SCHOOL OF GEOGRAPHY AND THE ENVIRONMENT

BIODIVERSITY INSTITUTE

Sacred forests and conservation on a landscape scale

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Thesis submitted for the degree of Doctor of Philosophy

Trinity term 2015

Thesis abstract

In the matrix of land uses beyond protected areas, people protect nature in a myriad of ways, and have, in some cases, for millennia.

With the growth of global databases of Indigenous and Community Conserved Areas and Territories (ICCAs) and registries of sacred natural sites, opportunities are emerging for conservationists to engage custodians of sacred forests beyond protected areas.

As conservation expands beyond protected areas, successful engagement emerges from unities in the perspectives of conservationists and custodians of sacred forests. This thesis aims to identify unities for conservationists’ engagement with custodians of sacred forests on a landscape scale.

The thesis geolocates sacred forests and assesses the implications for conservation in four diverse landscapes in the Gambia, Ethiopia, Malaysia and Japan. The scale of inquiry varies across the papers, from the sub-district level to a national scale.

This research indicates that while sacred forests may be overlooked by conservationists due to their small size and autonomous management, when they are considered in concert on a landscape scale, opportunities for conservation engagement become apparent. This thesis demonstrates that sacred forests can be prevalent in diverse landscapes, persist over time, and provide ecosystem services due to their spatial distribution.

Acknowledgements

I am especially indebted to my supervisors, Shonil A. Bhagwat and Kathy J. Willis, whose seemingly limitless guidance, support and patience made this thesis possible. I would like to thank my co-authors– Josh Fisher, Paul Porodong, Travis Reynolds, Sara Hamann, Alemayehu Wassie, Sandra Nogué and Meg Lowman. I am also thankful for my colleagues and the departmental staff of the School of Geography and the Environment and the Oxford Biodiversity Institute for enriching my intellectual life. I am grateful for the experience provided by the Alliance of Religions and Conservation, especially Chantal Elkin and Martin Palmer. Thank you to Tom Thornton and Raj Puri for engaging so thoughtfully and constructively with my research in examining this thesis.

I am grateful for field assistance in the Gambia from L. Njie, D. Samateh, K. Njie, F. Njie, J. Touray, T. Baro, L. Darboe, L. Sanyang, S. Sorra, D. Darboe, Kiang West National Park staff, Njie Kunda, and the villages of Dumbuto and Batelling. I would like to thank Peter Long, Jeremy Kerr, and David Benz for GIS/remote sensing assistance, Lydia Cole for comments, the World Database on Protected Areas and Micah Woods for national park boundary data, Erle Ellis and Navin Ramankutty for anthropogenic biome data and the United States Geological Survey for Landsat imagery. Financial support was provided by the Environmental Change Institute, Keble Association and Keble College, Oxford.

I would like to thank the many priests of the Ethiopian Orthodox Tewahido Church who provided information and access to their church forests and communities.
I am indebted to the Universiti Malaysia Sabah, Global Diversity Foundation, and PACOS Trust for logistical support and research access to an amazing array of welcoming custodians across Sabah. Special thanks to Agnes Agama, Gary Martin, and

the Lasimbangs. A warm thank you to my external supervisor in Sabah, Paul Porodong, who went above and beyond on every occasion to make this research a success. I am so grateful to the custodians, for generously inviting me into your lives. Fieldwork in Malaysian Borneo was supported by a Biosocial Society Postgraduate Bursary and Keble Association Gordon Smith Award. Additional support was provided by the Sir Richard Stapley Educational Trust and the Sidney Perry Foundation. I would like to thank Simon Abele for his assistance obtaining the Shinto shrine forest point data and prefectural boundaries. I am incredibly grateful for the financial support of the University of Oxford's Fell Fund and the James Martin Biodiversity Institute.

Finally, my family and friends were so understanding and patient throughout my degree. Their unfailing belief in my capabilities supported me in times of doubt, and for that I am forever grateful. This thesis is dedicated to my mother, Alice Craddock Massey, and to my father, the Honourable Joseph Price Massey, for never clipping my wings, even when it may have been prudent for them to do so. With love, I fly.

Preface

Four manuscripts form the foundation of the thesis. Works cited are included in the chapter with each manuscript as well as in a complete bibliography at the end of the thesis. Supplementary information follows the chapter when applicable. Statements of contribution to these papers by coauthors follow the bibliography at the end of the thesis.

PAPER 1: Massey, A., Fisher, J.B. and S.A. Bhagwat (2015) Do dragons prevent deforestation? The Gambia's sacred forests.
Manuscript for submission to *Nature*.

PAPER 2: Massey, A., Reynolds, T., Hamann, S., Wassie, A., Lowman, M., Nogué, S., Willis, K.J. and S.A. Bhagwat (2015) Ethiopian church forests and pollination services across an agricultural landscape.
Manuscript submitted to *Conservation Biology*, redrafted for submission to *Geoforum*.

PAPER 3: Massey, A., Porodong, P. and S.A. Bhagwat (2015) Incorporating social-ecological systems into protected area networks: Indigenous and Community Conserved Areas (ICCAs) in Sabah, Malaysian Borneo.
Manuscript submitted to *Ecology and Society*, redrafted for submission to *Human Ecology*.

PAPER 4: Massey, A. and S.A. Bhagwat (2015) Shinto shrine forests and happiness in Japan.
Manuscript for submission to *Frontiers in Ecology and the Environment.*

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Acronyms

ARC	Alliance of Religions and Conservation
CBC	Community-based Conservation
COP	Conference of the Parties
CPF	Culturally protected forest
ICCAs	Indigenous and Community Conserved Areas and Territories
IUCN	International Union for the Conservation of Nature
JGSS	Japanese General Social Survey
NGO	Non-Governmental Organisation
RHTs	Resource and Habitat Taboos
SANASI	World Database on Sacred Natural Sites
SI	Supplementary Information
SSF	Shinto shrine forest
TEK	Traditional Ecological Knowledge
UNDRIP	United Nations Declaration on the Rights of Indigenous Peoples
UNESCO	United Nations Educational, Scientific and Cultural Organization
WCPA	World Commission on Protected Areas
WDPA	World Database on Protected Areas
WPC	World Parks Congress

Chapter 1 INTRODUCTION AND LITERATURE REVIEW

This chapter begins by introducing conservation and forms of conservation engagement with local communities and indigenous peoples. It describes the roots of conservation, specifically the separation of humans from nature, the development of the protected area model, and its expansion over time. Next, the introduction explores conservation engagement with people, community-based conservation, the identification of new protected area categories and governance types, and finally the recent identification of Indigenous and Community Conserved Areas (ICCAs).

The literature review explores the human-nature relationships of local communities and indigenous peoples. It begins by introducing the discipline of ethnobiology. Next it describes taboos, religious edicts based on sacred knowledge that affect local patterns of resource use, including the regulation of the harvest of natural resources. It focuses on spatial forms of taboos, including two types of sacred forests, sacred groves and sacred natural sites. The literature review considers the challenges of conservationists engaging with the custodians of sacred forests. The gaps in the literature are identified, namely, comparative conservation value in the landscape, ecosystem services on a landscape scale, and sacred forests in bioculturally diverse landscapes.

The conceptual framework positions sacred forests at the confluence of the human, natural, and spiritual worlds, and recognizes that conservationists and custodians have unities of interest and values which overlap, but also have diversities which diverge. Having identified the gaps in the literature and the conceptual framework of the thesis, chapter one ends by identifying the aims, objectives, and research questions of the thesis.

1.1 Introduction

The Transcendentalists of early America are oft credited as the forefathers of the conservation movement. The Oxford Dictionary (2014) defines conservation as the "preservation, protection, or restoration of the natural environment, natural ecosystems, vegetation and wildlife." In the late 1820s and 1830s, Henry David Thoreau, Ralph Waldo Emerson, and other proponents of the religious philosophy of Transcendentalism espoused that the divine was imbued in nature and in the human spirit. In the dominant Puritanical worldview of that era, humans were separate from the nature God created, serving as either stewards of creation, as in Genesis 1:27-28:

> "So God created man in his *own* image, in the image of God created he him; male and female created he them. And God blessed them, and God said unto them, 'Be fruitful, and multiply, and replenish the earth, and subdue it: and have dominion over the fish of the sea, and over the fowl of the air, and over every living thing that moveth upon the earth'" (King James Bible)

or conversely, as fallen sinners destroying God's perfect creation (Callicott and Nelson, 1998, Coogan et al., 2007). The Transcendentalists depicted the divine-human-nature connection in a more positive light; as Ralph Waldo Emerson wrote in his essay *Nature* (1850:8):

> "In the woods, we return to reason and faith. There I feel that nothing can befall me in life, — no disgrace, no calamity, (leaving me my eyes,) which nature cannot repair. Standing on the bare ground, — my head bathed by the blithe air, and uplifted into infinite space, — all mean egotism vanishes… In the wilderness, I find something more dear and connate than in streets or villages. In the tranquil landscape, and especially in the distant line of the horizon, man beholds somewhat as beautiful as his own nature".

Emerson describes the landscape's beauty as compared to human nature. As such, humans are viewed as separate from the tranquility and beauty of the natural world.

In the mid 19th century, the British Raj in India established forest conservancies and developed forestry practices for natural resource use (Vedant, 1986), however the creation of Yellowstone National Park in the United States in 1872 heralded an era of preservationism. The first director of the National Park Service, Stephen Mather, sought out "scenery of supreme and distinctive quality or some natural feature so extraordinary or unique as to be of national interest" to create national parks (Ise, 1961:195). In the same era in Europe, conserved lands maintained a distinctive human element in the form of villages, farms, hedgerows, and copses (Brockington et al., 2008). In 1869, John Stuart Mill argued for the preservation of species for their own sake (i.e. their intrinsic value), echoing an emerging discourse of animal welfare (Thomas, 1983). Worster (1977:*xi*) describes the philosophical tension of the era: "[O]ne might very well cast the history of ecology as a struggle between rival views of the relationship between humans and nature: one view devoted to the discovery of intrinsic value and its preservation, the other to the creation of an instrumentalized world and its exploitation" (Table 1-1).

Table 1-1 “Changing Goals, Means, and Actors in the U.S. Conservation Strategy, 1870-1969” (Adapted from Mulder and Coppolillo 2005)

Time Period	Goals	Means	People Involved
Pre-1870 (Claiming access to resources)	Utilitarian, preservationist	Utilization, protectionism	Wealthy elites, local custodians (including indigenous peoples)
1870s-Present (National Parks)	Preservationist	Protectionism	Elites and professional managers
1890s-1910s (U.S. Forest Service) (Scientific management: production of a single resource)	Utilitarian	Utilization	Professional land managers
1910s-1920s (Game management: single resources and game species)	Utilitarian	Utilization	Professional land managers
1930s-1940s (Multiple use: single resources and game and nongame species)	Utilitarian, preservationist	Utilization	Landowners, land managers
1950s-1960s (All species: genetic variability)	Preservationist	Protectionism	International non-governmental organizations, communities

Economic growth promoted a culture of resource use and in 1891, conservationist and U.S. President Theodore Roosevelt, and his chief forester, Gifford Pinchot, oft-touted the ‘father of conservation’, created forest preserves to enable the sustainable use of natural resources (Mulder and Coppolillo, 2005). Jeffrey Salmon (Rubin, 2000:52) notes: “Roosevelt’s conservationism was always informed by particularity, by awareness of locality and specificity, and thus that an ‘abstract value judgment on nature was close to meaningless for T.R., since he knew of nature only as it presented itself in peculiar circumstance’”. Conversely, John Muir, the father of preservationism, called for the preservation of wilderness, citing its intrinsic value.

1.1.1 Protected areas

In 1908 a wildlife refuge system was established in the United States and President Theodore Roosevelt promoted the idea of national parks on a European tour (Strum et al., 1994, Mulder and Coppolillo, 2005). Further afield in the colonies, resourcism[1] drove the conservation of British Indian forests via conservancies and the creation of parks and game reserves across Africa (Strum et al., 1994). The protected area model of conservation was applied globally and the total area protected increased exponentially (Figure 1-1).

[1] In American environmental philosophy, the utilitarianism of economist John Stuart Mills was applied to conceptualize useable nature as 'natural resources' and subsequently, 'resourcism' emerged as a counter to 'preservationism' CALLICOTT, J. B. & NELSON, M. P. 1998. *The Great New Wilderness Debate*, University of Georgia Press.

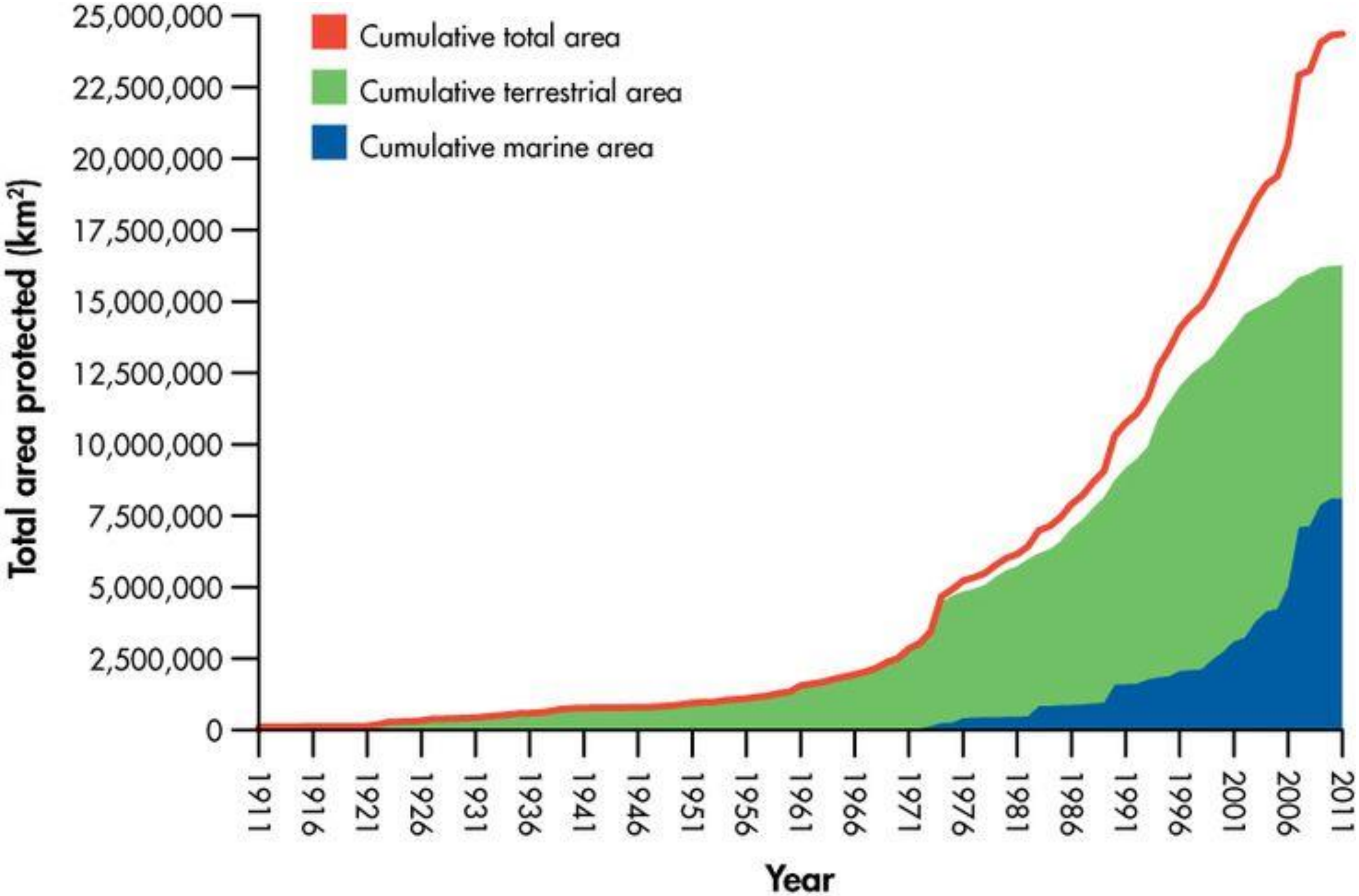

Figure 1-1 Global growth in nationally designated protected areas (1911-2011) (Biodiversity Indicators Partnership, 2014)

In the growing realm of protected area management, preservationism and resourcism were given updated monikers, fortress conservation and sustainable use, respectively. In 2014, protected areas covered 15.4% of the Earth's terrestrial surface (UNEP-WCMC, 2012) (Figure1-2).

