into policy and become the common sense solutions to environmental problems, particularly in the context of an environmental 'crisis' in the islands. A political ecology perspective proved useful in deconstructing such boundaries, particularly in cases of protected areas where human populations living within or near them become subject to particular types of post-colonial rule (Neumann 1998), or what Agrawal (2005) has called 'environmentality'.

The goals of this research were to 1) describe the processes of invasion, by plants, animals and people, that are occurring in the Galápagos Islands; 2) evaluate the political and conservation institutions and interventions designed to mitigate those processes; and 3) characterize the complexity of invasion in the context of the crisis. Through case studies based on over a year of fieldwork in the archipelago I have tied the lives of people, plants and animals to local, regional, national and international institutions, documenting changes in the archipelago's environmental and social

landscapes that are connected to larger political and economic forces. I wish to reiterate that I fully support biodiversity conservation in Galápagos, and elsewhere. I agree with ecotourism specialist George Wallace that "protected areas like Galápagos are worth fighting for and protecting for all people, for their own sake, for all time. It is an achievable goal" (Wallace 1993). The motivation for this research was not to question the ultimate goals of conservation projects to combat environmental change, but to understand the implications of the processes by which policy makers and conservation practitioners set out to achieve those goals.

I first outlined the geographical imaginaries held by conservation institutions, primarily the GNPS and the CDRS that enroll places, people, plants and animals into conservation projects in a 'natural laboratory' (Chapter 2). In Chapter 3, I analyzed the landscape-level effects of feral goat invasion and eradication in a protected area, finding that far more than the idea of 'naturalness' is at stake in today's management efforts. Chapter 4 expanded on this theme to examine the social, political and economic determinates of landscape change in the highland regions of Isabela and Santa Cruz Islands, where privately-owned land abuts the national park. Then, using participatory mapping I showed how different stakeholder groups 'see' the highland landscape of Isabela Island as simultaneously degraded and productive (Chapter 5). In the final chapter, I demonstrated that through the double bind of tourism, attempts to maintain the current tourism 'bubble' (Cohen 1988) perpetuate power dynamics that make island residents, as anthropologist Diego Quiroga (2009) writes, "invisible, irrelevant and undesirable for the maintenance of Galápagos as a 'natural laboratory'." From a political perspective, some of these cases of 'invasion' are less complicated than others; feral goats that denude native vegetation within a protected area, for example, make an easier target for intervention than do agricultural crops that have different values for different stakeholders. Residents and migrants further complicate the politics of invasion when they themselves become conservation targets based on their goals and means to achieve them.

Summary of Findings and Policy Implications

At the beginning of this dissertation, I described how the geographic isolation of the archipelago has been reduced as the human population of the archipelago has continued to grow alongside introduced species. The CDRS, alongside the GNPS has been tracking species introductions since their inauguration in the 1960s, finding that "some of these problems have existed for more than a century, but many are new situations that have developed over the past 20-30 years" (CDF 2006). As former CDRS botanist Alan Tye (2006) rightly points out, the apparent exponential increase in the number of introduced species over time is due to the fact that their rate of discovery has been positively influenced by the emergence of new techniques for dating such species. Their continued presence and vectors of arrival are nevertheless cause for alarm, as UNESCO described following the 2010 monitoring mission of the World Heritage property:

> The principal factor leading to the inscription of the property on the List of World Heritage in Danger arises from the breakdown of its ecological isolation due to the increasing movement, mainly driven by growth in visitation, of people and goods between the islands and the continent, facilitating the introduction of alien species, which threaten native and endemic Galápagos species" (UNESCO 2010: 37).

There have been limited efforts by conservation agencies and the national government to change popular attitudes and pressures that lead to measures that threaten conservation efforts. For example, a road that was constructed in 2005 to provide residents and tourists with shorter access to an isolated beach on Santa Cruz Island has facilitated the migration of introduced plant species into regions of the GNP that were previously uninvaded. Although Galápagos retains 95% of its native and endemic biodiversity, 60% of those species now fall under the IUCN threatened categories of threatened or higher (Tye 2006; Trueman 2010).

With over five decades as the central scientific research agency in Galápagos and a formal relationship with the Ecuadorian government, the CDF through its local office, the CDRS, has achieved significant international visibility. This status has not always been viewed positively. The CDRS has been criticized by residents and other stakeholders for focusing too heavily on conservation strategies while ignoring the islands' growing human dimension. But as the eminent

field biologist George Schaller argued in Mitchell (2006), it is not the role of conservation organizations to engage in local economic or development goals:

> "There are certain natural treasures in each country that should be treated as treasures, and it is up to conservation organizations to fight on behalf of these special places. Too many of these organizations have lost sight of their purpose. Their purpose is not to alleviate poverty or help sustainable development. Their purpose must be to save natural treasures."

Schaller's manifesto is echoed by members of the CDRS as well as the GNPS who continue to argue that their emphasis is strictly conservation. Whether or not it is warranted, the CDF and CDRS are frequently and unfortunately tied to proposals like one by physicist Freeman Dyson, who recently advocated for the removal of entire island communities in the name of conservation:

> "A park kept clear of the larger feral species, including humans, is a reasonable compromise between total preservation of the ecology and total freedom for the settlers. … Boundaries could be redrawn so that each island is wholly in the park or wholly outside. For example, the two heavily populated islands Santa Cruz and San Cristóbal might be opened and the two lightly populated islands Isabela and Floreana might be closed to settlers. If this land swap were done now, it would require moving about 4,000 settlers out of a total of about 40,000" (Dyson 2008).

It is in the context of human-induced species invasions that the research conducted for Chapter 3 was undertaken. Despite decades of eradication and control measures, invasive species continue to inhabit and arrive to the islands. The feral goat invasion of the Alcedo volcano region of Isabela Island likely began over 50 years ago, but vegetation growth related to a series of strong El Niño events in the 1980s and 90s contributed significantly to their rapid reproduction and the expansion of their range at the end of the twentieth century. The growing numbers of goats denuded habitat and nesting sites for giant tortoises, not only in the Alcedo region but also on neighboring Santiago Island. In response, Project Isabela was planned and executed by scientists at CDRS and GNPS wardens who sought expertise from New Zealand's world-class eradication specialists, culminating in the largest mammal eradication project in the world to date.