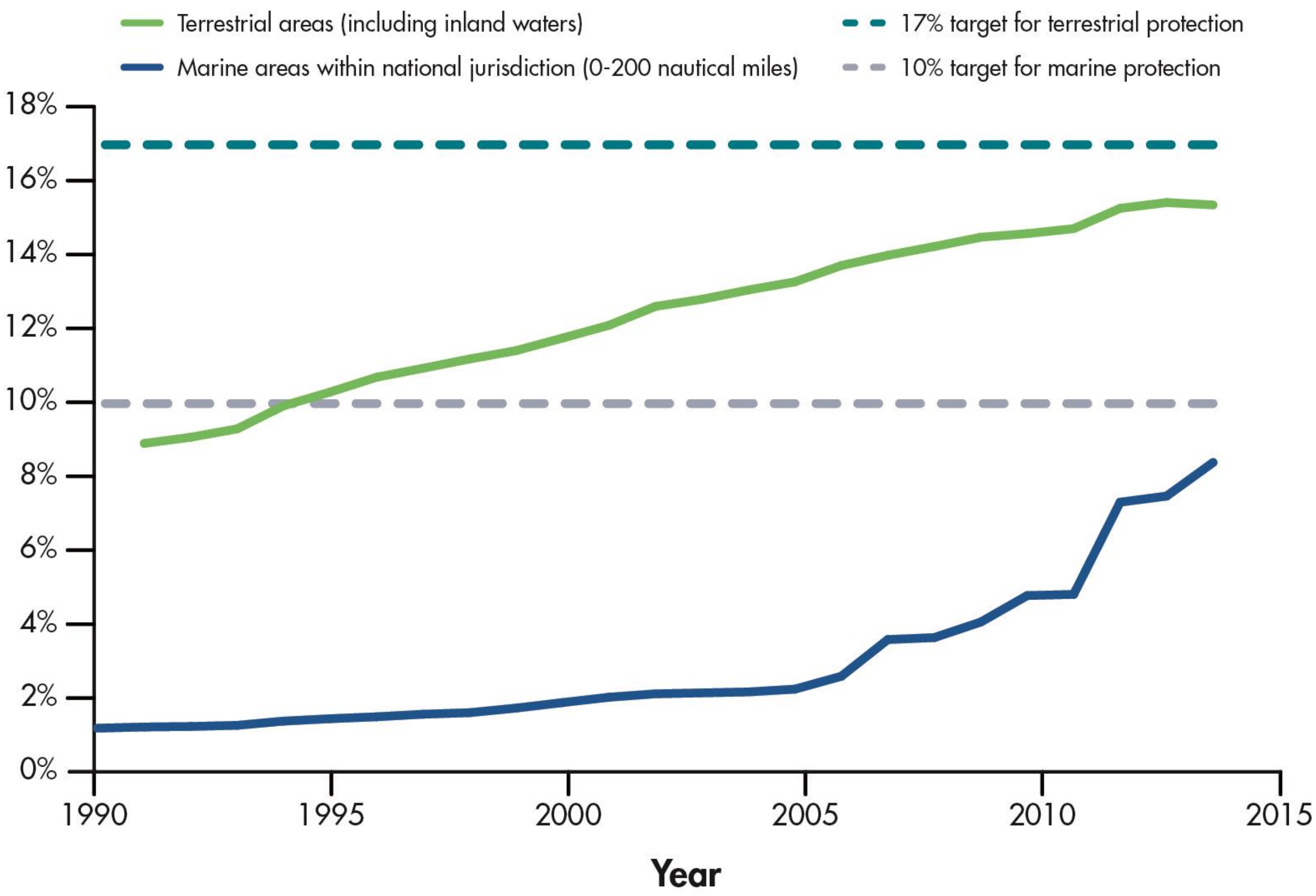

Figure 1-2 Growth in nationally and internationally designated protected areas (1990 – 2014) (Biodiversity Indicators Partnership, 2014)

By 2020, the Convention on Biological Diversity aims to protect 17% of the Earth's terrestrial surface; the global biodiversity conservation targets were developed in Aichi, Japan, with 194 countries as parties and 168 as signatories (Secretariat of the Convention on Biological Diversity, 2011).

1.1.2 Negative impacts of protected area expansion

The expansion of protected areas has occurred, in most cases, at the expense of local communities and/or indigenous peoples. Dowie (2011:*xxi*) notes that "about half the land selected for protection by the global conservation establishment over the past century was either occupied or regularly used by indigenous peoples. In the Americas that number is over 80 percent". Custodians have been forcibly removed from their ancestral lands and restricted from utilizing the associated natural resources. In this way, conservation has acted as a colonizing force around the world. This separation of indigenous peoples and local communities from their lands in the name of global conservation is not relegated to conservation history. Dowie (2011:*xxi*) continues, "In Guyana, for example, of the ten new areas gazetted for protection, native people currently occupy eight".

In the Western preservationist paradigm, humans are not viewed as a functional part of the natural system. However, there are few truly 'wild' places on earth where humans have not left their mark in some way (Adams and McShane, 1992). More than simply 'leaving their mark', humans have also played a critical functional role as ecosystem engineers. When the Maasai people of East Africa were removed from the Serengeti, the wildlife populations plummeted. The former combination of cattle and wildlife practiced grazing succession on the Serengeti, creating a diversity of vegetation that supported a thriving ecosystem. Once the Maasai (and their cattle) were forcibly removed from the national park, the ecosystem shifted to a wildlife-only system, with decreased biodiversity as a result (Adams and McShane, 1992).

1.1.3 Community-based conservation

The protected area ‘fortress’ conservation model, which views people as a threat to conservation, underscored the protected area movement. However, in the 1980s the growing recognition that local communities and indigenous peoples bordering protected areas played an instrumental role in their success led to targeting their participation in conservation schemes. This philosophical shift was promoted as ‘New Conservation’ (Hulme and Murphree, 1999). ‘Community’ is a simplistic term used to denote self-regulating groups of natural resource users; the value of this term has been debated (Agrawal and Gibson, 1999, Barrow and Murphree, 2001, Creed, 2006). Community-based conservation (CBC) devolves natural resource management from national governments to local communities (Horwich and Lyon, 2007). The third World National Parks Congress in 1982 acknowledged the potential of conservation to address poverty in communities with the theme ‘Conservation for Sustainable Development’ (Strum et al., 1994).

Successful CBC is achieved in autonomy-supportive environments, characterized by the “provision of personal choice, substantive recognition of stakeholder identity (beliefs, values, preferences, concerns), and non-coercive social interaction” (DeCaro, 2008:1446). A systematic review of 146 CBC studies across 40 countries presents four definitions of CBC success: 1) attitudinal (positive changes in views of conservation goals), 2) behavioural (decreased off-take), 3) ecological (improved outcomes for the habitat or species of interest) and 4) economic (variety of livelihood benefits) (Brooks et al., 2012) (Table 1-2).

Table 1-2 Factors increasing the likelihood of successful community-based conservation: results of a systematic review of 146 studies across 40 countries (Brooks et al., 2012)

Type of success	Definition of success	Factors that increase likelihood of success
Attitudinal	Positive changes in views of conservation goals	• Project creates or develops social capital • Communities participate in project initiation, establishment and daily management • Equity of benefits across community members
Behavioural	Decreased off-take	• Project designs develop individual and institutional capacity • Smaller communities • Local engagement in cultural traditions and governance
Ecological	Improved outcomes for the habitat or species of interest	• Local engagement in cultural traditions and governance • Project designs develop individual and institutional capacity • Communities participate in project initiation, establishment and daily management
Economic	Variety of livelihood benefits	• Project designs develop individual and institutional capacity • Communities with tenure rights

These four different types of success for community-based conservation were affected by different factors. Especially notable for this thesis, local engagement in cultural traditions and governance increased the likelihood of behavioural success (defined as decreased off-take) and ecological success (defined as improved outcomes for the habitat or species of interest).

While CBC was deemed successful in some cases (Brooks et al., 2012, DeCaro, 2008), it was heavily critiqued in the literature for "conflict between CBC's fundamental objectives to promote both natural resource conservation and local development, competing local and conservation interests, unreliable and/or unsustainable (economically or socially unwise) incentive systems, and failures to implement genuine local participation" (DeCaro, 2008:1444). Furthermore, Berkes (2007) critiques the use of community-based conservation as a blueprint and panacea for successful conservation, nothing that multilevel management is required for managing biodiversity as a commons. Just as top-down government-imposed protected areas may stymie conservation, so might the sole use of grassroots community-based conservation. Successful conservation of the commons must engage with multiple levels of governance.

Despite the backlash against community-based conservation, the focus on grassroots forms of conservation identified local forms of conservation via customary laws and cultural practices, specifically the sacred groves of India. As recognition of the conservation contributions of these sites increased, another form of potential conservation engagement with communities emerged– Indigenous and Community Conserved Areas (ICCAs).

1.1.4 New protected area categories and governance types

The exponential growth of protected areas and ambitions for further growth results in not only the identification of new types of protected areas, but also new forms of protected area governance. The preservationist definition of protected areas as wildernesses expanded to include a range of IUCN protected area categories: Strict Nature Reserve (Ia), Wilderness Area (Ib), National Park (II), National Monument (III), Habitat/Species Management (IV), Protected Landscape/Seascape (V) and Managed Resource Protected Area (VI) (Kothari et al., 2013). Governance of protected areas also shifted to include forms of government governance, shared governance, private governance, and in 2008, governance by indigenous peoples and local communities (Kothari et al., 2013, Dudley et al., 2010). The premier global protected area database, the World Database on Protected Areas, is managed by the United Nations Environmental Programme World Conservation Monitoring Centre (UNEP-WCMC), and includes protected areas of different protected area categories and governance types (Table 1-3).

Table 1-3 IUCN protected area categories and governance types matrix (adapted from Kothari et al., 2013). Of the 219,771 protected areas in the World Database on Protected Areas (WDPA), n=number of protected areas for each protected area category and governance type (IUCN and UNEP-WCMC, 2016). If n=0, examples are given, but these are not officially delineated in the WDPA.

Governance Types / Protected area categories	A. Governance by government			B. Shared governance			C. Private governance			D. Governance by indigenous peoples and local communities		Not Reported
	Federal or national ministry or agency in charge of management (n=135,177)	Sub-national ministry or agency in charge of management (n=37,476)	Government-delegated management (e.g. to an NGO) (n=300)	Transboundary management (includes other protected area categories in addition to the one indicated) (n=1)	Collaborative management (various forms of pluralist influence) (n=4,766)	Joint management (pluralist governance bodies) (n=2,774)	Declared and run by individual land-owners (n=5,439)	By non-profit organisations (e.g. NGOs, universities, co-operatives) (n=7,378)	By for-profit organisations (e.g. individual or corporate land-owners) (n=34)	Indigenous territories and conserved areas—declared and run by indigenous peoples (n=1,026)	Community conserved areas—declared and run by local communities (n=586)	(n=24,904)
Ia. Strict Nature Reserve (n=11,060)	Honeycombe Hill Caves (New Zealand) (n=9,853)	Danum Valley (Malaysia) (n=718)	Tsaratanana (Madagascar) (n=13)	Tatry Mountains UNESCO transboundary biosphere reserve (Poland & Slovakia) (Dudley, 2011) (n=0)	Actun Tunichil Mucknal (Belize) (n=137)	Fagamalo Village (American Samoa) (n=67)	Swanston Private Nature Reserve (Australia) (n=13)	New Island South (Great Britain) (n=9)	Shamwari Game Reserve (South Africa) (Shamwari Game Reserve, 2015) (n=0)	Kytalyk Resource Reserve (Russian Federation) (Beltrán, 2000) (n=0)	Bikar Atoll (Marshall Islands) (n=1)	(n=249)
Ib. Wilderness Area (n=3,125)	Kelani Valley (Sri Lanka) (n=2,588)	Mount Tom (Canada) (n=268)	Governor's Island (Bermuda) (n=12)	Rhodope Mountains (Bulgaria & Greece) (Lysenko et al., 2007) (n=0)	Sundarban East (Bangladesh) (n=221)	Lapa Rios Conservation Easement (Costa Rica) (n=4)	Mili Atoll (Marshall Island) (n=3)	Conway Sandhills Natural Area (Canada) (n=2)	Backcountry Wilderness Area of Highlands Ranch (USA) (Highlands Ranch Community Association, 2016) (n=0)	Wehexlaxo dıale (Canada) (n=1)	Majuro (Marshall Islands) (n=1)	(n=25)

(cont.) Governance Types / Protected area categories	A. Governance by government			B. Shared governance			C. Private governance			D. Governance by indigenous peoples and local communities		Not Reported
	Federal or national ministry or agency in charge of management (n=135,177)	Sub-national ministry or agency in charge of management (n=37,476)	Government-delegated management (e.g. to an NGO) (n=300)	Transboundary management (includes other protected area categories in addition to the one indicated) (n=1)	Collaborative management (various forms of pluralist influence) (n=4,766)	Joint management (pluralist governance bodies) (n=2,774)	Declared and run by individual land-owners (n=5,439)	By non-profit organisations (e.g. NGOs, universities, co-operatives) (n=7,378)	By for-profit organisations (e.g. individual or corporate land-owners) (n=34)	Indigenous territories and conserved areas—declared and run by indigenous peoples (n=1,026)	Community conserved areas—declared and run by local communities (n=586)	(n=24,904)
II. National Park (n=5,576)	Kidepo Valley (Uganda) (n=2,644)	Parc national de Frontenac (Canada) (n=2,195)	Sabah Al-Ahmad (Kuwait) (n=65)	Maya Tropical Forest Complex (Belize, Guatemala & Mexico) (Lysenko et al., 2007) (n=0)	Parc marin du Saguenay-Saint-Laurent (Canada) (n=73)	Abernethy (United Kingdom) (n=90)	Wongalara (Australia) (n=9)	Salt Rocks Land (Cayman Islands) (n=34)	Upper Navua Conservation Area (Fiji) (n=1)	Bouma Lavena (Fiji) (n=2)	Paruku (Australia) (n=8)	(n=455)
III. National Monument (n=26,736)	Kauri Mountain (New Zealand) (n=9,711)	Penwood State Park (USA) (n=7,985)	Barro Colorado (Panama) (n=16)	Daurian Steppes (China, Mongolia & Russian Federation) (Lysenko et al., 2007) (n=0)	Grandfather Mountain (USA) (n=105)	Grayson Highlands (USA) (n=1,613)	Thorp Mill Historical Society (USA) (n=126)	Hammershus (Denmark) (n=46)	Tabaconas Namballe (Peru) (Highlands Ranch Community Association, 2016, Servicio Nacional de Áreas Naturales Protegidas por el Estado, 2016) (n=0)	Sinub (Papua New Guinea) (n=1)	Birriliburu (Australia) (n=5)	(n=7,128)

(cont.) Governance Types / Protected area categories	A. Governance by government			B. Shared governance			C. Private governance			D. Governance by indigenous peoples and local communities		Not Reported
	Federal or national ministry or agency in charge of management (n=135,177)	Sub-national ministry or agency in charge of management (n=37,476)	Government-delegated management (e.g. to an NGO) (n=300)	Transboundary management (includes other protected area categories in addition to the one indicated) (n=1)	Collaborative management (various forms of pluralist influence) (n=4,766)	Joint management (pluralist governance bodies) (n=2,774)	Declared and run by individual land-owners (n=5,439)	By non-profit organisations (e.g. NGOs, universities, co-operatives) (n=7,378)	By for-profit organisations (e.g. individual or corporate land-owners) (n=34)	Indigenous territories & conserved areas—declared and run by indigenous peoples (n=1,026)	Community conserved areas—declared and run by local communities (n=586)	(n=24,904)
IV. Habitat/ Species Management (n=55,627)	Table Mountain Shore (Australia) (n=40,516)	Lakhari Valley (India) (n=8,560)	Xuan Nha (Viet Nam) (n=43)	Wadden Sea International Protected Region (Denmark, Germany & Netherlands) (Lysenko et al., 2007) (n=0)	Makogai Island (Fiji) (n=1,116)	Umm Gadair (Kuwait) (n=208)	Phophonyane Nature Reserve (Swaziland) (n=727)	Suffolk Coast (United Kingdom) (n=256)	Tide Private Reserve (Belize) (n=1)	Cayos Miskitos and Franja Costera Marine Biological Reserve (Nicaragua) (Beltrán, 2000)(n=0)	Bermudian Landing Community Baboon Sanctuary (Belize) (n=14)	(n=4,186)
V. Protected Landscape/ Seascape (n=46,818)	Hakusan Mountain Range (Japan) (n=17,405)	Lyons Corporate Park (USA) (n=13,440)	Dunseverick (United Kingdom) (n=16)	Pyrenees-Mount Perdu World Heritage Site (France & Spain) (Lysenko et al., 2007)(n=0)	Iles Musha et Maskhali (Djibouti) (n=2,277)	Las Palmas (Guatemala) (n=727)	IYSIS (Swaziland) (n=2,311)	North Point Joint Venture (USA) (n=6,888)	San Jose El Yalu (Guatemala) (n=29)	Dhimurru Indigenous Protected Area (Australia) (n=2)	Risdon Cove Indigenous Protected Area (Australia) (n=21)	(n=3,702)
VI. Managed Resource Protected Area (n=7,195)	Dans Hill (Australia) (n=3,047)	Carita (Indonesia) (n=2,161)	Khureemandal Mountain (Mongolia) (n=36)	Friendship Nature Reserve (Finland & Russian Federation) (Lysenko et al., 2007)(n=0)	Danao Fish Sanctuary (Philippines) (n=85)	Bequia Marine Conservation Area (Saint Vincent & Grenadines) (n=12)	**El Jordan** (Mexico) (n=1,123)	Eames Tidelands (USA) (n=16)	Vaturu Dam (Fiji) (n=2)	Djelk Indigenous Protected Area (Australia) (n=8)	Gasan Community (Philippines) (n=134)	(n=571)
Not Reported (n=62,396)	(n=49,339)	(n=2,143)	(n=88)	(n=1)	(n=291)	(n=53)	**(n=1,037)**	(n=127)	(n=1)	(n=1,012)	(n=402)	(n=7,902)
Not Applicable (n=1,238)	(n=552)	(n=6)	(n=11)	(n=0)	(n=461)	(n=0)	(n=0)	(n=0)	(n=0)	(n=0)	(n=0)	(n=686)

The World Database on Protected Areas only includes officially designated protected areas. In the designation of governance by indigenous peoples and local communities, there are 1,026 protected areas governed by indigenous peoples and 586 protected areas governed by local communities. The reported protected area category with the most protected areas governed by indigenous peoples or local communities (n=134) is Category VI Managed Resource Protected Areas governed by local communities. This is the largest number of protected areas in any reported category type governed by indigenous people or local communities, but most protected areas of this governance type have an unreported protected area category type (1,012 for indigenous peoples and 402 for local communities).