Relying on the enhanced vegetation index (EVI) MODIS satellite imagery data product, along with GPS points collected by hunters during the aerial hunting phases of Project Isabela, this

analysis showed that the feral goat invasion of the Alcedo region and the animals' eradication have had significant landscape-level effects, although not always in the areas of the greatest goat influence. Large-scale eradication projects have reached many milestones in the last decade, particularly with the use of GIS and remote sensing techniques that provide a foundation for sophisticated analysis and evaluation of eradication efficacy (Lavoie et al. 2007). But claims of "total restoration" by Project Isabela members and donor foundations may still be premature, as populations of the native Galápagos hawk have fallen following eradication, and as on Pinta Island it is still unclear what kind of vegetation makeup Alcedo and Santiago will have in the absence of goats. In the effort to remove a very real ecological threat, Project Isabela appears to be a success, unlike other eradication programs that actually prove detrimental to island ecosystems (Bergstrom et al. 2009), but the social nature of the project itself, in terms of the reality of human-induced restoration, as well as project beneficiaries and opponents, cannot be ignored. As Oppel et al. (2011) maintain, "The ecological benefits of eradication (e.g., improvement of endemic species' probability of survival) are difficult to trade-off against social and economic costs due to the lack of a common currency."

Such trade-offs are particularly difficult to negotiate in areas where privately-owned land is adjacent to (or contained within) a protected area. In Chapter 4, the proximate and distal factors influencing agricultural production on Isabela and Santa Cruz Islands were identified and described, including socio-economic characteristics, a history of land management and environmental conservation, migration regulations, climate change and the presence of introduced plant species. Without economically viable land use options, many landowners have chosen to diversify their livelihoods and only farm part-time or choose to abandon their land altogether. Because not enough food can be cultivated for subsistence levels, this results in high levels of imports and an economy dependent on subsidized products from the mainland. Food product imports like potatoes, rice, sugar, corn, onions and flour now make up around 7,000 tons, or around 13% of the weight of all products imported per year. Given that there is limited quality control of cargo shipping at departure and

arrival points, the islands are increasingly vulnerable to pests and diseases that are transported in this manner, what one GNPS employee refers to as a "vicious cycle of invasion."

It is generally agreed among Galápagos restoration specialists that highland landowners and their land use decisions directly impact (positively or negatively) conservation efforts in the highlands (Atkinson and Gardener 2009); therefore, instead of handing down management regulations as mandates, the GNPS and CDRS must find ways to incorporate rural landowners into their protocols. Engaging the rural community and facilitating participation in all stages of highland restoration projects – from gathering information to practical implementation – avoids the pitfalls of previous top-down and park-only management in the region. As Mauricio, an Isabela farmer pointed out, "In the first place, they don't even include us in their plans, so, let me ask you something: Why would we do just anything that they tell us to?" New GNPS projects on Santa Cruz Island are concerned with building rural capacity in the islands' agricultural zones and establishing conservation easements to provide incentives for landowners to continue to farm and keep their land pest-free. The GNPS has also implemented training programs for Santa Cruz landowners concerning pest management and invasive species control, using environmentally friendly technology, increasing productivity and improving marketing channels, and their efforts are matched by a growing constituent of agricultural households who are finding creative ways to align economic goals with conservation interests. Unfortunately, the beneficiaries of these programs are limited to more populated Santa Cruz, while the trends of land abandonment and plant invasions on Isabela Island that were noted by Chiriboga et al. in 2006 seem only to be accelerating.

Understanding how and why landowners choose to engage in farming reveals only part of the story of food production, land management and species invasions. Based on their different ways of using and valuing land on Isabela Island, different perceptions of the landscape emerged among stakeholder groups who were involved in the participatory classification exercise in Chapter 5. As Robbins and Maddock (2000) argue, participatory classification allows new voices to be heard within the landscape: "Remote sensing informed by local ground 'truths' can produce maps that point to

conflict as well as consensus in land management." Although there were many instances where perceptions of land cover types among GNPS employees and landowners overlapped, as in the case of invasive guava trees, other types of land cover evoked divergent opinions based on their presence as both an advantage and a nuisance. In other words, not all of Isabela Island's plant invaders are seen as weeds or pests by both stakeholder groups, and this perception translated into the almost complementary classification of 'other vegetation' and 'other invasive vegetation' on the part of landowners and GNPS employees, respectively. It is worth noting that at least one native plant that is present on all of the inhabited islands, *rodilla de caballo* (*Clerodendrum molle molle*), is considered a pest by landowners as it forms a dense carpet in pastures; they also consider endemic finches an 'invasive' species because of their interference with crop production.

The classification exercise further underscored the need to understand invasion as both a human and environmental process. The ability and interests different stakeholders have in dealing with the presence of guava and other plant invaders in the Isabela Island highlands, for example, are configured by how they are involved in what Robbins (2004) calls the "social ecology" of the plant. It is the conceptual separation of non-native organisms from indigenous varieties that underwrites expensive eradications and removal programs, in spite of the fact that environmental settings and invasive impacts vary according to the particular situation. "We cannot maintain the illusion of nature unadorned, writes biologist Brendon Larson on species invasions (2008), "but perhaps this is a reminder that we're not so separate after all."

According to UNESCO, the human 'invasion' of Galápagos is the second greatest threat after introduced species to biodiversity (UNESCO 2007: 9). Illegal behavior and migration are two types of human 'invasions' that complicate the enforcement of regulations while raising important questions about their true impacts on island biodiversity. Both are products of the 'double bind' of tourism, as the final chapter showed, enrolling subjects in economic development schemes that undermine expectations of environmentally responsible behavior and legal regulations.

A central theme in the current conservation discourse surrounding Galápagos is whether Galápagos tourism can be considered 'ecotourism', given the social and environmental changes it has brought to the archipelago over the last 30 years. Martha Honey defines ecotourism as "travel to fragile, pristine, and usually protected areas that strives to be low impact and (usually) small scale. It helps to educate the traveler; provides funds for conservation; directly benefits the economic development and political empowerment of local communities; and fosters respect for different cultures and for human rights" (Honey 1999: 25). As the final chapter showed, however, the Galápagos has suddenly become a cautionary tale to other island destinations of the dangers of so-called 'sustainable' tourism accompanied by rapid and unplanned growth and a lack of community-level benefits. At the same time, the economically viable aspects of Galápagos Island tourism holds it in tension with ecological and social concerns, and while biodiversity protection is gaining traction among some resident groups there are others who are less convinced that conservation is a critical component of an island-wide economic strategy.

The current regulatory framework for tourism has been outpaced by the industry's recent success, and little effort has been made to see to it that benefits are shared among the islands' residents. Uneven development related to tourism growth has also given rise to increased local conflict, unlawful environmental activities, and illegal migration, as the distribution of revenues from the protected areas unevenly benefit mainland tour operators and conservation organizations. Proposals to limit the tourist footprint to 30 days instead of 90, residents argue, will directly impact the revenues received by smaller business and hotel owners, while the structural and financial limitations to obtaining tourism permits keep residents from transitioning into tour operators. The economic logic of tourism continues to draw an unknown number of Ecuadorians from the mainland to work and live illegally, and in spite of their contribution to the booming economy they are now being targeted for deportation.

Each of these chapters has shown, through a variety of means, that invasion is far more complicated a process than claims of naturalness, nativeness or legality can contain. Environmental

protection from invasion, writ large, should (and can) be carried out in a manner that is not only ecologically viable, but also politically and socially equitable. Where biodiversity receives greater protection or intervention than its human counterparts, in the case of expensive eradication programs, emergency tortoise rescues or the closures of economic outlets, conservation and government organizations must be prepared for the social ramifications of their actions. Enrolling private landowners in highland restoration projects must not assume that rural economic interests and foreign environmental ideals are complementary or even compatible. Lastly, the oversimplification of communities living in or near protected areas overlooks their members' diverse motivations for participating (or not) in conservation programs. The rigid separation of people, plants, animals and places cannot always interrupt the tendency of a species to invade, a resident to act in an unlawful manner, or a migrant to reside in a place illegally.

In the end, eradication is not an ultimate denouement, nor is land use regulation, or the discipline of illegal acts and migration. Goats and rats will find new islands to colonize, landowners will make decisions to cultivate or abandon again and again, and people will seek social and economic justice through any means available to them. The inevitability of change in Galápagos has never been more clear, a sense that was captured in 2006 by National Geographic in their international survey of World Heritage Sites: "The outlook is pretty bleak. The islands seem to be at a crossroads. Discussions of increasing the size of cruise ships and the corruption surrounding illegal fishing activities and immigration pose serious threats" (National Geographic 2006).

Much change has come to Galápagos since I finished my fieldwork over one year ago. Under pressure from the Ecuadorian government, the 2010 World Heritage Committee voted to remove Galápagos from UNESCO's In Danger list, citing significant progress on the government's part in addressing the crisis. In July 2010 a triumphant Environmental Minister celebrated her successful persuasion of the committee with a festival, but members of the international conservation community, including UNESCO itself, unanimously rejected the decision. Tim Barman, director of the International Union for Conservation of Nature World Heritage Programme, said in August 2010,

"The recommendation is that Galápagos not be removed from the in danger list because there's still work to be done. The threats continue to be factors that make the situation critical" (El Colono 2010e: 3). Johannah Barry of the Galápagos Conservancy echoed Barman's sentiments:

> "It would be a big mistake to interpret the decision of the WHC as a signal that all is well in the islands. Galápagos continues to face extremely difficult challenges of invasive species, rapid growth of the human population, and lack of consensus on the kind of tourism which is best suited to the delicate ecosystems of the archipelago" (Galápagos Conservancy 2010).

Just as Galápagos was being removed from the list, in October 2010 the archipelago snared the coveted top spot in Travel and Leisure magazine's list of the world's best islands, and is one of 28 finalists in a contest for the 'New 7 Wonders of Nature'. "This award recognizes the effort that the Ecuadorian government has put into preserving the archipelago in the best possible condition," said the newly appointed GNPS Director Edwin Naula. "Tourism management in Galápagos seeks to ensure that tourists get closer to the natural and pristine ecosystems of these islands during their visit." The entrance fee for foreigners is expected to rise starting in 2012, pending the acceptance of revisions to the Special Law, to reflect a $20 general increase (bringing the total to $120) and an additional Environmental Impact supplement based on the number of days the visitor stays in Galápagos. The division of the visitor entrance fee among Galápagos institutions is also expected to change, providing a higher percentage of the revenue to the GNPS. In February 2011, the GNPS attempted to enact tighter controls on cruise ship traffic to visitor sites by requiring that all vessels must operate 15-day/14-night itineraries instead of the typical seven-night cycle. The goal is to establish a more even impact throughout the archipelago and rearrange itineraries to limit the number of people visiting a site. By effectively forcing tour operators to offer longer cruising packages the GNPS anticipates that the measure will actually reduce the number of tourists arriving to the islands (with an associated reduction in airline traffic) while maintaining the same number of people visiting the islands at any given time. In a more controversial decision, the GNPS approved a proposal by large tour agencies to allow cruise ships to dock in the waters that surround Isabela Island, angering a community that has prided itself on the promotion of local, small-scale tourism.

Unfortunately, seizures of illegal fishing catches continue to mar the pristine image of the Galápagos Islands and the marine reserve. In 2010, a week after 16,000 illegally harvested sea cucumbers were found in a San Cristóbal Island home, the GNPS marine patrol boat, the Guadalupe River, found yet another illegal fishing camp on Isabela Island and confiscated shark fins and over 80,000 sea cucumbers. Later that year a Costa Rican fishing boat was discovered in the marine reserve with shark meat on board, which the crew maintained they caught outside of the protected waters where shark fishing remains legal. In July 2011, nearly 400 dead sharks were found on an Ecuadorian fishing boat operating illegally in the marine reserve. The fact that each fin is worth around $80 to $100 in Asian seafood markets makes being caught inside the archipelago's reserve worth the risk, particularly when sanctions for illegal fishing as set forth in the 1998 Special Law are rarely enforced.

Some of the major institutions in Galápagos are also undergoing significant amendments and adjustments, in accordance with social and political fluctuations. Political change increasingly depends on the municipalities and the new Government Council, who play challenging roles that ultimately have an impact on biodiversity protection and development. The central focus of organizations like the CDRS and the GNPS is shifting from strictly biodiversity to business models and social change. Newly-appointed CDRS Social Science Coordinator Daniel Orellana specializes in the study of population development and mobility, expanding on his predecessor and fellow geographer, Christophe Grenier's, focus on the archipelago's decreasing isolation due to tourism, marine traffic and globalization in general. After serving as the CDF Director for only three years, Gabriel Lopez recently announced that he is stepping down, continuing a pattern of short-term scientific direction and leadership. In May 2011, following nearly three years of planning and construction, the University of North Carolina-Chapel Hill (UNC), in partnership with the private Ecuadorian Universidad San Francisco de Quito (USFQ), celebrated the dedication of the Galápagos Science Center on San Cristóbal Island. The research facility is adjacent to USFQ's satellite Galápagos campus, the Galápagos Academic Institute for the Arts and Sciences (GAIAS), and will

provide laboratory and office space for visiting researchers, as well as multi-purpose space to be used for community seminars and events. As the most recent member of the Galápagos scientific and conservation community, the joint UNC/USFQ Center must quickly establish itself as an organization dedicated to openness and knowledge transfer to avoid having the appearance of another foreign environmental enterprise providing little benefit to the resident population.