In comparison, there are 135,177 protected areas managed by federal or national ministries or agencies, with the majority as Category IV Habitat/Species Management protected areas (40,516 areas). This matrix shows that while protected area categories and governance types have expanded to encompass a wider variety of governance types and categories, most officially reported and internationally recognized protected areas are governed by a federal or national ministry or agency (62%) or a sub-national ministry or agency (17%). In comparison, indigenous peoples govern only 0.5% of reported protected areas, and local communities govern 0.25% of them. The remaining governance types (shared governance, private governance, and unreported) comprise the remaining 20.25% of the 219,771 protected areas in the database.

1.1.5 Indigenous and Community Conserved Areas (ICCAs)

Indigenous and Community Conserved Areas (ICCAs) are “natural and/or modified ecosystems containing significant biodiversity values, ecological services and cultural values, voluntarily conserved by indigenous peoples and local communities, both sedentary and mobile, through customary laws or other effective means” (IUCN, 2003:182). Borrini-Feyerabend, Kothari and Oviedo (2004:51) note that “the voluntary management decisions and efforts of such communities lead towards the conservation of habitats, species, ecological services and associated cultural values, although the protection status may have been set up to meet a variety of objectives, not necessarily related to the conservation of biodiversity”. The ICCA Consortium notes three defining characteristics of ICCAs:

> “1) A strong relationship exists between indigenous or local communities (sedentary or mobile) and their physical environment (such as a given ecosystem, habitat, resource or species) as a result of cultural, social, economic and other reasons.
>
> 2) The concerned indigenous peoples or local community plays a key role in making decisions about the management of the ecosystem, area or species. The community possesses (in law or in practice) the power to make and enforce key management decisions regarding the territory and resources.
>
> 3) The voluntary management decisions and efforts of the concerned community lead to, or at least are well in the process of leading to, the conservation of biodiversity, habitats, species, ecological functions and associated cultural values, regardless of the original management objectives as perceived by the community” (ICCA Consortium, 2013).

ICCAs can result from “cultural, social, economic, and other reasons,” including historical. International policy language suggests a propensity to promote, recognize, and support indigenous and community conserved areas and territories. In 2014, The Convention on Biological Diversity COP 12 called for the parties to:

> 1) “support collective action and non-market-based approaches for mobilising resources for achieving the CBD’s objectives, including *promoting* community-based natural resource management and indigenous and community conserved territories and areas” (XII/3),
>
> 2) “*support* indigenous and community conserved areas and territories, customary sustainable use and community governance of biodiversity” (XII/5),
>
> 3) “strengthen the enabling environment by, inter alia, taking into account the need to appropriately *recognise* indigenous and community conserved areas and traditional knowledge and conservation practices” (XII/5 Annex),
>
> 4) “include in requests to donors *support* for indigenous and local communities to develop community plans and protocols to document, map and register their

> community conservation areas and to prepare, implement and monitor their community conservation plans, and support for countries to *strengthen recognition* of indigenous and local community conserved areas" (XII/12),
>
> 5) "promote holistic and integrated planning for ecosystem conservation and restoration in indigenous and local community conserved areas and to *provide support and incentives* to indigenous people and local communities in their efforts to conserve biodiversity in indigenous and local community conserved areas" (XII/19) (emphasis added) (ICCA Consortium, 2013).

A wide variety of sites qualify as ICCAs with their own distinctive local contexts. Sacred forests encompass locally developed forms of forest management referred to in the literature as sacred groves, sacred natural sites, fengshui forests and church forests. The thesis employs this term to encapsulate the broad category of forests managed by custodians based on their spiritual or religious values. The extent of ICCAs has been estimated from equal that of protected areas (nearly 13% of Earth's terrestrial surface) to 20% of the Earth's surface (ICCA Consortium, 2013, Chape et al., 2008). Online global databases are collating descriptive and spatial data of ICCAs, including the ICCA Registry maintained alongside the World Database on Protected Areas (ICCA Consortium, 2013) and Mapping the Sacred which was developed from the World Database on Sacred Natural Sites (SANASI) (2013). National registries are also underway in Iran, Madagascar, and the Philippines and there are regional registries in Madhya Pradesh and Orissa, India (ICCA Consortium, 2013) and Sabah, Malaysian Borneo (Majid Cooke and Vaz, 2011). As efforts to identify and conserve forests expand beyond protected areas, the opportunity arises to engage with people in areas "voluntarily conserved by indigenous peoples and local communities… through customary laws or other effective means" (IUCN, 2003).

1.1.6 Landscape scale conservation and ecosystem services

Developments in conservation science have identified the limits of a conservation approach solely dependent on protected areas or 'islands of conservation' to conserve global biodiversity. Principles of island biogeography, such as species-area relationships, have been applied to terrestrial systems to inform reserve design and conservation planning (Whittaker and Fernández-Palacios, 2007). Brockington et al. (2008:17) describe the challenges of a protected area island approach: “Insistence on strong parks has been accompanied by pervasive dismissal of the ecological value of nature outside parks, which can lead to its neglect for conservation purposes” (Figure 1-3).

Figure 1-3 Stark contrast in land use across the boundary of Hwange National Park, Zimbabwe. The national park is the green forested area to the right of the boundary.

A common conservation approach to avoid the stark contrast in land use at the boundary of protected areas is to incorporate ‘buffer zones’ around protected areas (Haycock et al., 1996). Landscape ecology proposes that unprotected areas are functionally critical to meet the conservation goals of protected areas, providing connectivity and resilience to disturbance (Lindenmayer and Fischer, 2013). Mackey et al. (2007:207) concur, “Biodiversity conservation assessment and planning (including protected-area design) must move beyond traditional conservation design principles by aiming for the maintenance and restoration of large-scale (in space and time) ecological and evolutionary processes over the entire landscape”. In addition to conserving biodiversity on a landscape scale, UNESCO Biosphere Reserves aim to promote economic and social development while maintaining associate cultural values (UNESCO, 1996).

Another way that areas of conservation interest beyond protected areas are identified is the consideration of ecosystem services. The Millennium Ecosystem Assessment (2005:v) defines ecosystem services as the "benefits people obtain from ecosystems" and cultural ecosystem services as including cultural diversity, spiritual and religious values, recreation and ecotourism, aesthetic values, and knowledge systems. This anthropocentric conceptualization of ecosystems is in direct contrast to the wildlife preservation and 'fences and fines' approach of conservation. But in its unidirectionality, the Millennium Ecosystem Assessment's definition of ecosystem services is an oversimplification of the human-environment relationship, as humans not only receive benefits from ecosystems, they shape the natural world based on their needs and values. Wallace's (2007:237) review of ecosystem services classification suggests that like pollination or water regulation, spiritual and religious values are ecosystem processes rather than ecosystem services, in that they are "not ends that the manager will seek in their own right. Rather, they are all means (processes) to achieve ends (services)". Spiritual and religious values can act as powerful drivers for conservation.

1.1.7 Spiritual ecology

Sponsel's (2012:*xiii*) 'spiritual ecology' encompasses the nature/religion interface of both world religions and local religions/spiritualties as "the diverse, complex, and dynamic arena of intellectual and practical activities at the interface between religions and spiritualties on the one hand, and, on the other, ecologies, environments, and environmentalisms".

Major world religions have emerged as potential partners in conservation, for two major reasons. First, religions own and/or influence the management of vast swathes of land worldwide. Second, many people look to religions for moral authority, including on environmental issues. In his encyclical, Pope Francis (2015:1) said that Mother Earth

> "now cries out to us because of the harm we have inflicted on her by our irresponsible use and abuse of the goods with which God has endowed her. We have come to see ourselves as her lords and masters, entitled to plunder her at will… We have forgotten that we ourselves are dust of the earth (cf. *Gen* 2:7); our very bodies are made up of her elements, we breathe her air and we receive life and refreshment from her waters".

Pope Francis describes a different human-nature relationship than the stewardship role that formed the philosophical roots of early conservation. He describes humans as one with the nature, composed of the "dust of the earth", made up of and reliant upon the earth's elements. This is in stark contrast to the separation of humans from nature, where we are "her lords and masters". Pope Francis refers to Mother Earth as "our Sister", indicating a call for kinship with the earth rather than stewardship over it.

Founded in 1995, the Alliance of Religions and Conservation (ARC) helps "major faith bodies develop environmental programs and projects in association with secular bodies as diverse as WWF, the British Broadcasting Corporation (BBC) and the World Bank. As part of the Alliance each faith has compiled its own statement summarizing its relationship with, and beliefs about, the environment" (Palmer and Finlay, 2003:3). ARC currently works with eleven major faiths. By working with the leaders of these major faiths to identify and summarize their core teachings surrounding the human-nature relationship, ARC aims to contextualize the call for nature conservation in a faith-specific and relevant way for believers, and to encourage faith leaders to more actively engage with these tenets of their respective faiths.

The Interfaith Partnership for the Environment of the United Nations Environment Programme (UNEP), originally founded in 1986 to engage North American congregations in environmental issues, has grown into a global network of faiths and organizations linking religion and ecology (United Nations Environment Programme, 2015). Other notable groups include the Forum on Religion and Ecology at Yale and the International Society for the Study of Religion, Nature, and Culture. The field of religion and ecology has been growing over the past forty years, and has recently produced reference resources, including an encyclopedia, *The Encyclopedia of Religion and Nature*, and a textbook, *Grounding Religion: A Field Guide to the Study of Religion and Ecology* (Sponsel, 2012, Bauman et al., 2010).

Targeting conservation specifically, the Society for Conservation Biology created the Religion and Conservation Biology Working Group in 2007 (Awoyemi, 2013). Dudley's (2005) book, 'Beyond Belief: Linking faiths and protected areas to support biodiversity conservation', applied efforts to link religion to protected areas through the lens of sacred natural sites. The conservation of sacred natural sites was recently supported with an approved resolution at the 2016 World Conservation Congress in Hawai'i, 'Recognizing cultural and spiritual significance of nature in protected and conserved areas' (Motion 34) (International Union for Conservation of Nature, 2016). Sponsel (2012:xviii) notes that the spiritual aspect of spiritual ecology

> "may involve mysticism, rituals, ceremonies, and sacred places and landscapes. The locus of the spirituality may reside in the individual human being and/or in supernatural beings and/or forces in nature, depending on one's belief system. The spiritual domain is the least studied, documented, and understood aspect of spiritual

> ecology so far, although ultimately it is often the most important one serving as a catalyst for environmental activism".

The spiritual domain falls outside of contemporary conservation's purview, however Sponsel (2012) acknowledges that some well-known conservationists, such as Henry David Thoreau, are spiritual ecologists to a degree, in their awe at the natural world. This 'awe' Sponsel describes is the essence of the Transcendentalist roots of the conservation movement discussed at the beginning of this chapter. The conceptual framework of the thesis considers the intersectionality of the spiritual, natural, and human domains, where sacred forests conceptually reside.

1.2 Conceptual framework

The introduction described how conservation is rooted in the opposition between humans and nature, and in unprotected vs. protected areas. Conservationists prioritize large protected areas over small forest patches, supported by the application of principles of island biogeography to terrestrial landscapes and research on edge effects and fragmentation. In contrast, custodians' perceptions of landscape often describe humans as a part of nature. Small forest patches across the landscape, e.g. sacred groves or church forests, are surrounded by other land uses such as agriculture.

An emic understanding of human-environment relationships requires an appreciation of the interconnectedness of the social and the mundane (Ellen, 1996). Ecological knowledge does not exist devoid of its social context, rather it may "comfortably coexist with beliefs about the world which have not been empirically tested in a conventionally scientific sense. Everything is seen as connected through chains of mutual causation to give rise to a complex notion of nature" (Ellen, 1996:460). Alí García Segura, a Talamanca Bribri community member and professor of linguistics at the University of Costa Rica, notes that 'nature' is not even a word in his indigenous Bribri dialect – it is not seen as separate it from culture. At the 2016 World Conservation Congress conservation campus, ‘Sharing experiences about the role of indigenous and local knowledge in restoring interrelations between people and nature,’ participants were asked to brainstorm in small groups, “How does nature contribute to your well-being?” Indigenous participants across the small groups were perplexed and frustrated. Maori indigenous leader Tina Ngata from New Zealand articulated her frustration, saying, “That’s like asking how my head contributes to my wellbeing” (Segura and Ngata, 2016). An emic understanding of human-environment relationships does not seek to ‘fit’ indigenous perspectives into a pre-existing conservation paradigm.

Custodians view the landscape with multi-dimensional complexity rather than the dichotomous view of the protected as ‘sacred’ and the unprotected as ‘profane’. Barbara Bender (1993:1) writes of the landscape:

> “In contemporary western societies they involve only the surface of the land; in other parts of the world, or in pre-modern Europe, what lies above the surface, or below, may be as or more important… The landscape is never inert, people engage with it, rework it, appropriate and contest it. It is part of the way in which identities are created and disputed.”

Custodians’ perspectives can include cosmological geographies of meaning in the landscape that conservationists cannot ‘see’ (Johnson and Hunn, 2013) (Figure 1-4).

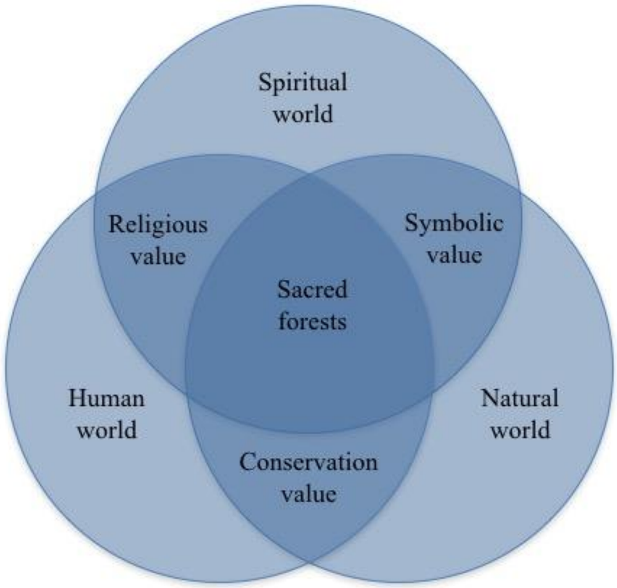

Figure 1-4 Geographies of meaning in landscape and associated values; Adapted from Verschuuren (2007)

Conservationists target the intersection of the human world and natural world, but neglect the intersections of the spiritual and natural worlds, and spiritual and human worlds, respectively. The inability to address these regions proves a significant limitation for collaboration between conservationists and indigenous peoples. Burgeoning research on the conservation contributions of small forest patches increases conservation interest in sacred forests previously deemed too small for conservation consideration. Formerly ‘invisible’ local forms of nature protection can be made visible to the conservation science community, which is particularly interested in identifying and developing new forms of conservation within the matrix of land use beyond protected areas.

While conservation resources are limited and competing with alternative land use pressures, locally developed and supported forms of management require marginal additional resources. Expanding conservation ideologies enable conservation scientists to assess landscapes and identify areas of conservation interest beyond formally protected areas, such as smaller forest patches managed by local custodians. The literature review looks beyond the conservation model to investigate alternative perspectives of the human-environment relationship.

1.3 Literature Review

1.3.1 Ethnobiology

Nature is conserved in a myriad of ways in the matrix of land uses beyond protected areas, and has been in some cases for millennia (Hughes and Chandran, 1998). To investigate the relationship between people and plants, the academic field of ethnobotany emerged in 1895, followed by ethnobiology in 1935. The incorporation of emic indigenous perspectives of plants, including linguistics, was popularized by the Yale anthropologist Howard Conklin (Conklin, 1954). In the 1970s and 1980s, ethnobiology considered local ecologies as well, including the concepts of Traditional Ecological/Environmental Knowledge (TEK), Indigenous Knowledge (IK), Traditional Knowledge and Wisdom (TKW) and Local Ecological/Environmental Knowledge (LEK) (Hunn, 2007). Traditional ecological knowledge has been defined as “a cumulative body of knowledge, practice, and belief, evolving by adaptive processes and handed down through generations by cultural transmission, about the relationship of living beings (including humans) with one another and with their environment” (Berkes et al., 2000:5).

Berkes and Turner (2006) attribute the development of conservation to two different conceptual mechanisms– the ecological understanding model and the depletion crisis model. The ecological understanding model roots conservation in the slow accumulation of knowledge describing the human-environment relationship, including observations of changes in ecosystems and natural cycles, lessons from the past and other enviornments, observations of predator-prey interactions and migration cycles, monitoring resource use and ecosystem engineering by humans (Turner and Berkes, 2006). The depeletion crisis model posits that conservation behaviour is developed following a realization of resource scarcity. In this model, conservation is often the result of a resource crisis (Berkes and Turner, 2006).

1.3.2 Taboos

Local cosmologies describe complex human-environment relationships that transcend the tangible natural realm to include the spiritual. Multi-dimensional cosmologies “in certain respects anticipated the systems view of the world which underlies modern ecology” (Ellen, 1996:460). Religious edicts based on sacred knowledge can affect local patterns of resource use, for example, taboos that temporally regulate the harvesting of natural resources across ecotopes. Ecotopes are “the smallest ecologically-distinct landscape features” in landscape classification systems (Hunn and Meilleur, 2010, Thornton, 2011:277).

In Madagascar, ‘*fady’* taboos are prohibitions from the ancestors, including species-specific taboos for animals that are not to be eaten, e.g. species of rare lemurs (Tengo, 2007). *Fady* vary by clan, and a species protected in one small geographic region can be hunted extensively nearby. In the Maluku Islands of Indonesia, a traditional method of natural resource management, ‘*sasi*,’ is used to limit marine resource use both temporally and spatially. The village chief, or 'kewang', identifies the prohibited area by circumambulating it while chanting and playing percussive instruments. The area is marked with vegetative constructions and instruments to prohibit entry to all persons except the *kewang* and his ten assistants during the set period. The *kewang* will repeat the process and remove the prohibitory markers to open the territory for use. ‘*Sasi*’ limits pressures on reefs and inshore waters and ensures the protection of breeding grounds (Zerner, 1994).