Within local communities, emerging grassroots and alternative development organizations offer proof of what can be accomplished. Ambiente Independiente, a *galapagueño* organization based out of Santa Cruz Island, initiated its efforts on Earth Day 2007 and promotes a variety of community activities that not only educate residents and visitors about their environmental impacts, but make them part of conservation solutions. Santa Cruz Island's Galápagos National High School has instituted a culinary training program for employment in the tourism sector, while the bilingual private school, Tomás de Berlanga, emphasizes a curriculum that contributes to the social, cultural and environmental development of the archipelago. The PMB continues to seek a middle ground for local fishermen who are unwilling or unable to transition into other, less extractive, livelihoods. Following a monitoring mission carried out by the CDRS, in June 2011 the sea cucumber fishery once again reopened with an extraction quota of 1 million individuals. The fishery has been closed since 2008, when the quota of 1.2 million was not met due to insufficient stocks. Development on 'El Mirador', the result of a recent land swap between the GNPS and the Santa Cruz municipality, has temporarily been stopped while a British architectural trust collaborates with the municipal planning department to design low environmental impact, low-cost modular homes for the neighborhood that will ultimately house over 1,000 residents. Lastly, Galápagos residents concerned about local development and the environment are increasingly using social media outlets such as Twitter and Facebook to distribute information at the grassroots level. Blogs like Insular Galápagos (http://insularGalápagos.blogia.com) and Nova Galápagos News (http://www.Galápagostoday.org), keep followers up to date on community, environmental and political issues while the Facebook group *Quiero que en Galápagos se respete la ley* [I want respect for the law in Galápagos] organized

a May 2011 silent march in Puerto Ayora to protest the construction of a new hotel without proof of an environmental impact assessment. According to the group's profile, their goal is to "report to the authorities and demand that projects being carried out in the islands without proper permits, without consulting the community and through the abuse of power, be closed, and in some cases demolished."

As he was preparing to leave the CDRS, Grenier was interviewed by El Colono, the local newspaper, regarding his thoughts about how conservation should proceed in Galápagos. He explained that he does not view conservation as a "hands-off" strategy of protecting the unique and unusual islands, but rather as a way of finding balance between the interests of project developers and scientists and those who derive other benefits from the environment they are striving to protect. Management plans in Galápagos in the past have focused on the archipelago's protected areas as though they are separate units from the rural and urban zones, an artificial boundary that has resulted in marginalization, resentment and ultimately, continued invasion. As these chapters have shown, environmental management is a collaborative and inherently social endeavor that requires an understanding of the integrated economic, cultural and ecological landscapes. Galápagos has a scientific heritage, concludes Grenier, "and by keeping aspects and places, even plants, in populated areas where people can see them, they'll begin to understand what that heritage means – and see it as a means for economic gain."

The Tsunami

Perhaps nothing brings the inevitability of change so sharply into focus as the threat or reality of a natural disaster. As my fieldwork was coming to a close, an event occurred that had the potential to cause extensive destruction within nearly every sector of Galápagos human, plant and animal life. In the early hours of Saturday morning, February 27, 2010, an 8.8 magnitude earthquake hit Chile. The tremor occurred just offshore around 350 km from the country's capital city of Santiago. Within hours, tsunami advisories had been issued for regions of 50 Pacific nations, including the U.S. Hawaiian Islands, French Polynesia, Australia, Japan and the Galápagos. As they radiated away from

the epicenter into the Pacific 'Ring of Fire', waves from the tsunami were expected to be at least 3 m in height, each one lasting from five to 15 minutes.

I was living in Puerto Ayora on Santa Cruz Island at the time, working on FUNDAR's demonstration farm in the Santa Rosa region of the highlands. Although I normally arrived to the Saturday morning farmers' market around 6 a.m., I was still asleep when my phone rang at 5:30 a.m. My friend Kasia, the Peace Corps agricultural volunteer on Isabela at the time, apologized for calling so early but wanted me to know that the Port Captain had stopped all inter-island boat traffic and that residents should move to higher ground immediately. I stepped outside into the courtyard in front of the apartment I was renting, but since there was no one in the streets I decided to walk to the fisherman's dock. From the water's edge I was surprised to see that dozens of fishing boats and a few of the larger tour vessels were not coming into the bay, but heading out into open water, which I later learned was ordered by the Port Captain to avoid being catapulted into the town on a wave. I looked down at the water line, abnormally low due to the prevailing neap tides that had caused several tour boats to run aground on Isabela's shallow reef earlier that week. As though a stopper had been pulled from a giant drain, the water level suddenly dropped more than a meter, exposing the rocky bottom of the bay for more than half a mile from shore. I turned and ran back toward my house.

By 6:30 a.m., the town was coming to life and as the news of the tsunami reached the streets people were piling into pickup trucks, dump trucks, tractors, anything with wheels and a motor (Figure 7.1). "Get into any car you can," the police announced over blaring sirens. I climbed into the back of my landlord's truck, shouting the news in English to bewildered tourists who stood watching the spectacle. Puerto Ayora is built on a hill, so within only a few blocks of the water we felt reassured that we would be out of harms' way; however, we kept driving until we reached the small highland village of Bellavista where the rest of town was waiting. We waited for hours in the central park, drinking coffee and crowded around a small radio that periodically announced when another wave had passed the islands. The last surviving Pinta Island giant tortoise, Lonesome George, listeners were assured, had been safely taken to higher ground along with the other animals at the

local breeding center. As we later realized, Puerto Ayora and the islands' other coastal towns were spared the damage of 10 successively stronger waves by the extreme low tides that are characteristic of that time of year.

Figure 7.1. Top: a municipal dump truck carries residents to the highlands during the tsunami warning. Bottom: a mother and daughter ride to safety in the back of a delivery truck.

The municipality of Santa Cruz later announced that thanks to their Emergency Plan, Puerto Ayora achieved a 90% evacuation rate, but on Isabela the process was far less organized. The farmers' market, which takes place in an indoor/outdoor stadium roughly at sea level, continued until 7 a.m., by which time the first wave was scheduled to pass the archipelago. No evacuation order was issued, and once news reached the majority of Puerto Villamil's inhabitants the few taxis on that island had already been hired and headed for the highlands. Jaime, a 42 year-old taxi driver with three small children, later told me that he made 12 trips back and forth from the coast to the highlands that morning, each time finding more frantic and frightened people who were unable to get to safety.

When asked if the islands were prepared for a tsunami, residents of Isabela and Santa Cruz Islands were equally disappointed with the level of organization and capacity, especially given the fact that the islands have been threatened by 19 registered tsunamis since 1960 (El Colono 2010f: 6). "Prepared? No, we're not prepared. I don't know how you could prepare for something like this, in the middle of the ocean, but our leaders need to be focused on finding ways to respond more quickly," said Gloria from Santa Cruz. Vicente, a former Isabela municipal employee agreed, "No we're not prepared, because before the alarm there wasn't a contingency plan. At the last minute the authorities made a plan, but that should have happened much earlier. You never know what's going to happen, because nature is unpredictable." "We need to be more aware," concluded another Isabela resident, "It isn't enough that we're just now starting a process to educate and prepare ourselves for a disaster of this magnitude."

The archipelago's preparation for natural disasters was again tested just over a year later, when a much more severe tsunami hit the Galápagos. Originating from the deadly earthquake in Japan in early March, 2011, the tsunami arrived to the Galápagos Islands 18 hours later, after residents had received advanced warning and took to higher ground. Unlike the prior tsunami, however, the waves struck at high tide and manifested as a series of marine surges, rising almost 2 m above the normal high water mark. They forced their way into coastal buildings throughout the afternoon, flooding the police station, destroying computing and communications facilities and

causing significant damage to the CDRS marine biology lab located near the water's edge. Roque Sevilla's Finch Bay Hotel was heavily affected by flooding, as was the GNPS boat dock. Lonesome George had once again been evacuated prior to the tsunami as a precautionary measure and remained out of harm's way, although environmental impacts were more severe in other regions of the archipelago, destroying nesting populations of flightless cormorants on uninhabited Fernandina Island. In a comment thread on the Galápagos Conservancy website, several tourists preparing to depart for their vacations expressed concern that the quality of their tours, too, would suffer from the damage. As one recent visitor reassured them, "The streets were clean and had no debris. The Tortuous [sic] breading center looked as though it sustained no damage. The grocery store and the open air fish market were just fine. And more important the plants and the animals at about 10 or 11 islands we visited looked unharmed and at peace."

I believe that the vulnerability that I felt and that was expressed to me following the 2010 tsunami perfectly captured the uncertain nature of life on a remote set of islands in the Pacific. It again revealed the attitude, alarmingly commonplace, that in Galápagos a human life is secondary to its charismatic plant and animal counterparts. And, like the recent eruptions of Isabela Island's volcanoes in 2005 and 2008, it also served as an all-too-natural reminder that the islands' pristine image could be swept away in one violent instant.

Theoretical and Methodological Contributions

In explaining environmental degradation due to invasive species, scholars have focused almost exclusively on the damage to and reduction of native species, and rather uncritically on the designation of a species as an alien invader itself. The presence of questionable natives and the discovery of evolutionary mutualisms between endemic finches and introduced seeds expose the inherent subjectivity to species designations and call for a need to evaluate them based on their impacts rather than their origins. Throughout this dissertation, I have strived to assess environmental policies intended to reduce the presence of non-native species through an analysis of their social and

ecological outcomes. To be sure, some species in the Galápagos have unpleasant, destructive and even dangerous qualities, and while most of them are known as 'invasive' to environmental managers, to be unpleasant, destructive and dangerous does not require that they be introduced. In the maintenance of protected areas, there are, as Slobodkin (2001) writes, "real problems and real solutions must be found." Feral goats decimating giant tortoise habitats and native vegetation are highly problematic indeed, and despite appeals by animal rights groups and island residents alike, elimination is currently considered to be the only conceivable intervention. The destruction wrought by guava trees, on the other hand, constitutes a greater loss to rural landowners than to conservation officials, yet environmentally-acceptable control measures remain out of reach for those who value economic productivity over biodiversity for biodiversity's sake. I believe that an enhanced public awareness of the importance of environmental problems in Galápagos must be met by a willingness among policy makers to attend to what Robbins (2004) calls the "cultural and political ecology of species invasion," in order to address, as Gabriel Lopez said in this introduction, "the *causes* of environmental degradation."

I have also argued for a closer interrogation of the politics of territory and legality inherent in migration restrictions and resource use controls as the human 'invasions' of Galápagos. My data on Galápagos migrant illegality was limited by a lack of available sources; nevertheless, the situation in the islands has strong parallels to the U.S./Mexico border crisis, where the pattern of undocumented labor migration from Mexico to the United States has become a problem of illegality. I chose to focus on the lived reality of illegality among migrants from the Ecuadorian mainland and the vulnerability associated with a sense of deportability in everyday mundane behavior. My investigation into illegal environmental behavior further characterized the "political usage of the emergent concept of space" (Elden 2005) by Galápagos policy makers in making the archipelago a sovereign territory within which legality could be defined and defended. Foucault's governmentality analytic (1991) proved useful in understanding how conservation-as-governance set up power relations that enlist subjects in the project of their own rule. This facilitated a departure from the preoccupation with state territory

and into an exploration of sovereignty and social relations in which classifications of migrant illegality lie in stark contrast to everyday activities.

Finally, when dealing with large, complex systems like inhabited oceanic archipelagos, the tendency among conservationists to repair to assumptions of a prior, 'pristine' nature in policy rhetoric is to presume that such a state exists to which to return. Modern ecological theory has shed past paradigms claiming that systems tend towards equilibrium and homeostasis, emphasizing the importance of historical time, periodicity, scale, and heterogeneity (Zimmerer 1994). Often, however, conservation practice remains predicated on outdated assumptions of a state that is prior to and separate from human influence even as it inserts the human hand in so-called 'natural' systems. Meanwhile, 'pristine' nature is held in tension with its opposite, development, in the islands. By attending to these two paradoxes in Galápagos through my case studies, I have argued for the utility of a framework that views the Galápagos as an entangled human/natural landscape. This facilitates a departure from a preoccupation with fixed spatial, conceptual and territorial boundaries (what Smith (1996) calls 'naturalized space'), and an entry into the investigation of how relations among and between humans and nature mutually produce and condition one other.

Conceptualizing the processes of 'invasion', writ large, at the local level is crucial, since it is the individual landowner, conservation manager, fisher and migrant agent that is the vehicle by which environmental decisions and changes are made. Understanding why members of Galápagos communities choose to support or reject eradication procedures, land management regulations or migration restrictions is as essential a question for conservation policy developers as it is for research on the biological, agricultural or demographic outcomes. As a result, individual-level decisions are situated within broader political, economic and environmental contexts that exert significant influence on their ambitions and everyday activities. To the degree that some community members have benefited from conservation measures in the past, it is likely that these same people will be especially supportive of future stages of biodiversity protection and regulations.