Challenges of viewing taboos through a conservation lens

Following an era of community-based conservation messaging that community buy-in is critical for conservation success, the intentions or motivations of local people remain a prominent consideration of conservationists. Smith and Wishnie (2000:493) argue, "to qualify as conservation, any action or practice must not only prevent or mitigate resource overharvesting or environmental damage, it must also be designed to do so". They propose five predictive conditions for conservation:

1. Controlled or exclusive access (stable land rights);
2. Distinct or confined resource populations (to which controlled access can apply);
3. Resource populations that are resilient or rapidly renewing (hence likely to respond to management controls);
4. Low discount rates, such that the value of sustained yield exceeds the value of immediate yield; and
5. Social parameters (e.g. small group size and stable membership) and institutions (monitoring and sanctioning) that counter free-riding.

(Smith and Wishnie, 2000:505)

This narrow definition of conservation can prevent the integration of taboos with contemporary conservation frameworks (Tengo, 2007, Berkes et al., 2002).

Another challenge is conservation biologists' focus on taboos that appear as conservation analogs, e.g. sacred forests/protected areas, disconnected from the greater social context. Ecologists Johan Colding and Carl Folke created a typology of taboos and their associated resource management functions (Table 1-4).

Table 1-4 Taboos and their functions for natural resource use regulation (Colding and Folke, 2001)

Category	Function
Segment taboos	Regulate resource withdrawal
Temporal taboos	Regulate access to resources in time
Method taboos	Regulate methods of resource withdrawal
Life history taboos	Regulate withdrawal of vulnerable life history stages of species
Species-specific taboos	Total protection of species in time and space
Habitat taboos	Restrict access and use of resources in time and space

These categorical constructions of taboos translate as conservation analogs, but in the process they are removed from their *in situ* social contexts; 'information' is extracted from 'knowledge' (Ellen, 1996:458). A postmodernist critique is that the very act of translating indigenous concepts to conservation analogs stems from modernist hegemony (Hunn et al., 2003). Ellen (1996:458) proposes a 'progressive contextualist' approach which "locks local knowledge within increasingly more general but denser culturally-relative paradigms, and which links indigenous ecological know-how to general subsistence and social behavior" (Ellen, 1996, Vayda, 1983).

Furthermore, the focus on taboos has been critiqued. Dove et al. (Dove, 2011:9) note, "Excessive attention to sacred forests leads to neglect of the dynamics of the wider natural landscape, of which it forms just a small part". This bias has led to inaccurate descriptions of sacred forests as relict stands of vegetation or 'remnant forests' (Fairhead and Leach, 1998, Bhagwat et al., 2013). Fairhead and Leach (1998) question the narrative of village forest patches as the last stands of local forest, finding instead that supposed 'remnant' forest patches in a Guinean village are the product of afforestation due to the proximity of the village.

When referencing the people conserving sacred forests, the thesis uses the term 'custodians'. Custodians of sacred forests are "individuals or groups of people who have responsibility of looking after and often managing them. They generally reside in or close to the sacred sites" (Wild and McLeod, 2008:7). Other terms, such as 'local communities' and 'indigenous peoples', are used when they are explicitly cited as such in the literature, for example, in reference to 'Indigenous and Community Conserved Areas'.

Finally, it is important to note the danger in portraying people as 'ecologically noble savages' due to observed links between cultural practices and conservation outcomes (Redford, 1991, Hames, 2007). Some cultural practices conserve natural resources, while others overexploit them. Just as there are a multitude of sacred groves and sacred natural sites, there are also examples of exploitation and destruction of nature by local resources users. For example, the Hawaiian bird, the Mamo, was driven to extinction in no small part by the Hawaiians' use of its yellow feathers; 80,000 Mamos were killed to make a single cloak for King Kamehameha (Fuller, 2013).

1.3.3 Sacred forests

Sacred forests encompass locally developed forms of forest protection also referred to in the literature as sacred groves, sacred natural sites, fengshui forests and church forests. The thesis employs this term to encapsulate the broad category of local forms of forest management rooted spiritual and religious values, cosmologies and worldviews; the specific form (e.g. sacred grove, church forest, Shinto shrine forest) is used in context (Figure 1-5).

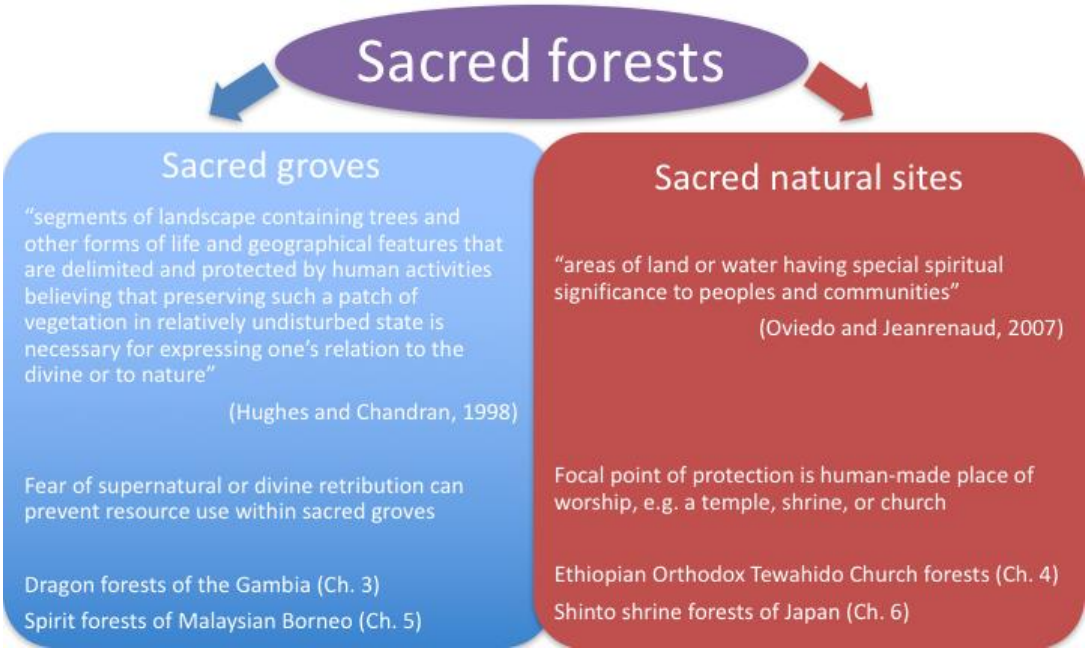

Figure 1-5 The thesis employs the term 'sacred forests', which encompasses sacred groves and forested sacred natural sites

Sacred forests can be quite large and conserve biodiversity over time; for example, the 2000 years-old Japanese Shinto shrine forest at the Grand Shrine of Ise is 5,400 hectares in size and includes stands of primeval forest (Public Affairs Headquarters for Shikinen-Sengu, 2010) (Figure 1-6).

Figure 1-6 Grand Shrine of Ise in Japan. Photo credit: Norbert Woehnl (Most Beautiful Places, 2015)

A key challenge for sacred forests in terms of biodiversity conservation is that they can also be quite small. For example, many Indian sacred groves are smaller than a hectare (Bhagwat et al., 2005b)-. As species richness increases with area (MacArthur and Wilson, 1967), small sacred groves admittedly make limited contributions to biodiversity conservation (Hill and Curran, 2001). However, even small sacred forests can serve as refugia for species and add ecological memory (Bengtsson et al., 2003) in the landscape, enabling forest regeneration (Mgumia and Oba, 2003a, Ntiamoa-Baidu, 2008, Bhagwat et al., 2005b). In Ghana, sacred groves provide habitat for small mammal and plant communities (Decher, 1997). Sacred groves in the Western Ghats of India conserve tree species and macrofungi that have local non-timber uses including medicinal properties – in some cases species that no longer occur in the rest of the landscape, even within formally protected areas (Bhagwat et al., 2005a, Brown et al., 2006, Chandran and Mesta, 2001, Mgumia and Oba, 2003a). Similarly, sacred groves in central Tanzania contribute to miombo woodland biodiversity, exhibit greater woody species richness and taxonomic diversity than Forest Reserve plots and serve as refugia for some species (Mgumia and Oba 2003).

Most research on sacred forests in terms of ecosystem services considers the conservation of medicinal plants or native crop varieties (Boraiah et al., 2003, Malhotra et al., 2001). Sacred forests also provide ecosystem services such as pollination, seed dispersal and watershed protection that are critical for productive agroecosystems (Bodin et al., 2006, Tambat, 2005, Chandran and Hughes, 1997). Bodin et al. (2006) find that the location of sacred forests in Madagascar is more important than their size for providing the ecosystem services of seed dispersal and pollination in a predominantly agricultural landscape. Heland and Folke (von Heland and Folke, 2014) define ecosystem service provision in southern Madagascar as one functional component of a social-ecological system including sacred forests, cattle economy, crop pollination, subsistence farming, and societal transition and purification rituals.

Due to their spatial arrangement in the matrix of land uses beyond protected areas, sacred forests can increase landscape connectivity (Bodin et al., 2006, Ishii et al., 2010). Limiting the focus of conservation interventions to protected areas overlooks the potential contributions of sacred forests in the matrix of land uses beyond protected areas (Bhagwat et al., 2005b, Brockington et al., 2008, Cronon, 1995, Rosenzweig, 2003). Furthermore, Margules and Pressey (2000) add that protected area networks are commonly relics of a historic preservationism rather than products of systematic conservation planning. As such, the conservation of land beyond protected areas may play a critical role in achieving the conservation of biodiversity (Mackey, 2007).

Sacred groves

Sacred groves are “segments of landscape containing trees and other forms of life and geographical features that are delimited and protected by human activities believing that preserving such a patch of vegetation in relatively undisturbed state is necessary for expressing one’s relation to the divine or to nature” (Hughes and Chandran, 1998:69). Sacred groves provide for the worship of deities and/or the reverence of ancestors (Ramakrishnan et al., 1998, Tengo, 2007), or serve as burial grounds (Mgumia and Oba, 2003a, Wadley, 2004) (Figure 1-7).

Figure 1-7 Sacred grove in Kodagu, India; Photo credit: Shonil Bhagwat

An estimated 100,000 to 150,000 sacred groves are found in 19 of the 28 states in India alone (Verschuuren et al., 2010, Malhotra et al., 2007). Sacred forests range in size from less than a hectare to covering hundreds of hectares (Ntiamoa-Baidu, 2008, Malhotra et al., 2007). Despite lacking formal government protections, locally developed and enforced social norms, regulations, or taboos conserve sacred groves from competing land uses. For example, a fear of supernatural or divine retribution, e.g. sickness or death, can prevent resource users from harvesting resources within a sacred grove or from encroaching upon its boundaries (Gadgil and Vartak, 1976, Chandrakanth and Romm, 1991, Barre et al., 2009). In addition to India, sacred groves have been found to preserve forest patches across Africa (Sheridan and Nyamweru, 2008, Campbell, 2004, Doffana, 2014) and Asia (Wadley, 2004, Mansberger, 1991).

Sacred natural sites

Sacred natural sites are "areas of land or water having special spiritual significance to peoples and communities" (Oviedo and Jeanrenaud, 2007:79). Mountain peaks where deities or ancestors are believed to reside are a common example of sacred natural sites (Verschuuren et al., 2010, Pungetti and Oviedo, 2012) (Figure 1-8).

Figure 1-8 Mount Kinabalu is the highest peak in Sabah, Malaysian Borneo (4,095 m above sea level) and is regarded as the resting place of ancestors' spirits for Kadazandusun communities across Sabah (Hamzah et al., 2013)

Perhaps the most notable distinction between forest patches classified as sacred groves versus sacred natural sites is that the focal point of protection in forest patches that are sacred sites is a human-made place of worship, e.g. a temple, shrine, or church. Functionally, a sacred site's forest patch may be conserved in a similar manner as a sacred grove, but the trees are conserved due to their proximity to the place of worship instead of serving as the focal point of preservation themselves.

Roughly 80,000 Shinto shrines are spread across Japan (Jinja Honcho, 2011) and in northern Ethiopia there are as many as 35,000 Ethiopian Orthodox Tewahido church forests (Wassie et al., 2005). Forest patches surrounding the Shinto shrines and Ethiopian Orthodox Tewahido church forests are preserved due to their creating ambiance for the human-made places of worship, and the trees host *kami* spirits in the case of Shinto shrines (Domenig, 1997) or are protected by the church's angels in the Ethiopian church forests (Wassie et al., 2005). Frascaroli (2013) notes that sacred natural sites research targets the tropics, however Europe is rife with sacred natural sites, *inter alia* Catholic convents, hermitages, monasteries, and shrines including the 539 sites in Central Italy mapped in his study. In addition, Native Americans have sacred sites across North America, from the Pueblo Indians' Jemez Mountains of New Mexico to areas preserved by the Navajo for the harvesting of medicinal plants (Gibson, 1987, Eibender and Wood, 1991).

To provide guidelines for the management of sacred natural sites within protected areas, in 2009 the IUCN published 'Sacred Natural Sites: Guidelines for Protected Area Managers' (Wild and McLeod, 2008). The Australian Aboriginal sacred site of Uluṟu, also known as 'Ayers Rock' is a prominent example of a sacred natural site found within a National Park and World Heritage Site (Figure 1-9).

Figure 1-9 Uluṟu, also known as 'Ayers Rock' is co-managed by the Aṉangu Aboriginal people and Parks Australia (Oviedo and Jeanrenaud, 2007). Photo credit: (Unknown World)

Uluṟu is co-managed by the Aṉangu Aboriginal people and Parks Australia (Oviedo and Jeanrenaud, 2007). Another Australian co-management agreement exists between Kakadu National Park and the Gagadju aboriginal community. Their agreement not only recognizes the rights of the Gagadju to use natural resources and move throughout the park, it also attempts to incorporate traditional aboriginal methods of natural resource management, such as the concept of 'caring for country', and the protection of sacred sites from outsiders (Igoe, 2004).

1.4 Gaps in the literature

1.4.1 Comparative conservation value in the landscape

Most research to date on the conservation value of sacred forests assesses their biological diversity by measuring the plant species richness within their boundaries. Mgumia and Oba (2003:263) note, "Proper understanding of their contribution to conservation has, however, been hampered by lack of comparative data. Researchers who reported higher plant species richness in sacred groves worldwide did not report values for adjacent managed forest ecosystems". Notable exceptions are in the Western Ghats of India, where Boraiah et al. (2003) compare medicinal plant species richness between sacred groves and state-managed reserve forests and Bhagwat et al. (2005a) compare the diversity of trees, birds and macrofungi across 58 sites including forest reserves, sacred groves, and coffee plantations. The literature's lack of comparative data for the landscapes surrounding sacred forests precludes the assessment of their conservation value for landscape scale conservation planning and engagement. The thesis meets *Objective 1) To perform quantitative and spatial analyses of sacred forests on a landscape scale,* addressing this gap via *Research question 1) How well do sacred forests conserve forests over time in comparison with 'formally' protected areas?*

1.4.2 Ecosystem services on a landscape scale

Patterns of distribution of sacred forests across the diverse landscapes in which they are located are unknown. Verschuuren (2010:68) notes, "More information is needed on the levels of biodiversity of sacred natural sites and their capacity for ecological connectivity at a landscape scale". The literature mentions ecosystem services provided by sacred forests due to the nature of their plant species diversity, for example, serving as seed banks for 'ecological memory' in the landscape (Bengtsson et al., 2003). However, the application of an ecosystem service approach for assessment of the conservation value of culturally protected forests on a landscape scale is rarely the aim of the study (Bodin et al., 2006). The thesis applies ecosystem services approaches on a landscape scale in two divergent landscapes, asking *Research question 2) How do the location and distribution of sacred forests affect ecosystem service delivery in diverse landscapes?* The development of databases of geolocated sacred forests will enable future landscape scale analyses and comparisons across diverse landscapes on multiple scales; this thesis presents potential applications and limitations of this approach.

1.4.3 Sacred forests in bioculturally diverse landscapes

In bioculturally diverse landscapes, engagement with local custodians can be resource-intensive and prohibitive for conservation practitioners. Dudley et al. (2010:26) note,

> "although we recognize the need for further studies, evidence for the conservation value of sacred natural sites is already clear enough to justify their incorporation within conservation strategies. It is therefore recommended that national conservation priorities urgently include the safeguarding of sacred natural sites for both their social and biological importance".

The thesis addresses this gap in the literature via *Research question 3) How can conservationists engage with custodians of sacred forests in bioculturally diverse landscapes?*

Dudley et al. (2010:26) call for additional research "to expand the geographical range of studies; to increase the types of habitats and ecosystems covered; to generate specific management advice for custodians regarding management and regeneration of sacred natural sites". This thesis considers sacred forests across diverse landscapes in Africa and Asia. In terms of 'specific management advice', the results of the thesis' constituent four papers are discussed in the conclusion, with the aim to achieve *Objective 2) To identify opportunities and challenges for conservationists to engage with custodians of sacred forests in diverse landscapes.*

1.5 Aim

The thesis aims to determine unities between conservationists and custodians of sacred forests.

1.6 Objectives

1) To perform quantitative and spatial analyses of sacred forests on a landscape scale
2) To identify opportunities and challenges for conservationists to engage with custodians of sacred forests in diverse landscapes

1.7 Research Questions

1) How well do sacred forests conserve forests over time in comparison with 'formally' protected areas?
2) How do the location and distribution of sacred forests affect the provision of ecosystem services in diverse landscapes?
3) How can conservationists engage with custodians of sacred forests in bioculturally diverse landscapes?

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Chapter 2 METHODOLOGY

This chapter begins by describing the methodological approach of the thesis and describes the criteria for selection of the four study areas that each comprise one of the four papers of the thesis. Next the four study areas are described in terms of national context, scale, size, number of sacred forests, land tenure, management institutions and supporting organizations. Researcher access to each of the study areas for fieldwork and/or datasets was detailed. Reasons for the selection of each study area follow the applicable research question it addresses, along with the paper title and a brief summary of the paper. Next the chapter discusses the thesis' scope and terms of ethical engagement.

A concise version of the methods used in each paper is presented along with a discussion of their limitations. Two of the papers, papers one and three, included interviews, surveys, and participant observation to contextualize and inform the landscape scale assessments. Limitations of these methods include potential sources of bias on the part of the researcher and the participants, including omission or commission bias, observation bias, and case study selection bias. Paper two combined remote sensing analysis and on-the-ground datasets with a range of reference materials and methods to draw inferences about the pollination services of church forests.

Acknowledging the limitations of remote assessments but constrained by time and resources with the scope of the thesis, paper three is co-authored with local and international researchers who contributed biodiversity data and photographs of bees within the church forests, and who described the local context. Paper four performed a land cover analysis and identified the prevalence and distribution of Shinto shrine forests in urban versus rural areas in Japan. It explored the relationship of Shinto shrine forest distribution with a national happiness index across the 47 prefectures of Japan. While the observed correlation is supported by literature on the benefits of Shintoism for social cohesion and a breadth of Japanese empirical research on the stress-relieving benefits of *shinrin-yoku*, or ‘forest bathing’, instead of definitive answers, the paper demonstrates how culturally ecosystem services can be conceived in an urbanised national context and suggests a new research agenda on the cultural ecosystem services provided by sacred forests.

Landscape scale assessments based on remote sensing and limited on-the-ground data are by nature, limited, and must be ground truthed for confirmation and contextualization of findings. Landscape scale assessments relying on limited datasets can identify new research agendas and highlight additional forms of forest conservation value beyond forest cover, such as ecosystem services, galvanizing engagement with custodians. Full methods sections are found in each paper of the thesis.

2.1 Methodological approach

The overall methodological approach of the thesis was to identify diverse landscapes around the world containing sacred forests and assess their prevalence, persistence, and distribution. The implications of their distribution were then considered in terms of the context of the study area. The findings of the four study areas were compared including their land tenure regimes, management institutions, and supporting organisations to address the aim of the thesis, which was to identify unities between conservationists and custodians of sacred forests.

2.2 Study areas

Four areas were identified, one for each paper, to demonstrate the diversity of landscapes where sacred forests occur around the world. Landscapes dominated by land uses associated with forest clearance (i.e. agriculture or urbanization) were prioritized, as the ecological role of forest patches in these landscapes is of growing interest to conservationists. The four study areas were selected to meet the following criteria:

1) Sacred forests conserved by taboos and/or religious and spiritual values (2 sacred natural sites, 2 sacred groves)

2) Landscapes dominated by land uses associated with forest clearance (i.e. agriculture or urbanization)

3) Individual sacred forests are autonomous (they have individual management control, not linked to other sites in terms of ownership or management)

4 Diversity of national contexts (e.g. development, urbanization, biodiversity)

5) State land tenure

6) Diversity of management institutions and supporting organisations

7) Researcher access

The thesis investigated sacred forests in four diverse landscapes: sacred natural sites in Ethiopia and Japan, and sacred groves in the Gambia and Malaysia (Figure 2-1).

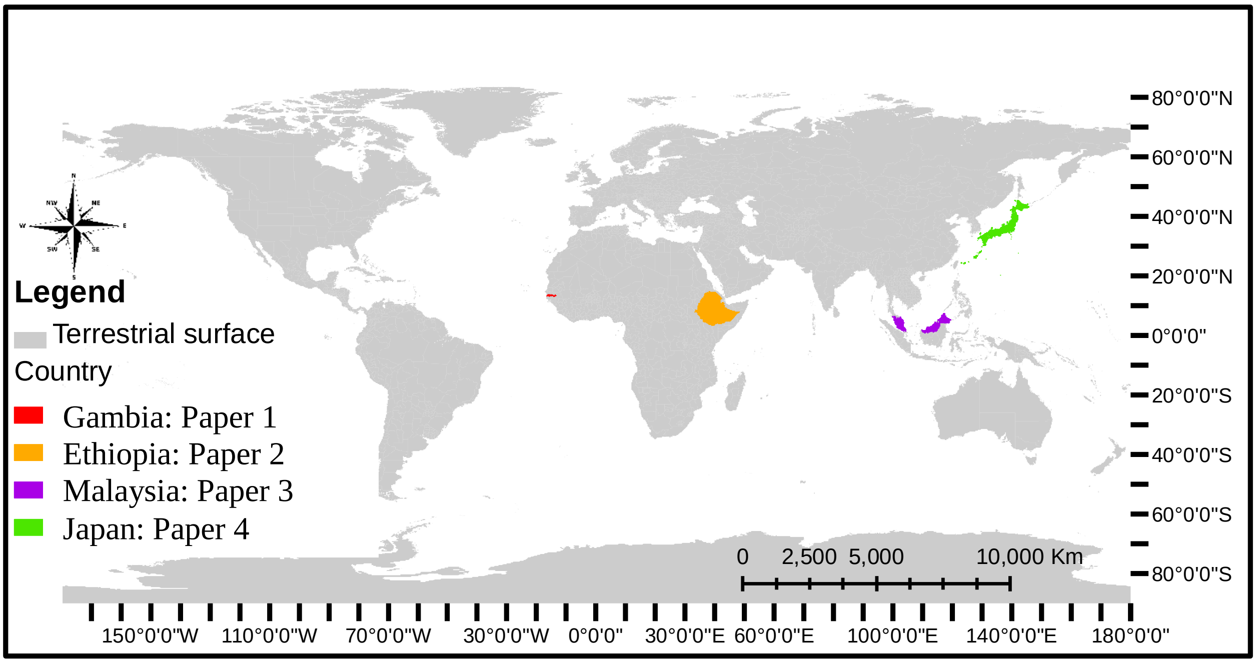

Figure 2-1 World map with four study countries identified

Study area contexts varied by type of sacred forest, scale of the landscape, level of human development, source of livelihoods, food security, biocultural diversity index, ecoregion, extent of protected areas, population density and distribution, forest cover, rates of deforestation and urbanization (Table 2-1).

	Gambia	Ethiopia	Malaysia	Japan
Sacred forests	Dragon (*ninkananko*) forests	Ethiopian Orthodox Tewahido Church forests	'Spirit forests', village forest reserves	Shinto shrine forests
Size of country	1,130,000 ha	110,430,000 ha	33,080,000 ha	37,800,000 ha
Ecoregions	Canary Current	East Africa Acacia Savannas; Ethiopian Highlands; Horn of Africa Acacia Savannas; Rift Valley Lakes; Sudanian Savannas; Sudd-Sahelian Flooded Grasslands and Savannas	Borneo Lowland and Montane Forests; Greater Sundas Mangroves; Kayah-Karen/Tenasserim Moist Forests; Kinabalu Montane Scrub; Peninsular Malaysian Lowland and Mountain Forests; Sulu-Sulawesi Seas; Sundaland Rivers and Swamps	Lake Biwa; Nansei Shoto; Nansei Shoto Archipelago Forests; Okhotsk Sea
Forest cover	480,000 ha forest, 800 ha primary forest, 477,800 ha naturally regenerated forest, 1,400 ha planted forest	12,296,000 ha forest, 0 ha primary forest, 11,785,000 naturally regenerated forest, 511,000 planted forest	20,456,000 forest, 3,820,000 ha primary forest, 14,829,000 ha naturally regenerated forest, 1,807,000 ha planted forest	24,979 ha forest, 4,747,000 ha primary forest, 9,906,000 naturally regenerated forest, 10,326,000 planted forest
Deforestation rate (2005-2010)	+2,000 ha/yr, +0.38%	-141,000 ha forest/yr, -1.11%	-87,000 ha forest/yr, -0.42%	+9,000 ha forest/yr, +0.04%
Terrestrial and marine protected areas (percent total territorial area) (2013)	4.40%	18.40%	13.90%	11%
Biological diversity index	0.589	0.708	0.736	0.664
Total number of bird and mammal species	9	903	801	438
Total number of plant species	974	6,603	15,500	5,565
Biocultural diversity index	0.458, ranked 119 of 208 in world	0.613, ranked 20 of 208 in world	0.640, ranked 14 of 208 in world	0.545, ranked 45 of 208 in world

Table 2-1 National contexts of study areas including ecological and social factors (The World Bank, 2015, FAO 2015, FAO Statistics Division, 2015a, World Wide Fund for Nature, 2015, United Nations Development Programme, 2014, FAO, 2010, Loh and Harmon, 2005)

	Gambia	Ethiopia	Malaysia	Japan
Sacred forests	Dragon (*ninkananko*) forests	Ethiopian Orthodox Tewahido Church forests	'Spirit forests', village forest reserves	Shinto shrine forests
Total number of ethnic groups	32	145	174	34
Total number of languages	23	88	146	18
Total number of religions	11	118	123	208
Population density and distribution (2013)	183 people/100 ha; 58% of population is urban	94 people/100 ha; 19% of population is urban	90 people/100 ha; 73% of population is urban	349 people/100 ha; 92% of population is urban
Human development index	Low (172 of 187)	Low (173 of 187)	High (62 of 187)	Very high (17 of 187)
Gross national income per capita (Atlas method)	$500	$470	$10,430	$46,330
Agricultural economy (top 5 crops, average production 2010-2013)	59% of Gambian land is agriculture (665,000 ha); Millet (113,785 tonnes), groundnuts (108,741.25 tonnes), paddy rice (68,737.25 tonnes), maize (38,194.75 tonnes), palm oil fruit (35,000 tonnes)	32% of Ethiopian land is agriculture (34,985,000 ha); maize (5,971,976 tonnes), roots and tubers (5,048,562.74 tonnes), sorghum (3,963,428.75), cereals (3,854,535.5 tonnes), wheat (3,311,458.75)	Palm oil fruit (91,943,513.75 tonnes), oil palm (18,476,691.75 tonnes), palm kernels (4,640,951.25 tonnes), paddy rice (2,566,770.25 tonnes), natural rubber (921,167.5 tonnes)	Grasses for forage and silage (25,712,250 tonnes), pumpkins for fodder (10,125,000 tonnes), paddy rice (10,629,000 tonnes), maize for forage and silage (4,742,250 tonnes), sugar beets (3,457,500 tonnes)
Food security indicators (2015)	Average dietary supply adequacy (%): 132%; Prevalence of undernourishment (%) – 3 years' average: 5.3%	Average dietary supply adequacy (%): 99%; Prevalence of undernourishment (%) – 3 years' average: 32%	Average dietary supply adequacy (%): 129%	Average dietary supply adequacy (%): 112%

The scale of inquiry also varied across the papers, from the sub-district level (section of Kiang West, the Gambia) to the district level (South Gondar, Amhara, Ethiopia) to spanning multiple districts across a region (Sabah, Malaysian Borneo) and finally to a national scale (Japan) (Table 2-2).

Table 2-2 Summary of study areas

	Kiang West, Lower River Region, the Gambia	**South Gondar, Amhara, Ethiopia**	**Sabah, Malaysian Borneo**	**Japan**
Paper(s)	Paper 1	Paper 2	Paper 3	Paper 4
Chapter(s)	Chapter 3	Chapter 4	Chapter 5	Chapter 6
Scale	Sub-district	District	Regional	National
Size of study area (hectares)	104,957 ha	1,461,537 ha	7,363,100 ha	37,800,000 ha
Number of sacred forests	15 dragon forests	1,173 Ethiopian Orthodox Tewahido church forests	43; Case studies: 3; Surveyed: 16 village forest reserves, 9 ‘spirit forests’, 8 tagal/bombon (rivers), 5 water catchment areas, 2 village adat/regulations	57,742 Shinto shrine forests
Type of sacred forests	Sacred groves	Sacred natural sites: church forests	Sacred groves, Community forests, Natural resource management via taboos	Sacred natural sites: shrine forests
Land tenure	State land; common property managed by village committee	State land; State sanctions church control	State land, Applied for Native Forest Reserve status	State land designation for Shinto shrines
Management institutions	None; Parents inform their children	Church forest priests	JKKK (village committee)	Shrine priests
Supporting organizations	none	Ethiopian Orthodox Tewahido Church	PACOS Trust, Sabah Fisheries Department, UNEP Programme on Climate Change	National association of Shinto Shrines (Jinja Honcho)

All study areas had land tenure regimes managed by the state, but they had different levels of control for local management on the ground. Management institutions and supporting organizations were also variable between the study areas.

The smallest scale study area, Kiang West in the Gambia, was chosen because its sacred forests were interspersed with formally managed areas (a national park and forest reserves) and the sacred forests had no recognition, land tenure, management institutions, or supporting organizations. They were rarely spoken about, even within the local community, so their persistence over time compared to formally protected areas was of particular interest for this research.

In terms of access, the author had prior experience as a United States Peace Corps volunteer living in a rural village in Kiang West and working with the national park. Local knowledge of the rarely mentioned *ninkananka*, or dragon, was shared with the author as mutual trust developed with the custodians. This provided rare access to sacred forests 'quietly' conserved, which were present in the same landscape as protected areas. Deforestation rates in the region were quite high (FAO, 2010, 2012) and Landsat satellite imagery was available for the region over a 25-year period, which enabled a longitudinal study.

Research question 1) How well do sacred forests conserve forests over time compared with 'formally' protected areas?

Study area: Kiang West, the Gambia

Title: Do dragons prevent deforestation? The Gambia's sacred forests

Brief summary: To investigate the dynamic nature of sacred forests, the forest cover of sacred forests was assessed in Kiang West, the Gambia, over time, and in comparison with protected areas in the same landscape (i.e. forest reserves and a national park).

The study area of South Gondar, Amhara, Ethiopia, was selected due to the stark contrast between the sacred forests and the agricultural lands surrounding them. The lack of forest in the region, save for the church forests, indicated that the church forests might provide ecosystem services that the surrounding agricultural areas could not. Another reason this study area was selected was due to the availability of literature on the biodiversity of church forests, which also indicated that church forests are prevalent throughout the landscape. The empirical research on the biodiversity in church forests, observational data of photographs of bees in the church forests, combined with reference sources, enabled an inferential analysis of pollination services. This research was supported by access to researchers with experience in the study area, namely Dr. Alemayehu Wassie, Dr. Meg Lowman and Dr. Travis Reynolds.

Research question 2) How do the location and distribution of sacred forests affect ecosystem service delivery in diverse landscapes?

Study area: South Gondar, Amhara, Ethiopia

Title: Ethiopian church forests and pollination services across an agricultural landscape

Brief summary: In South Gondar, Amhara, Ethiopia, church forests are islands of forest in a landscape dominated by subsistence agriculture. This paper determines the spatial distribution of the church forests and estimates pollination zones based on the intertegular span of honeybees and flowering calendars for bee-friendly plant species in church forests.

The study area of Japan was selected to parallel the aims of the Ethiopian paper regarding sacred natural sites and ecosystem services, but at a larger scale, in a highly urbanized and developed country context. Like the Ethiopian study area, which was selected due to the stark contrast between agricultural land and church forests, the Japan study area has heavily forested countryside and densely populated urban areas. This stark contrast between the Japanese countryside and urban areas made the question of where Shinto shrine forests occur in the landscape and the implications of their distribution for ecosystem services compelling. Shintoism is practiced by nearly 85% of the Japanese population and Shinto shrine forests are universally accessible (Central Intelligence Agency (US), 2014). A comprehensive online database of geolocated Shinto shrine forests enabled spatial analysis on a national scale. Like the Ethiopian church forests' biodiversity research, there is a rich Japanese literature on the benefits of *shinrin-yoku*, or 'forest bathing', and the social cohesion that Shintoism provides, which underscored the spatial analysis of ecosystem services.

Study area: Japan

Title: Shinto shrine forests and happiness

Brief summary: This paper applies the assessment of ecosystem services of sacred forests to the highly urbanized and developed nation of Japan. First reviewing the literature on the social trust and stress relieving benefits of Shinto practice and *shinrin-yoku*, Japanese 'forest bathing', it considers the implications of the distribution of Shinto shrine forests across the 47 prefectures of Japan in terms of the provision of ecosystem services. A correlation is found between the density of Shinto shrine forests per capita and a national happiness index.

The fourth study area was selected due to its biocultural diversity in the face of land use change. Borneo is undergoing widespread conversion of forests to oil palm plantations; oil palm expansion accounted for 86% of deforestation in Malaysian Borneo from 1995-2000 (WWF Germany, 2005)and the state of Sabah had near-complete clearance by 2010 of forest beyond Permanent Forest Reserves and State Parks (Reynolds et al., 2011). While biodiversity attracts conservation intervention, cultural diversity can pose a challenge to conservationists with limited resources. Indigenous people comprise 60% of Sabah's population, with over 30 ethnic groups speaking 50 languages and 80 dialects (Tongkul, 2002). During the pilot study, it was also discovered that a governmental process of identifying and integrating Indigenous and Community Conserved Areas (ICCAs) was in the early stages. The logistical support of the Universiti Malaysia Sabah and NGOs – the PACOS Trust and the Global Diversity Foundation – facilitated research access across the study area.

Research question 3) How can conservationists engage with custodians of sacred forests in bioculturally diverse landscapes?
Study area: Sabah, Malaysian Borneo
Title: Incorporating social-ecological systems into protected area networks: Indigenous and Community Conserved Areas (ICCAs) in Sabah, Malaysian Borneo
Brief summary: With high rates of biocultural diversity across Sabah, it can be challenging for conservationists to engage with custodians. This paper surveys sacred forests and rivers across Sabah to identify unities and diversities, and presents successful case studies of governmental and nongovernmental engagement with custodians.