One of the most important contributions of this work to the broader human-environment literature and political ecology in particular, is the mixed methods approach that integrates spatial, quantitative and qualitative lines of inquiry and analysis to tell a fuller story than a single method. The case studies undertaken in this research are viewed as interpretative, and stress the importance of local and particular interventions. Empirical studies can be useful in linking humans and the environment both in place and emphasizing the relationships that stretch beyond it. For example, proximate and distal factors can be identified that result in environmental and social change. Spatial themes, such as the structure and function of the environment under particular social or economic conditions, are important to empirical work that ties humans to the environment by linking people, place and policy in multiple ways (Neumann 1998; Walsh and Crews-Meyer 2002; Zimmerer and Bassett 2003). Political ecologists often study cases of disenfranchised or vulnerable social groups, extending their analyses to include environmental factors that influence or are in turn influenced by political, economic or social change. Empirical work often informs development projects and action-oriented interventions both locally and further afield.

This research expands on the numerous case studies involving humans and the environment that played a role in its design. Research concerning the efficacy of park boundaries and the behavior of people living in and at the edges of protected areas facilitated qualitative comparisons with the historical and current situation in Galápagos. The potential for community-based conservation or a participatory system of environmental governance have been evaluated by case studies in the Philippines (Alcala and Russ 2006) and the Bay Islands of Honduras (Stonich 2004), both tropical locations where tourism comprises a large segment of the local economy and conflicts over conservation and development projects have historically hindered cooperation between environmental managers and local residents. Selecting individual people and places as the unit of analysis in this research proved to be vital to understanding what the current trajectory of 'sustainable' development means for island social and environmental conditions, particularly when livelihoods are tied directly to the preservation and maintenance of environmental resources.

In my use of mixed methods, I relied on a variety of quantitative sources and analyses to frame my arguments and document patterns among members of Galápagos society. Quantitative analysis does not, however, contain explanatory powers (Sayer 1992). I also found that the use of GIS and remote sensing was an appropriate tool for linking people to the landscape, as in the case of participatory remote sensing and eradication programs, but caution that spatial analysis or mapping techniques are not in themselves explanatory tools. While quantitative and spatial analyses assist in understanding behavioral data that change over time and in space, they do not necessarily capture the features that shape such interactions. Therefore, I relied on open-ended discussions and qualitative engagements such as focus groups and participant observation with my informants to allow them to voice their own opinions, concerns and priorities. Research that engages local, often marginalized, populations benefits from the comprehensive understanding provided by multiple research methods to minimize biases, such as the assumption that community members are homogenous or 'against' conservation (Shackeroff and Campbell 2007).

This research combined analyses using GIS and remote sensing technologies with qualitative interviews of key informants and participant observation among members of Galápagos Island society. To assess vegetation change near the Alcedo volcano following the eradication of feral goats, for instance, I used remote sensing to provide a broad spatial characterization of the differential impacts of an invasive species eradication program. In order to adequately address on-the-ground processes I also used spatial data points collected during a field visit in 2007, along with in-depth interviews with members of the GNPS who visited the area before, during, and since the goat eradication program. The goal was to obtain a detailed understanding of the patterns of landscape change, informed by the observations and opinions of a variety of people with the understanding that there may be unexpected processes in play in the region that would not be captured by either assessment alone. In the case of guava on Isabela Island, I combined participatory remote sensing with interviews and surveys to understand not only the dynamics of vegetation change in place, but to identify the webs of relations that extend beyond farming areas and the GNP. The understanding

gained from qualitative methods assisted my interpretations of findings from remote sensing and survey analyses (why GNPS employees 'see' more forest and introduced species than landowners do in a landscape, for example, or what makes certain resident groups likely to engage in unlawful environmental activities). These methods were also used to verify one another, as evidenced by Chapters 3 and 4, which showed how uneven political and environmental management practices translate not only into uneven landscape change but social change, as well. Lastly, my day-to-day interactions with my informants – planting and harvesting with landowners, playing soccer with children, fishing and camping alongside fishermen, and swapping gossip and recipes with my female neighbors – proved to be invaluable contributions to my knowledge of Galápagos people and places, and frequently not only informed but directed my evaluations of analysis results.

Future Work

Through the use of case studies and mixed methods this dissertation research facilitated a critical analysis of the processes of invasion that are occurring in Galápagos, and the politics designed to deal with them. The approach was limited, however, by a lack of available data, particularly related to social and demographic trends. Although three population censuses have been carried out in the Galápagos since 2000, residents were tallied in different ways according to where their 'legal' residence is or where they were residing at the time of the census. In 2006, only inhabitants who claimed the islands as their legal home were counted, while in 2010 all people, regardless of citizenship or residency who were present on census day (including tourists), were supposedly counted. This limits the potential to conduct longitudinal population analyses resulting in the population 'snapshots' that have been provided here. Based on these findings and the anticipated availability of data sources, three goals have been identified for future work.

First, local capacity must be developed to establish local communities as the beneficiaries of tourism, and island conservation more broadly. In recent years, financial and research investment in Galápagos has turned to the neglected social sector, reflecting a shift from a focus on conservation

work toward human welfare issues. The management of the islands should proceed in an integrated, interdisciplinary manner in order to address the criticism of stakeholders who claim that the international community exclusively focused on saving plants and animals while basic human needs have been ignored. The benefits that the GNPS provides to island residents should be realistically assessed in a participatory manner through workshops and focus groups, as well as household surveys to evaluate productive practices, economic conditions, education, health and environmental perceptions of protected area management. The INEC-CGREG 2009 household survey provides a rich baseline dataset with which to begin to assess population impacts on the environment and social change among rural and urban communities, as well as between islands. Future projects that define demographic and environmental pressure indicators at the pixel level will facilitate the integration of a social/spatial modeling framework that will assist policy makers in targeting incentives for sustainable island management and development.