2.3 Scope and ethical engagement

The thesis' scope is broad: sacred forests and conservation on a landscape scale in four study areas in Africa and Asia. In doing so, it seeks to build upon the literature on the biodiversity found in individual or small groups of sacred forests to consider persistence over time, ecosystem services, and adaptive management. As described in chapter one, custodians and conservationists exhibit unities and diversities in their perceptions of the landscape, or geographies of meaning. This thesis explores the unities of these perspectives, and it is important to reiterate that there are additional diversities that are unable to be captured within this scope. The thesis' focus on the intersectionality of these perspectives must not diminish the importance of additional rigorous engagement with the diversities. For example, while conservationists and custodians may both support the declaration of a sacred forest as an Indigenous and Community Conserved Area (ICCA), their priorities may differ. Conservationists prioritize the intersections of the natural and human world, while custodians may prioritize the intersections of the human and spiritual world. These diversities in perspectives must be acknowledged and respected.

It is important to note that conservationists or custodians can profess a unity of perspectives as a means to an end. The literature is replete with critiques of community based natural resource management (CBNRM) and co-management projects where people agreed to participate in participatory decision making and management, only to discover that their power in the decision-making process was less than that of conservation managers when their viewpoints diverged (Pimbert and Pretty, 1994, Berkes, 2009, Agrawal and Gibson, 1999). On the other side, custodians can engage with conservation projects solely as a means to gaining land tenure or management rights denied to them by local or national governments. If their aim is to gain land tenure or management rights to practice conservation coherent with the conservation project, there is a unity of interests, however there are instances where the true aim is to use the land for activities incompatible with conservation (e.g. mining) (Anaya, 2013). Ethical engagement between custodians of sacred forests and conservationists occurs when both parties come together for a mutual goal rooted in unities of interest. If priorities change, custodians maintain the human right of self-determination (Figure 2-2).

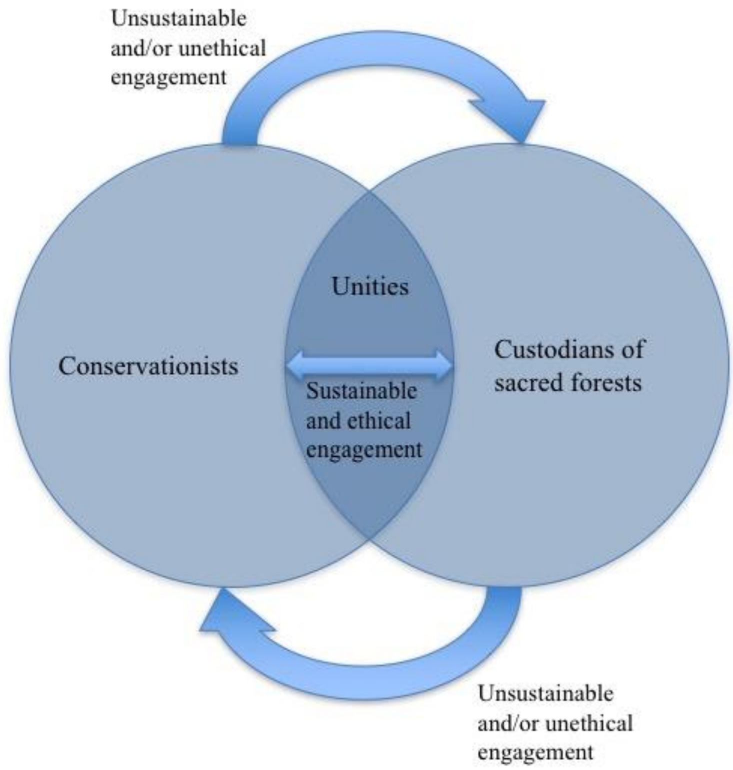

Figure 2-2 Perceptions of the landscape by conservationists and custodians exhibit diversities and unities; sustainable and ethical engagement is rooted in unities

The presentation of the preliminary findings of chapter three yielded a common question from primary school students and academics alike, "Why don't conservationists promote the idea of the *ninkananka* living in the forest to protect additional areas they prioritize for protection?"[2] While promoting beliefs in this way may seem a requisite means to an end to promote conservation behaviours, it is short sighted and fails to account for the dynamic nature of cultural adaptation and change over time. Put simply, if conservationists begin putting their eggs in the dragon tape recorder basket, what happens when peoples' belief in the dragons shifts over time? And what would the implications be for future engagement with conservation? Naturally this raises critical questions regarding conservation ethics. Recognizing the conservation implications of sacred forests in the

[2] In the words of a sixth grader in Virginia: "Why don't you just put a tape player in the forest playing dragon sounds?"

landscape beyond protected areas is a very different matter than actively promoting their underlying belief.

2.4 Methods and limitations

The selection of four study areas provided breadth and diversity of sacred forests and landscapes, however this breadth limited the depth of inquiry for each study area in the thesis. The scale of inquiry was also varied between study areas, thus a definitive interpretation of the results of the papers is difficult without replicating the methods on multiple scales. The methods of the four papers were tailored to the research questions of each paper, and in concert they address the aim of the thesis– to determine unities between conservationists and custodians of sacred forests. For a comprehensive methodology of each individual paper, please refer to the methods section within chapters 3-6.

In chapter three, paper one explores the persistence of forest patches in Kiang West, the Gambia, over time by assessing forest cover change. *Ninkananko*, translated by villagers as ‘dragons’ in English, are believed to reside in certain areas of the forest, and fear of death upon seeing them reportedly deters people from entering those parts of the forest. We employed high-resolution Landsat imagery from 1984-2007 in conjunction with *in situ* field campaigns to compare forest cover change over time in dragon areas, formally protected areas (forest reserves and a national park), and unprotected surrounding areas. Dragon areas, forest parks, and villages were field mapped via GPS June - August 2009. While dragon areas are distributed throughout the landscape, local informants reported to know about only one or two areas closest to their villages or agricultural areas. Thus, we identified guides from each village in the study area, usually hunters who spent a significant amount of time in the bush and felt comfortable leading us close to the dragon areas. The boundary of the national park was downloaded from the

World Database on Protected Areas (UNEP-WCMC, 2012) and inaccuracies improved in ArcMap v.9.1 via a list of 320 boundary post coordinates and the GPS field mapping of 115 boundary posts. An oral survey was administered to 89 respondents, randomly selected from village census data and representing 13.5% of the village. The survey included demographic questions of education, religious practice, and residence outside the village, followed by questions about the *ninkananko*.

While the environmental histories of the study areas in the thesis suggests these sacred forests are relict forest fragments in the midst of land use conversion landscapes, it is important to note that similar well-entrenched narratives have been debunked in the past, finding that some sacred forests are the result of afforestation due to proximity to human settlement (Fairhead and Leach, 1998). This remains a possibility for our study areas, and does not affect the aims of the thesis to investigate the implications of the distribution of sacred forests for conservation. Whether sacred forests persist in the face of deforestation or, rather, are the result of afforestation, religious or spiritual values affect the distribution of forest in the landscape.

In chapter four, paper two similarly utilizes land cover classifications in South Gondar, Amhara, northern Ethiopia, to identify church forest distribution. The landscape structure of South Gondar is quite homogenous, predominantly composed of a sea of agricultural land with islands of church forests. This simple landscape structure, along with photos of bees in church forests, church forest biodiversity data and flowering calendars of bee forage species, enabled us to estimate the pollination services of sacred forests on a landscape scale. Honeybee hives in South Gondar are predominantly traditional hives placed in forests. We assumed the church forests are the only location for hives, however there may be non-traditional hives kept by farmers outside of the church forests within the agricultural matrix. Our pollination services map therefore only covers potential pollination zones from hives in forest patches. Our church forest flowering season analysis indicated that at times of forage scarcity, church forests are the only source of food for bees in the landscape. In this case, the maximum foraging distance of honeybees would be the same distance, but mapped to the church forest (as a source of forage) from the hives, as opposed as mapped from the church forests (as a nesting resource). In this case, the pollination services zones would cover an even greater area, making the church forests as nesting zones a more conservative estimate.

While the estimated pollination zones indicate where pollination services may occur in the agricultural landscape of South Gondar, pollination service delivery is also strongly dependent on landscape structure, pollinator abundance, microclimate and the presence of competitors, predators, pathogens and parasites, and therefore pollinator services will be heterogeneous in these landscapes (Kremen et al., 2007). Pollination services studies in this landscape to date have been unsuccessful, with field survey equipment being removed by local farmers and livestock unfamiliar with their purpose. Performing this analysis with a map of agricultural crops planted would also be useful; our map has croplands that fall outside of the pollination areas, but as self-pollinating crops are dominant in this region, it is conceivable that farmers have altered where they plant their crops based on observed yields. Landscape scale assessments based on remote sensing and limited on-the-ground data are by nature, limited, and must be ground truthed for confirmation and contextualization of findings. In this case, remote sensing was combined with limited on-the-ground data to make inferences about ecosystem services provision, which can encourage the development of new research agendas and galvanize future engagement between conservationists and the custodians of church forests.

In chapter five, paper three details a survey of natural resource management practiced by custodians across Sabah, Malaysian Borneo, and applies social-ecological systems theory for conservation interventions over time. The reporting of natural resource management strategies by village representatives and three case studies may not form a representative sample of villages in Sabah. In terms of survey responses, the familiarity of respondents with the forms of natural resource management in their home areas may vary. Thus, it is important to note that questionnaire results may suffer from bias of omission and additional research in the home villages across Sabah may uncover other forms of natural resource management. The context of the quarterly PACOS meetings helped limit this bias; the representatives' regular representation of their villages at these meetings may have improved their awareness of conservation activities in their village throughout the year.

Finally, in chapter six, paper four applies the ecosystem services framework in the highly developed urbanised nation of Japan, assessing the implications of the distribution of Shinto shrine forests for cultural ecosystem services. Urban green space and happiness have been linked at smaller scales and support this finding (Wolf et al., 2012). However, at a prefectural scale, there are numerous drivers of happiness. For example, the number of Shinto shrine forests per capita may be the result of factors that affect happiness, for example, good local governance or historical political processes. However, even if Shinto shrine forests are not the primary driver of happiness, but rather, the result of a driver of happiness (e.g. strong local governance), the depth of research linking urban green spaces and Shinto shrine forests with increased happiness is compelling, and warrants further investigation across multiple scales.

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Chapter 3 Do dragons prevent deforestation? The Gambia's sacred forests

'Evil forests' and 'sacred groves' are prevalent across Africa (Sheridan and Nyamweru, 2008), and similar 'informally' protected sacred forests are found around the world. For example, there are nearly 35,000 Ethiopian church forests (Bongers et al., 2006), 80,000 Japanese Shinto shrine forests (Jinja Honcho, 2011) and 100,000-150,000 Indian sacred groves (Malhotra et al., 2001). It is estimated that the global land area informally conserved by custodians equals that of formally protected areas (ICCA Consortium, 2013). This chapter presents the first of four papers of the thesis, and addresses research question 1) How well do sacred forests conserve forests over time in comparison with 'formally' protected areas?

This paper assesses the persistence of sacred groves in an agricultural landscape in the Gambia, West Africa, over a 25-year period, 1984-2009, and compares the sacred groves with formally protected areas, a national park and three forest reserves. At 104,957 ha, the study area and the scale of analysis, sub-district, are the smallest of the thesis. This paper assesses the fewest number of sacred forests of the study areas, 15 dragon forests, which are a form of sacred groves. The land tenure of this landscape is all state-controlled. In practice, the common property resource is managed by village committees.

The *ninkananko*, or translated by villagers into English as 'dragons', are believed to reside in certain areas of the forest, and if people see the dragons, they are said to die on the spot or soon after. This belief is rarely spoken about in the village, and is communicated on a need-to-know basis. For example, on a young child's first outing into the bush to collect firewood, the parent will indicate to the young child the parts of the the bush to avoid. Dragon forests are not discussed or given any special consideration in terms of land use management, and there are no supporting organisations.

This study demonstrates that in a state-owned common property regime, widespread belief in local cosmologies can conserve forest patches over time, as well as or better than formally protected areas. Across the land cover types, dragon areas were 'greenest' (measured by Normalized Difference Vegetation Index) over time, and both dragon areas and formally protected areas were significantly greener than unprotected surrounding areas. This study also showed that local cosmologies can be syncretic with major world religions; in the Muslim village, 85.7% of respondents and the imam expressed belief in the dragon. Interviews with urban residents who had spent years away from the village also expressed belief in the dragon, indicating that a local cosmology may be retained after separation from the location where it was formed.

Our remote sensing analysis comparing these sites to formally protected areas in the same landscape over time indicates that the persistence of sacred groves is of interest for conservation planning and management beyond protected areas. In the case of sacred groves, the aim of conservationists' engagement with custodians is not to promote local beliefs beneficial to their mutual aims, but rather to recognize the conservation benefits that the sacred groves provide and to support the autonomy of custodians in management. For example, if sacred groves face threats from outsiders, such as the leasing of state land to resource extraction companies, conservationists can align with custodians to support their gaining land tenure. Emphasis on the importance of current land tenure regimes and resilient management institutions may result in conservationists overlooking the presence and persistence of sacred groves like dragon forests that are 'quietly' yet effectively conserved by custodians, even in the face of rapid land use change.

3.1 Paper 1: Do dragons prevent deforestation? The Gambia's sacred forests

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Journal: *Nature*

3.2 Abstract

One in four people live in agricultural villages, which cover 7.7 million km^2 of the Earth's terrestrial surface. Forest loss due to changing land use has precipitated an unparalleled rate of global biodiversity loss, altering ecosystem functioning and the provision of ecosystem services. However, in the face of intense pressure of agricultural conversion, forest patches persist in agricultural landscapes. Custodians conserve sacred groves via local cosmologies. In West Africa, belief in *ninkananko*, translated by residents as 'dragons' in English, spans ethnic groups from Senegal to Sierra Leone. It is said that if people see a *ninkananka*, they will die on the spot or very soon after. We ask, does the belief in dragons prevent deforestation (or other forest uses) in forests where they are believed to reside? We employ 25 years of high-resolution Landsat satellite imagery in conjunction with *in situ* field campaigns to compare forest cover in dragon areas, formally protected areas (forest reserves and a national park), and unprotected surrounding areas. We find that like formally protected areas, dragon areas are significantly 'greener' than surrounding areas, as indicated by Mean Normalized

Difference Vegetation Index (NDVI). This study demonstrates that in a state-owned common property regime, widespread belief in local cosmologies can conserve forest patches over time, even more consistently than formally protected areas. Our remote sensing analysis comparing these sites in the same landscape over time has serious implications for conservation planning and management beyond protected areas and could be extended worldwide.

3.3 Introduction

One in four people live in agricultural villages, which cover 7.7 million km^2 of the Earth’s terrestrial surface (Ellis and Ramankutty, 2008). Urbanization and increased exports of agricultural products are linked with deforestation in the humid tropics (DeFries, 2010). Drivers of forest clearance at the rural household level vary by region, and include availability of male labor, amount of forest cover, market access, and asset holdings (Babigumira et al., 2014). Destruction of habitat due to changing land use has precipitated an unparalleled rate of global biodiversity loss, altering ecosystem functioning and the provision of ecosystem services (Cardinale, 2012).

However, in the face of intense pressure of agricultural conversion, patches of forest persist in agricultural landscapes. Custodians conserve these forest patches due to their religious and spiritual values, cosmologies, or worldviews. For example, a forest patch may be conserved due to the presence of medicinal plants or cosmological beliefs, e.g. spirits believed to inhabit a geographic feature such as a tree, spring, or hilltop.

While performing biodiversity research in the Gambia, West Africa, local community members warned us to avoid certain parts of the forest due to the presence of *ninkananko*, a Mandinka word they translated into English as ‘dragons’ (Figure 3-1).

a)

b)

Figure 3-1 *Ninkananko* are believed to inhabit patches of forest across West Africa; a) A patch of forest in a cleared agricultural landscape in Jiffarong, Kiang West, the Gambia, conserved by belief in a *ninkananka*, b) A drawing of a *ninkananka* by Adama M. Saidy, grade six at Dumbuto Lower Basic School, Kiang West, the Gambia

They told us that if one sees the *ninkananko*, he or she will die on the spot or soon after. Belief in the *ninkananko* spans ethnic groups across West Africa, including Senegal, the Gambia, Guinea, and Sierra Leone (Ax, 2000). In 2006 a team of 'dragon hunters' went on an expedition to the Gambia seeking proof of the *ninkananko's* existence, yet they determined it was likely to be 'local folklore' (BBC News, 2006). We asked, does the belief in dragons prevent deforestation (or other forest uses) in forests where they are believed to reside?

3.3.1 Study area

Primary forest covers only 0.2% of the Gambia today (FAO Statistics Division, 2015b). Mangroves have declined by 47% in the Gambia in 28 years (2012). The population density of the Gambia is one of the highest in Sub-Saharan Africa; nearly 70% of people live in rural areas and depend on forest resources for fuel wood and building materials. Overgrazing by livestock, annual bushfires, and the exporting of timber also threaten Gambian forests (FAO Statistics Division, 2015b). Formal forest management in the Gambia includes protected areas serving as wildlife sanctuaries (37,400 ha), nationally gazetted forest parks (77,000 ha), community forest reserves (300,000 ha), and coastal mangrove forests (66,000 ha) (Bojang, 2001). Gazetted in 1987, Kiang West National Park is the Gambia’s largest and most biodiverse wildlife reserve, its 11,000 ha comprise half of the forest cover of Kiang West District. Most of all other land is owned by the state but in practice is treated as open access or managed by local institutions including village chiefs and elders. The 104,957 ha study area in Kiang West, Lower River Region of the Gambia (13.38 N, -15.92 W) lies at an ecoregional boundary between Guinean forest-savanna mosaic and West Sudanian savanna, with Guinean mangroves buffering the Gambia River (Figure 3-2) (SI 3-1).

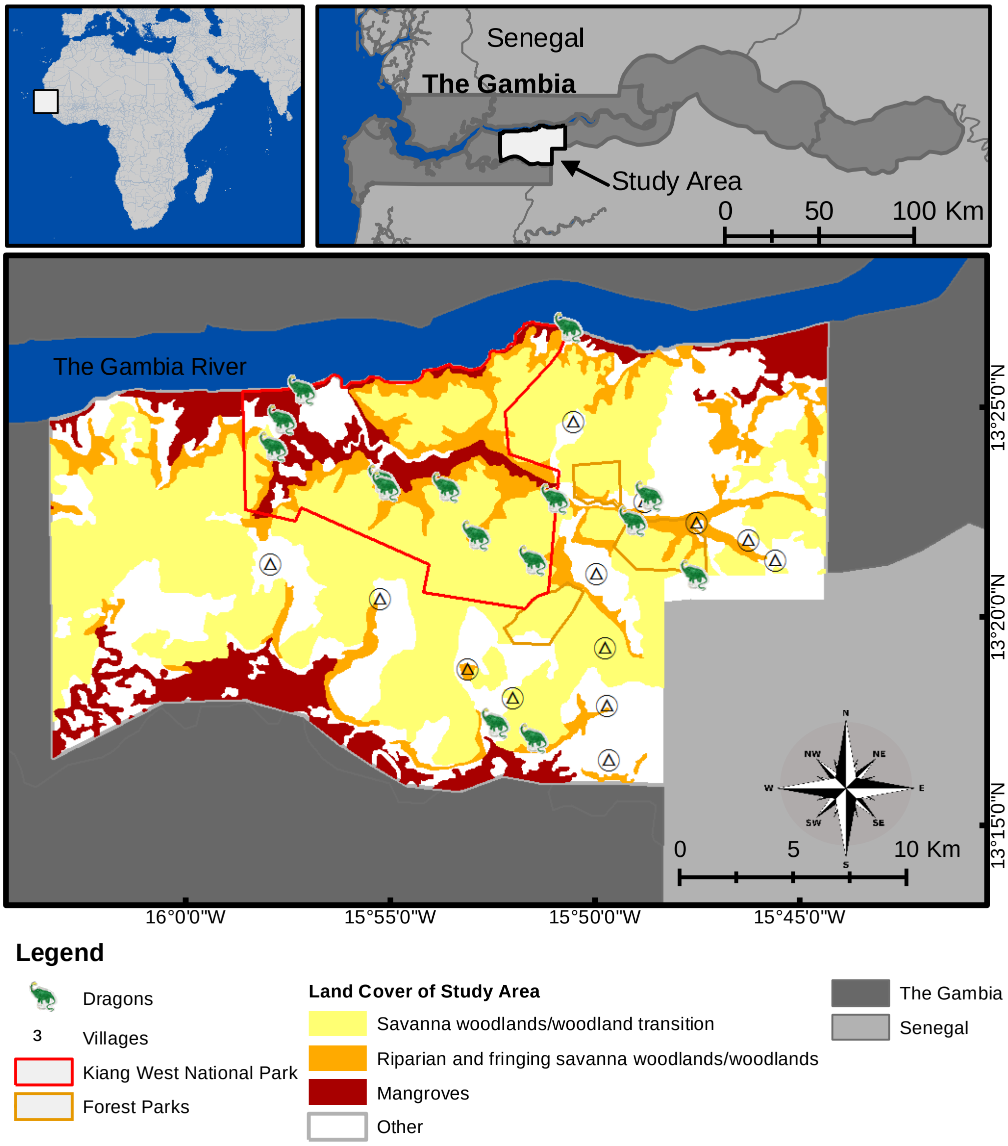

Figure 3-2 Map of study area (104,957 ha) including 15 dragon areas, 3 forest parks, Kiang West National Park and surrounding areas

Only 2% of the Guinean forest-savanna mosaic ecoregion is protected and 6.7% of West Sudanian savanna is protected, however most of these protected areas are in practice "paper parks" (World Wildlife Fund, 2008 and 2007).

3.4 Methods

3.4.1 Field Mapping

Dragon areas, forest parks, and villages were field mapped via GPS June - August 2009. While dragon areas are distributed throughout the landscape, local informants reported to know about only one or two areas closest to their villages or agricultural areas. Thus, we identified guides from each village in the study area, usually hunters who spent a significant amount of time in the bush and felt comfortable leading us close to the dragons areas, which we mapped via Garmin eTrek GPS. The boundary of the national park was downloaded from the World Database on Protected Areas and inaccuracies improved in ArcMap v.9.1 via a list of 320 boundary post coordinates and the GPS field mapping of 115 boundary posts (UNEP-WCMC, 2012). Forest park boundaries were identified via GPS field mapping of boundary posts and referencing a 1984 Landsat image with clearly defined fire breaks. Villages were identified via GPS, Landsat imagery and Google Earth. A study area of 104,957 ha incorporating the dragon areas, forest parks, national park and villages was drawn as a polygon in ArcMap v.9.3, bounded by the Gambia River to the north, a mangrove-lined bolong to the south, and Senegal to the east. Surrounding areas comprised the parts of the study area not covered by dragon areas, forest parks, the national park or villages, and thus served as a control.

3.4.2 Land Cover

Land cover data was overlayed in ArcMap v. 9.3 and the dragon areas, forest parks, national park and surrounding areas were divided into their respective land covers (Tyldum, 1982). The three predominant land covers shared by all area types were selected for analysis: mangroves, savanna woodlands/woodland transition, and riparian and fringing savanna woodlands/woodlands. Contiguous pixels of a land cover served as the units of analysis (n) within each area type: dragon areas, forest parks, national park and surrounding areas (SI 3-2).

3.4.3 Pre-processing Satellite Imagery

Landsat Thematic Mapper (TM) 5 and Landsat 7 satellite imagery were obtained from the United States Geological Survey for 1984, 1988, 1991, 1999, 2002, 2006 and 2009 (United States Geological Survey, 2012). Scene years are 3-4 years apart, excepting for a seven-year gap from 1992-1998 due to satellite sensor malfunction. To maintain seasonality across images and reduce climatic variation, scene dates were chosen for the end of the rainy season, when vegetation is green and bushfires are not present (26 Oct. 1984, 30 Oct. 1988, 15 Nov. 1991, 29 Nov. 1999, 5 Nov. 2002, 24 Nov 2006, 16 Nov 2009). All scenes (WGS 84, utm-28n, ellipsoidal projection) are characterized by 0% cloud cover. Landsat 7 scenes (1999 and 2002) were calibrated so as to be comparable with the Landsat 5 scenes using empirically derived values in Idrisi v.15.0 (Vogelmann et al., 2001). Bands from all scenes were atmospherically corrected using the Cos(t) model in Idrisi v.15.0 where the Dn value was assigned as the darkest pixel value observed in the Gambia River in each scene (Chavez Jr, 1988). All scenes had a resolution of 30 meters, except 1988, which had a resolution of 28.5 meters and was resampled to 30 meters via Idrisi v.15.0; all seven year scenes were then accurately geocoded.

NDVI is a spectral transformation of two reflectance bands from remote sensing imagery used to identify and quantify the ‘greenness’ of vegetated areas. NDVI has been widely employed as an indicator of change in vegetation cover over time, including in Sub-Saharan Africa (Lambin and Ehrlich, 1997). We compare the NDVI of dragon areas, formally protected areas and unprotected surrounding areas within each year as opposed to the inter-annual variations in NDVI[3] which geophysical scientists attribute to regional climate signals (Jarlan et al., 2005). NDVI was calculated: $\frac{near\text{-}infrared-red}{near\text{-}infrared+red}$ where near-infrared is band 4 (0.76-0.90 μm) and red is band 3 (0.63-0.69 μm).

3.4.4 Statistics

The mean NDVI of contiguous land cover pixels (n) within each area type- dragon areas, forest parks, national park and surrounding areas- were calculated in Idrisi Andes v.15.0 for all image years (1984, 1988, 1991, 1999, 2002, 2006 and 2009). For the normally distributed mangroves data, Repeated Measures ANOVA with a Greenhouse-Geisser correction was employed to test the difference between the NDVI of area types over the seven years (alpha level p=0.05) (SI 3-3). For non-normally distributed data for all land covers, savanna woodlands/woodland transition and riparian and fringing savanna woodlands/woodlands, Kruskal-Wallis Independent Samples test compared NDVI of area types within each year (alpha level p=0.05).

3.4.5 Survey methods

Survey data were collected in six weeks of fieldwork from June 26th to August 7th, 2009. Fieldwork coincided with the Gambia's rainy season when village members living in the urban area return to the village to assist with rice farming, which improved the representativeness of the survey sample. The January 2009 Dumbuto census consisted of a list of households, and the gender and ages (0-30, 30+) of household members (SI 3-4). To select survey respondents, the census data were recorded in a SPSS data sheet and a random sample of 20% of the 697 members of the village was selected via the 'Select Cases' function. The survey was administered to 89 respondents, representing 13.5% of

[3] Fluctuations in NDVI between years were directionally similar in all land cover types.

the village (SI 3-5). The representativeness of the Dumbuto random sample of the village population was determined via a Chi-square test. The oral survey included demographic questions of education, religious practice, and residence outside the village, followed by questions about the *ninkananka* (SI 3-6). The oral survey was translated into the local language, Mandinka. The translator, Lahmin Njie, was instructed to deliver the same translation of questions to each respondent, and the researcher's proficiency in Mandinka ensured continuity of translation.

Key informants were recommended from villages in the study region and government departments, and included local villagers, a hunter, wildlife and forest park managers, field guides to dragon areas, and a snake expert. The 18 key informant interviews were semi-structured and described local encounters with the *ninkananka*, the impacts of the belief on forest management, and place-specific *ninkananka* information.

3.4.6 Limitations

The remote sensing methodology of the paper presumes forest cover is an effective indicator of biodiversity conservation. However, the presence of forest patches alone does not indicate species are present. Redford (1991) described 'empty forests' as seemingly 'intact' forests with large trees defaunated of large mammals. Future work could measure the biodiversity of dragon forests. A remote approach was chosen for this study to track forest cover over a 25-year period, and out of respect for local beliefs. Indeed, despite stopping a respectful distance from the dragon areas to map their near-boundaries, our gun-toting hunter guides ran away on numerous occasions after hearing sounds or seeing an animal near a termite mound. Having completed his assistance of our study, one guide remarked he would never again venture so close to the dragon areas, not for any amount of money. Despite consistency in translator and translation, administering the survey via translation limits the researcher's understanding of the nuances of local cosmologies and beliefs. Belief in the *ninkananka* is an excellent example of this as it is such a secretive belief that people are hesitant to discuss it openly.

3.5 Results

Knowledge of the *ninkananko* and their whereabouts is gained on a need-to-know basis by community members; for example, a mother will point out a dragon area to her daughter on her daughter's first trip to the forest to collect firewood. Dragon areas are located within a variety of different management zones (including protected areas, forest parks and surrounding areas) and are not acknowledged by the state or local institutions. Local people are extremely reticent to speak of the *ninkananko* for fear of negative supernatural repercussions (primarily, death) and regularly expressed concern for our safety in the field. When we initially asked community members about the mysterious forest patches, we received vague and non-committal responses; it was only after living in the rural community for six months and people learned we had biked through these areas that they expressed concern and warned us about the *ninkananko.*

The Dumbuto random sample was determined to be representative of the village population by gender (village: 45% male, 55% female; sample: 48% male, 52% female), age (village: 32% 6-14, 28% 15-29, 22% 30-49, 18% 50+; sample: 33% 6-14, 27% 15-29, 23% 30-49, 17% 50+), and education (village: 45% none, 23% some primary, 22% some junior secondary, 10% some senior secondary; random sample: 44% none, 26% some primary, 19% some junior secondary, 11% some senior secondary) (Chi-square test; $\chi^2 = 0.585$, df = 1, $p = 0.444$; $\chi^2 = 0.553$, df = 3, $p = 0.907$; $\chi^2 = 1.878$, df = 3, $p = 0.598$, respectively).

Descriptions of the *ninkananka* were highly variable amongst our key informants and respondents. Seventy-two percent of our respondents said they knew what it looks like and said it was: like a snake (55%) or python (5%), big (12%), like a lamp or mirror

(8%), different colors (7%), able to change shape/animal (5%) like a goat or sheep (5%), crocodile (3.4%), able to change from small to big (3.4%), big-eyed (2.2%), like an insect (2.2%), scaled (2%), green (2%), brown (2%), white if you were lucky (2%), fire breathing (1%), making noise like clanging metal (1%), having crested head/horn (1.1%), having legs (1.1), like a bird (1.1%). Informants told us that *ninkananko* often lived in hollowed trees or termite mounds, or in holes in the ground. Some of the dragon areas had a prominent such feature where the *ninkananka* was believed to reside.

When we asked a representative sample of 89 respondents in the village of Dumbuto[4] "Is the *ninkananka* real?", 81% responded yes, 10% I don't know and 3% no; 6% had not heard of the *ninkananka*[5]. No significant difference in belief is attributable to the demographic factors of gender, age, having lived outside the village, having relatives outside the village, frequency of prayer, frequency of mosque visits, or purpose of visits to the bush (Fisher's exact test, $p > 0.05$, all factors) (SI 3-7). However, belief in the *ninkananka* was negatively correlated with education ($p=0.01$) (SI 3-8) and Islamic Studies[6] ($p=0.03$) (SI 3-9) and positively correlated with frequency of trips to the bush ($p=0.03$) (SI 3-10). When we asked, "Are there (bad) places in the bush you will not go?" 84 % responded yes, there are places they avoid. To compensate for self-reporting error, we also asked the question "Do other people believe the *ninkananka* is real?" and 90% of respondents answered that other people believe the *ninkananka* is real, of which 73.4%

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[4] Updated census (2009) reports total Dumbuto population as 697; our random sample of 89 is 13.5% of total population and is representative by gender, age and education (Appendices B and C).

[5] To compensate for self-reporting error, I also asked the question "Do other people believe the ninkananka is real?" and 90% of respondents answered that other people believe the ninkananka is real, of which 73.4% responded that everyone, nearly everyone, or most people believe it is real.

[6] Islamic studies are supplemental to classroom education, not an alternative form.

responded that everyone, nearly everyone, or most people believe it is real. Key informants we interviewed who had inhabited the capital city for many years and worked for international organizations expressed belief in the *ninkananko*.

The NDVI of dragon areas (0.35±0.01, 0.50±0.01, 0.34±0.01, 0.49±0.01, 0.64±0.01, 0.49±0.01, 0.52±0.01) was higher than the forest parks (0.31±0.01, 0.42±0.02, 0.35±0.01, 0.43±0.02, 0.64±0.01, 0.41±0.01, 0.51±0.01), national park (0.32±0.01, 0.43±0.01, 0.30±0.01, 0.45±0.01, 0.56±0.02, 0.42±0.01, 0.46±0.01), and surrounding areas (0.29±0.01, 0.38±0.01, 0.30±0.01, 0.37±0.02, 0.50±0.02, 0.36±0.01, 0.40±0.02) across most years, excepting in 1991 (when forest parks were 0.01 greener) and in 2002 (when forest parks were 0.003 greener) (Figure 3-3) (SI 3-11).

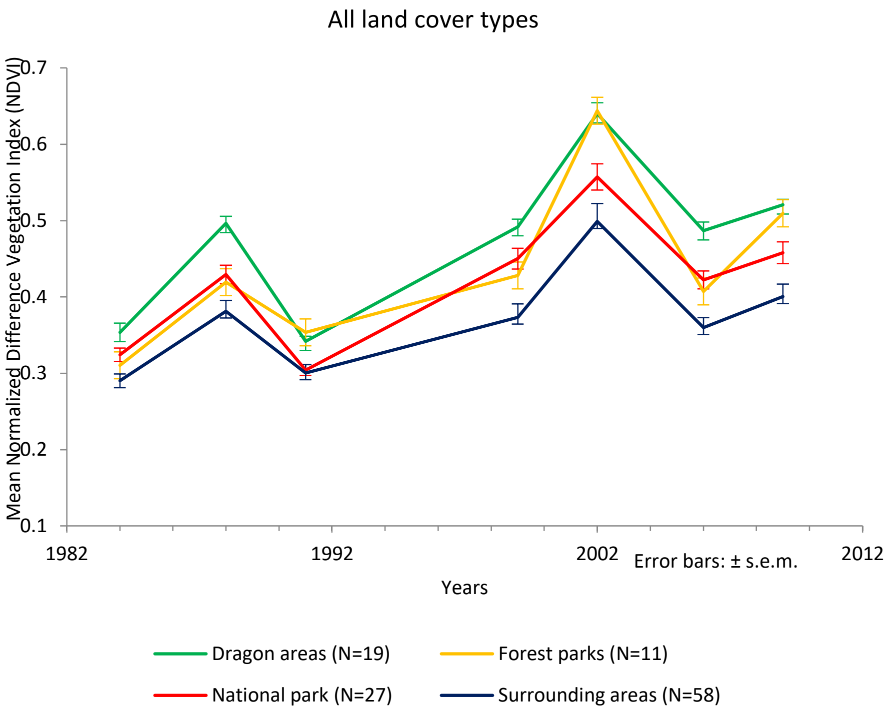

Figure 3-3 Mean Normalized Difference Vegetation Index (NDVI) of dragon areas, forest parks, national park and surrounding areas in all land covers (mangroves, savannah woodlands/woodland transition, riparian and fringing savannah woodlands/woodlands)

The NDVI of the area types was significantly different in all years (p=0.002, 0.000, 0.008, 0.000, 0.000, 0.000, 0.000) (SI 3-12).

When we break the data down by land cover types, we find that in the Gambian mangroves, dragon areas exhibited the highest NDVI of the area types across all years (0.30±0.01, 0.55±0.01, 0.31±0.02, 0.46±0.02, 0.53±0.01, 0.49±0.02, 0.49±0.03), followed by the national park (0.27±0.02, 0.41±0.04, 0.27±0.02, 0.38±0.03, 0.45±0.03, 0.37±0.03, 0.38±0.03) and surrounding areas (0.19±0.02, 0.23±0.04, 0.18±0.02, 0.17±0.04, 0.22±0.05, 0.22±0.03, 0.22±0.04) (Figure 3-4).