This work will also investigate the impact of revisions to the Special Law and the establishment of the new Government Council on the stabilization of island governance and migration regulation. Institutions in Ecuador and Galápagos have experienced high rates of turnover: since 1996 there have been 11 different Presidents, six Environmental Ministers, 12 GNPS Directors, eight provincial governors and eight Directors of INGALA (now part of the Government Council). Interviews conducted with the heads of many institutions during my fieldwork as recently as a year ago may no longer be relevant, making follow-up dialogues essential to a transparent and pragmatic interpretation of these changes. The mobility of the legal and illegal inhabitants of the islands should be assessed in the context of the tourism industry to establish a clear understanding of migrant flows and push and pull factors between their place of origin and the archipelago. In early 2010, Migration Control Coordinator Erick Sotomayor estimated that 30% of migrants who were living illegally in Galápagos had left, but there are no reliable estimates as to the number of people that number represents, or their status as former tourists, temporary residents, family members or undeclared professionals. Planned analyses of data collected by the GNPS on each visitor to the islands will

reveal demographic and spatial trends that make some visitors more (or less) likely to come to the islands and stay.

Finally, with the closure of one of three mainland shipping docks in 2010, the path to a secure and sanitary Galápagos cargo transport system has only begun. The Ecuadorian government has confirmed a total of $5 million for the infrastructure of the cargo loading and unloading system and made Guayaquil and Isabela Island priority sites. To ensure long-lasting environmental benefits, a clear timeframe should be established for the consolidation and retrofitting of a single mainland loading dock to comply with international biosecurity standards. Routine species audits must be implemented at loading and off-loading points and on cargo ships during transit, as well as capacity building for Agrocalidad personnel. Like the GNPS, Agrocalidad has also experienced high turnover in the appointed Director's office with seven different Directors since 2001. As UNESCO has pointed out, the political nature of the position limits the ability of the office to design and implement monitoring activities beyond the daily operations of the system (UNESCO 2006). Although they argue that the current fee-based budget that is dependent on tourism and imports should be replaced by more engagement with the Ministry of Agriculture, Agrocalidad is currently being incorporated under the leadership of the GNPS (Murillo, personal communication 2010).

Future work will coordinate efforts between key Galápagos and Ecuadorian institutions, international NGOs, and communities to ensure that the biosecurity goals of the 2010 World Heritage Committee, in tandem with the Ecuadorian Ministry of the Environment, are addressed in a holistic and timely manner. It will set up a framework for effective monitoring of maritime shipping and construct a preliminary database of dangerous species that are commonly transported via cargo ship to the islands. This project will also forge the beginnings of vital partnerships between conservation NGOs and government institutions to raise community awareness about the risks associated with imported goods to island agriculture, fisheries, and human and environmental health. Conservation goals in Galápagos are rarely made transparent to residents, resulting in a general lack of

understanding of or incentives for project participation; therefore, fostering community engagement in island biosecurity may be this project's most significant long-term impact.

Conclusions

Since the archipelago's discovery by the Western world in 1535, the history of Galápagos Island nature has been intertwined with its human one, bringing unexpected changes to the islands known globally as the inspiration for evolutionary theory. 'Invasion', by plants, animals, insects, diseases and even people, has been a central part of this process. This dissertation is a step toward understanding the agents of environmental and social change, and the politics designed to control them. As these case studies have shown, such measures can have unexpected, and unintended, results. A great potential exists for aligning conservation and community goals in Galápagos and in other places worldwide where human populations exist on the margins of protected areas. It is laudable that in the context of the Galápagos environmental crisis, institutions like the GNPS and CDRS have begun to extend their protocols across physical, conceptual and territorial boundaries to include the islands' human residents alongside their non-human counterparts. Doing so will hopefully represent a win-win situation for conservation and development interests in the Galápagos Islands and beyond.

Appendix I. Landowner Survey and Interview Guide.

Interviews with Santa Cruz and Isabela Island landowners

Interview dates: June 2009 – March 2010

Interviewer: Laura Brewington

1. Do you or a member of your household currently own land on this island? If no, discontinue interview.

2. Date: _____

3. Island: _____

4. Name: _____

5. Sex:

    1 Male
    2 Female

6. What is your age? _____

7. What is your highest education level attained?

    1 Primary
    2 Secondary
    3 Post-secondary
    4 University
    5 Post-graduate
    6 Other _____

8. How many years have you or your family owned this property?

    _____

9. How large is your farm (in hectares)?

   _____

10. What is the sale value of your land (in dollars)?

    $_____

11. Do you or members of your household live on your farm? If yes, how frequently do you/they stay there?

    1 Yes

    2 No

    _____

12. Including yourself, how many members of your household participate in agricultural activities?

    _____

13. Do you or members of your household participate in other off-farm economic activities? If yes, please describe the activity.

    1 Yes

    2 No

    _____

14. What is the principle activity on this farm?

    1 Agriculture

    2 Ranching

    3 Combination of agriculture and ranching

    4 Other _____

15. Please circle the food items you produce regularly on your farm:

    1 Fruits
    2 Vegetables
    3 Dairy
    4 Poultry
    5 Beef
    6 Grains
    7 Beverages
    8 Other _____

16. Please indicate what proportion of total farm production each category represents:

    1 Fruits ____
    2 Vegetables ____
    3 Dairy ____
    4 Poultry ____
    5 Beef ____
    6 Grains ____
    7 Beverages ____
    8 Other ____

17. What was the value of your combined (fruit, vegetable, forest, livestock) farm sales for the last 12 months?

    $ _____

18. What proportion of each type of food product do you consume yourself, give as gifts, or sell to local restaurants and stores?

	Household consumption	**Gifts to friends/family**	**Sale to local markets**
Fruits			
Vegetables			
Poultry			
Beef			
Dairy			
Grains			
Beverages			
Other			

19. Do you have problems with any plant, animal, or invertebrate species on your land, and does that affect your use of it? Please describe.

20. If the answer to the previous question is yes, are any of these considered invasive by the Galápagos National Park and the Charles Darwin Research Station?

21. Are any of them NOT considered invasive by these organizations? Please explain.

22. What do you do to control or eliminate these organisms? Do you find this to be challenging, or part of the normal clearing and planting cycle?

23. Please describe the impacts of government/national park policies on your agricultural decision-making. For example, are incentives offered in exchange for controlling invasive plants?

24. Please rank the following items according to how negatively they affect agricultural production on your land. For example, if you believe invasive species are the *greatest* threat, rank them as #1:

1	Birds/finches	_____
2	Insects and worms	_____
3	Invasive plants	_____
4	Manual labor shortage	_____
5	Rats and mice	_____
6	Transportation difficulty	_____
7	Unstable markets	_____
8	Water (too much or too little)	_____

25. Based on your responses to the previous question, please describe the most pressing issues you experience in maintaining your farmland (i.e. items 1 to 4).

26. Please rank the following organizations in order of the benefits they provide to landowners, through policy, subsidies, financial or labor assistance:

1	Agricultural cooperatives	_____
2	Charles Darwin Research Station	_____
3	Galápagos National Park	_____
4	INGALA	_____
5	Municipalities	_____
6	Parochial *juntas*	_____

27. Please describe any financial or social incentives that you have to continue to farm here.

28. Do you think that tourism is affecting agricultural practices in the islands?

29. Do you think the future of this island's agricultural industry is sustainable? Please describe the kinds of economic alternatives you might pursue in the coming years.

Appendix II. Restaurant and Store Survey.

Survey of Santa Cruz and Isabela Island restaurant and store owners

Interview dates: June 2009 – September 2009

Interviewer: Laura Brewington

1. Date: _____

2. Island: _____

3. Name of store: _____

4. Name of store owner: _____

5. Do you purchase food products from:

    a. The Ecuadorian mainland?

        1 Yes (if yes, continue to question #6)

        2 No

    b. Local farms?

        1 Yes (if yes, continue to question #9)

        2 No

    c. Both?

        1 Yes (if yes, continue to question #6)

        2 No

6. Please circle each type of imported food products you purchase:

    1 Fruits
    2 Vegetables
    3 Beans
    4 Dairy
    5 Poultry
    6 Beef
    7 Grains
    8 Beverages
    9 Other _____

7. How often do you purchase imported food products?

    1 Daily
    2 Weekly
    3 Bi-weekly
    4 Monthly
    5 Other _____

8. How are imported food products delivered to you?

    1 By air
    2 By cargo ship
    3 Other _____

9. Please circle each type of local food products you purchase:

    1 Fruits
    2 Vegetables
    3 Beans
    4 Dairy
    5 Poultry
    6 Beef
    7 Grains
    8 Beverages
    9 Other _____

10. How often do you purchase local food products?

    1 Daily
    2 Weekly
    3 Bi-weekly
    4 Monthly
    5 Other _____

11. If you purchase *both* imported *and* locally-produced food, what proportion of each type of food product comes from the mainland or from local farms?

	Ecuadorian mainland	**Local farms**
Fruits		
Vegetables		
Beans		
Poultry		
Beef		
Dairy		
Grains		
Beverages		
Other		

Appendix III. Resident Interview Guide and Opinion Survey.

Interviews with Santa Cruz and Isabela Island residents

Interview dates: June 2009 – March 2010

Interviewer: Laura Brewington

1. Date: _____

2. Island: _____

3. Sex:

    1 Male
    2 Female

4. Where were you born?

    1 Galápagos
    2 The mainland – If yes, please select:
        a. The coast
        b. The Sierra
        c. The Oriente/Amazon

5. What is your age? _____

6. What is your highest education level attained?

    1 Primary
    2 Secondary
    3 Post-secondary
    4 University
    5 Post-graduate
    6 Other _____

7. How long (in years) have you lived in Galápagos? _____

8. If you moved here from the mainland or another country, please select your reason for moving from the following:

    1 Employment
    2 Marriage/family
    3 Education
    4 Health
    5 Environment
    6 Other _____

9. Have you ever lived on another island? If yes, please explain why you chose to leave.

10. How many of your immediate family members (grandparents, spouse, siblings, children, or cousins) live in Galápagos?

11. What do you do for a living? If there are multiple activities, please explain.

    1 Primary activity: _____
    2 Other/secondary activities: _____

12. If you selected your primary or secondary activity as tourism, please answer the following questions:

    1 Do you own a tour agency?

        If yes, which one? _____

    2 Do you own a tour cupo?

        If yes, how many? _____

    3 Are you an employee of a tour operator?

        If yes, which one? _____

    4 How many years have you participated in tourism? _____

13. Do you think your livelihood on this island is secure? Why or why not?

14. Have you ever worked for any of the following organizations? If yes, indicate when and for how long:

    1 Galápagos National Park Service _____
    2 Charles Darwin Research Station _____
    3 INGALA _____
    4 Municipality _____
    5 Other _____ _____

15. What do you a) like and b) dislike the most about living in Galápagos?

    a. _____
    b. _____

16. How do you feel about current policies controlling imports, invasive species, and community expansion here on this island?

17. Why would you participant in environmental protection? Please choose one of the following four choices:

    1 Galápagos is unique in the world
    2 We should preserve Galápagos for future generations
    3 The environment is the source of our well-being
    4 There is a good quality of life in Galápagos

18. Please describe any past conflicts or problems you have had or know of with policies designed to protect biodiversity.

19. Do you think that there is a need for more or less government involvement in tourism and development?

20. How do you feel about the role of the Galápagos National Park Service when it comes to social and community matters? Should they be more or less involved?

21. Please check whether you Strongly Agree, Agree, Are Neutral, Disagree or Strongly Disagree with the following four statements:

	Strongly Agree	Agree	Are Neutral	Disagree	Strongly Disagree
Migration restrictions for family members are needed					
Migrants result in environmental damage					
Migration increases local crime					
Migration increases local unemployment					
Migrants erode *galapagueño* culture					

22. If you selected Strongly Agree or Agree to the previous statements about migrants and migration in Galápagos, please explain why.

23. Do you think there is a relationship between population growth and invasive species in Galápagos? On this island?

24. Are you a member of a community (i.e. grassroots, local-based) organization? If yes, please answer the following questions:

    1 Name of the organization:

    2 Your level of involvement/membership:

    3 How long you have been a member:

    4 Why you support the organization:

    5 Does your organization cooperate with other government or conservation organizations? If yes, please describe:

25. What kinds of community (i.e. grassroots, local-based) conservation organizations exist on this island? If yes, are they affiliated with or involved with the Galápagos National Park or Charles Darwin Research Station?

26. Who or what local organization do you consider most influential in policies that directly affect your day-to-day life?

27. What do you think is the most significant impact or change that tourism has brought to the Galápagos? To this island?

28. Over the past decade, what changes have you seen with regard to community development in Galápagos? On this island?

29. Over the past decade, what changes have you seen with regard to agriculture in Galápagos? On this island?

30. Over the past 10 years, what changes have you seen with regard to overall environmental health in Galápagos? On this island?

31. Are there any specific challenges that you think Galápagos faces now and in the future, that did not exist or were minor in the past? What about on this island?

32. In general, what do you think should be a top priority for government organizations like the municipalities, INGALA, and the Galápagos National Park Service in the Galápagos? Please rank the following items in order of importance to you:

1	Tourism	_____
2	Public works	_____
3	Environmental protection	_____
4	Economic growth	_____
5	Education	_____
6	Health	_____

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