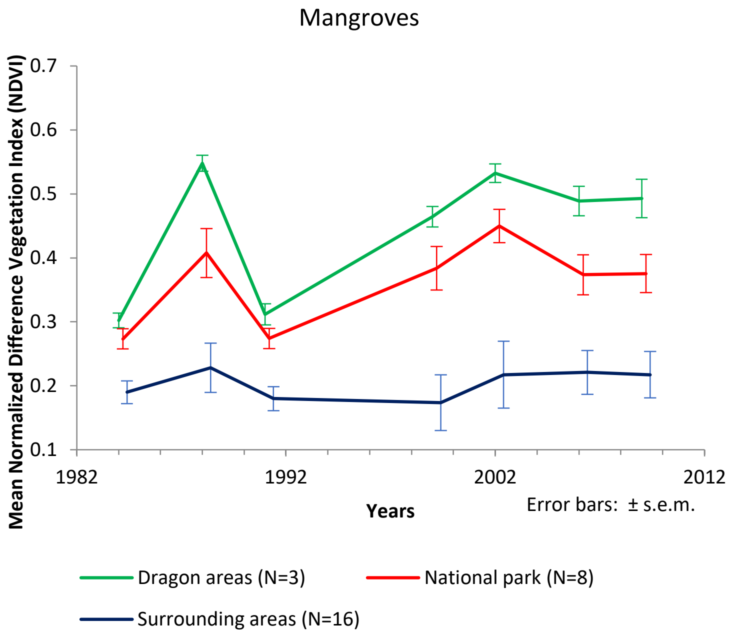

Figure 3-4 Mean Normalized Difference Vegetation Index (NDVI) of mangroves found in dragon areas, national park and surrounding areas

Mean NDVI differed statistically significantly between area types ($F(3.746, 22.257)=5.607$, $p = 0.001$). Post hoc tests using the Bonferroni correction revealed that mean NDVI differed statistically significantly between the national park and surrounding areas ($p=0.011$) and between dragon areas and surrounding areas ($p=0.007$) (SI 3-10).

In savannah woodlands/woodland transition, dragon areas exhibited the highest NDVI across all years except for 1991 (Figure 3-5).

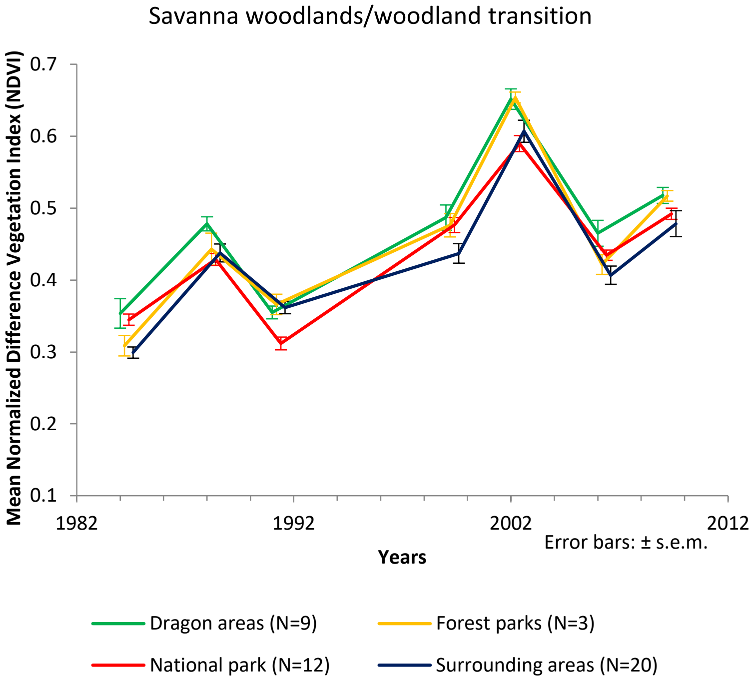

Figure 3-5 Mean Normalized Difference Vegetation Index (NDVI) of savanna woodlands/woodland transition found in dragon areas, forest parks, national park and surrounding areas

The NDVI of the area types was significantly different in 1984 (p=0.003), 1991 (p=0.003), 1999 (p=0.049) and 2002 (p=0.039).

In riparian and fringing savanna woodlands/woodlands, the NDVI of dragon areas was highest in all years except for 1991 (Figure 3-6).

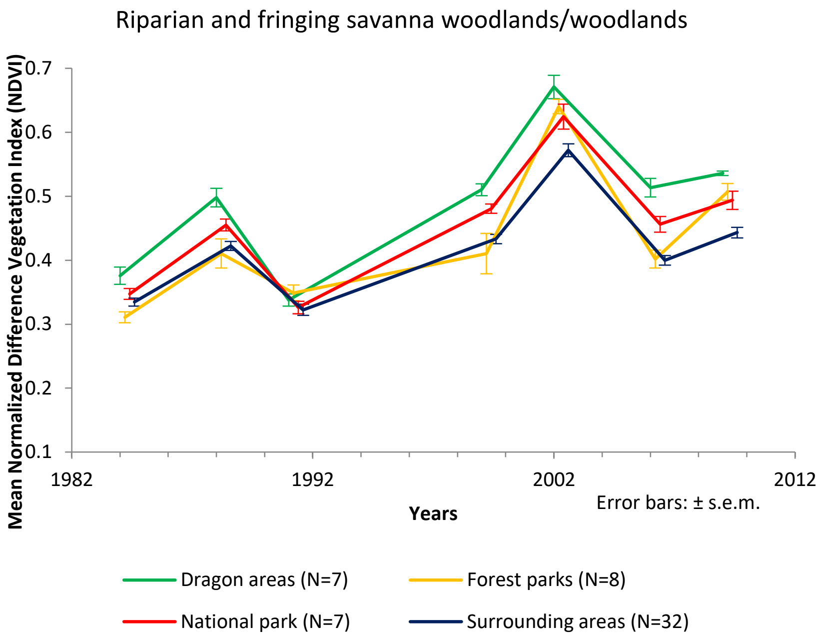

Figure 3-6 Mean Normalized Difference Vegetation Index (NDVI) of riparian and fringing savanna woodlands/woodlands found in dragon areas, forest parks, national park and surrounding areas

The NDVI of the area types was significantly different in all years except for 1991 (p=0.006, 0.001, 0.000, 0.000, 0.000, 0.000) (SI 3-13).

3.6 Discussion

Like formally protected areas, dragon areas are significantly 'greener' than unprotected surrounding areas. While this may indicate selection bias, that is, dragon areas may be identified by local people as areas comprised of different or denser vegetation than surrounding areas, the longitudinal nature of the study demonstrates that these areas have been effectively maintained over time. Importantly, dragon areas conserve forest in a landscape where formal protection is limited: only 2% of the Guinean forest-savanna mosaic ecoregion is protected and 6.7% of West Sudanian savanna is protected (World Wildlife Fund, 2008 and 2007). These forest patches, like most sacred natural sites and other 'informally' protected areas, do not appear in conservation maps, plans or networks. However, in the land use matrix beyond protected areas, sacred natural sites and other 'informally' protected areas offer an endogenous approach to conservation widely acknowledged by local people, such as the respondents in our study (Verschuuren et al., 2010). While we found that 85.7%[7] of people expressed belief in the *ninkananko,* sceptical respondents had achieved higher levels of education or Islamic studies. Their scepticism does not necessarily affect local patterns of resource conservation as they may respect the majority view. Cultural psychologists Atran and Norenzayan (2004) attribute the resilience of supernatural beliefs to evolutionary forces affecting psychology. The mnemonic of a belief, i.e. the memorability of a belief, is the most powerful cognitive factor affecting 'cultural success' of a belief in a population.

Conservation planners may be reticent to acknowledge sites conserved by local beliefs that can change over time and specifically those that employ fear instead of support. However adaptive management can address the changing nature of ecosystems as well as institutions and local beliefs (Scoones, 1999), and fear is not relegated to local belief systems but rather underscores some contemporary approaches in conservation management, for example the use of armed poaching units to prevent illegal resource use (McClanahan and Wall, 2016).

3.7 Conclusion

Emphasis on the importance of current land tenure regimes and resilient management institutions may result in conservationists overlooking the presence and persistence of sacred groves like dragon forests that are 'quietly' yet effectively conserved by custodians, even in the face of rapid land use change. Conservation efforts have underscored the importance of community buy-in and support, and custodians endogenously conserve sacred groves via local cosmologies. In cases of secretive, rarely

[7] Calculated as percentage of respondents who answered yes to "Is the *ninkanaka* real?" (n=72) out of the number of respondents who knew what the *ninkanaka* is (n=84).

spoken about beliefs, or cosmologies difficult to comprehend by outsiders, conservationists may be wary to engage with custodians of dragon forests or similar sacred groves. However, this study demonstrates that in a state-owned common property regime, widespread belief in local cosmologies can conserve forest patches over time, as consistently as formally protected areas. This study also showed that local cosmologies can be syncretic with major world religions; in the Muslim village, 85.7% of respondents and the imam expressed belief in the dragon. Interviews with urban residents who had spent years away from the village also expressed belief in the dragon, indicating that a local cosmology may be retained after separation from the location where it was formed.

In the case of sacred groves, the aim of conservationists' engagement with custodians is not to promote local beliefs beneficial to their mutual aims, but rather to recognize the conservation benefits that the sacred groves provide and to support the autonomy of custodians in management. For example, if sacred groves face threats from outsiders, such as the leasing of state land to resource extraction companies, conservationists can align with custodians to support their gaining land tenure. 'Evil forests' and 'sacred groves' are prevalent across Africa (Sheridan and Nyamweru, 2008), and similar 'informally' protected sacred forests are found around the world. For example, there are nearly 35,000 Ethiopian church forests (Bongers et al., 2006), 80,000 Japanese Shinto shrine forests (Jinja Honcho, 2011), and 100,000-150,000 Indian sacred groves (Malhotra et al., 2001). It is estimated that the global land area informally conserved by custodians equals that of formally protected areas (ICCA Consortium, 2013). Our remote sensing analysis comparing these sites to formally protected areas in the same landscape over time indicates that the persistence of sacred groves is of interest for conservation planning and management beyond protected areas.

3.8 Supplementary Information

SI 3-1 Land cover of study area: area (hectares) and percentage area

Land cover of study area	Hectares	Percentage
Savanna woodlands/woodland transition	24785.91	47.23
Mangroves	6264.54	11.94
Riparian and fringing savanna woodlands and woodlands	6216.03	11.84
Current Agriculture	5677.38	10.82
Shrub and tree savanna	5102.46	9.72
Herbaceous steppes	1914.21	3.65
Grass savanna	1123.47	2.14
Barren flats	980.46	1.87
Water	345.42	0.66
Savanna woodlands	39.33	0.07
Swamp rice	29.25	0.06
Total	52478.46	100.00

SI 3-2 Size, number of pixels, and number of clusters for area types in each land cover category (mangroves, savanna woodlands/woodland transition, and riparian and fringing savanna woodlands/woodlands)

Land cover	Type	Area (hectares)	Number of pixels (30m x 30m)	Number of clusters
Mangroves	Dragon Areas	7.74	86	3
	National Park	1,760.58	19,562	8
	Surrounding Areas	4,509.90	50,110	16
Savanna woodlands/woodland transition	Dragon Areas	80.73	897	9
	Forest Parks	2,468.70	27,430	3
	National Park	10,953.00	121,700	12
	Surrounding Areas	49,759.65	552,885	20
Riparian and fringing savanna woodlands/woodlands	Dragon Areas	14.94	166	7
	Forest Parks	273.06	3,034	8
	National Park	2,289.33	25,437	7
	Surrounding Areas	3,600.27	40,003	22

SI 3-3 Normality of NDVI data was tested for a) all land covers and then for the pixel clusters in each area type (b-d) in each year. Normality was assessed via Shapiro-Wilks tests in SPSS v.19 (alpha level p=0.05)

a) All land covers (Mangroves, Savanna woodlands/woodland transition, and Riparian and fringing savannah woodlands/woodlands)

Area Type		Shapiro-Wilk		
		Statistic	n	p
1984	Dragon areas	.959	19	.559
	Forest parks	.932	11	.434
	National park	.915	27	.030
	Surrounding areas	.896	68	.000
1988	Dragon areas	.929	19	.169
	Forest parks	.937	11	.488
	National park	.800	27	.000
	Surrounding areas	.802	68	.000
1991	Dragon areas	.961	19	.584
	Forest parks	.828	11	.022
	National park	.945	27	.159
	Surrounding areas	.898	68	.000
1999	Dragon areas	.959	19	.551
	Forest parks	.870	11	.078
	National park	.764	27	.000
	Surrounding areas	.751	68	.000
2002	Dragon areas	.835	19	.004
	Forest parks	.826	11	.021
	National park	.941	27	.128
	Surrounding areas	.781	68	.000
2006	Dragon areas	.950	19	.394
	Forest parks	.869	11	.076
	National park	.819	27	.000
	Surrounding areas	.813	68	.000
2009	Dragon areas	.826	19	.003
	Forest parks	.912	11	.260
	National park	.846	27	.001
	Surrounding areas	.847	68	.000

b) Mangroves

	Area Type	Shapiro-Wilk		
		Statistic	n	p
1984	Dragon area	.991	3	.814
	National park	.925	8	.469
	Surrounding areas	.942	16	.379
1988	Dragon area	.994	3	.851
	National park	.882	8	.197
	Surrounding areas	.938	16	.321
1991	Dragon area	.933	3	.499
	National park	.947	8	.682
	Surrounding areas	.958	16	.631
1999	Dragon area	.797	3	.108
	National park	.854	8	.106
	Surrounding areas	.944	16	.401
2002	Dragon area	.991	3	.815
	National park	.941	8	.619
	Surrounding areas	.905	16	.095
2006	Dragon area	.974	3	.693
	National park	.907	8	.336
	Surrounding areas	.967	16	.786
2009	Dragon area	.922	3	.459
	National park	.941	8	.621
	Surrounding areas	.960	16	.656

c) Savanna woodlands/woodland transition

	Area Type	Shapiro-Wilk Statistic	n	p
1984	Dragon areas	.956	9	.755
	Forest parks	.954	3	.586
	National park	.976	12	.960
	Surrounding areas	.944	20	.286
1988	Dragon areas	.906	9	.292
	Forest parks	.816	3	.152
	National park	.959	12	.768
	Surrounding areas	.975	20	.848
1991	Dragon areas	.916	9	.364
	Forest parks	1.000	3	.997
	National park	.956	12	.728
	Surrounding areas	.874	20	.014*
1999	Dragon areas	.967	9	.872
	Forest parks	.901	3	.390
	National park	.928	12	.358
	Surrounding areas	.891	20	.028*
2002	Dragon areas	.899	9	.246
	Forest parks	.776	3	.059
	National park	.894	12	.134
	Surrounding areas	.958	20	.512
2006	Dragon areas	.930	9	.485
	Forest parks	.953	3	.584
	National park	.921	12	.296
	Surrounding areas	.836	20	.003*
2009	Dragon areas	.931	9	.489
	Forest parks	.981	3	.733
	National park	.927	12	.347
	Surrounding areas	.890	20	.027*

d) Riparian and fringing savannah woodlands/woodlands

	Area Type	Shapiro-Wilk Statistic	n	p
1984	Dragon areas	.924	7	.502
	Forest parks	.880	8	.189
	National park	.886	7	.254
	Surrounding areas	.987	32	.963
1988	Dragon areas	.963	7	.847
	Forest parks	.893	8	.251
	National park	.875	7	.206
	Surrounding areas	.965	32	.384
1991	Dragon areas	.932	7	.567
	Forest parks	.809	8	.036*
	National park	.858	7	.145
	Surrounding areas	.981	32	.823
1999	Dragon areas	.958	7	.800
	Forest parks	.909	8	.348
	National park	.954	7	.770
	Surrounding areas	.963	32	.333
2002	Dragon areas	.605	7	.000*
	Forest parks	.877	8	.175
	National park	.894	7	.299
	Surrounding areas	.983	32	.880
2006	Dragon areas	.929	7	.539
	Forest parks	.866	8	.139
	National park	.937	7	.609
	Surrounding areas	.982	32	.848
2009	Dragon areas	.931	7	.558
	Forest parks	.932	8	.532
	National park	.918	7	.456
	Surrounding areas	.982	32	.851

SI 3-4 Dumbuto village demographics

Factor	*Frequency*	*Percentage*	*Cumulative Percentage*
Gender			
male	251	45.4	45.4
female	302	54.6	100
total	553	100	
Age			
6-14	177	32	32
15-29	156	28.2	60.2
30-49	123	22.2	82.5
50-69	82	14.8	97.3
70+	15	2.7	100
total	553	100	
Education			
none	248	44.8	44.8
some < grade 5	106	19.2	64
finished grade 5	22	4	68
grade 5 < x < grade 9	72	13	81
finished grade 9	51	9.2	90.2
grade 9 < x < grade 12	18	3.3	93.5
finished grade 12	36	6.5	100
total	553	100	

SI 3-5 Dumbuto random sample demographics

Factor		*Frequency*	*Percentage*	*Cumulative Percentage*
Gender				
	male	41	47.7	47.7
	female	45	52.3	100.0
	total	86	100.0	
Age				
	6-14	28	32.6	32.6
	15-29	23	26.7	59.3
	30-49	20	23.3	82.6
	50-69	13	15.1	97.7
	70+	2	2.3	100.0
	total	86	100.0	
Education				
	none	38	44.2	44.2
	some < grade 5	19	22.1	66.3
	finished grade 5	3	3.5	69.8
	grade 5 < x < grade 9	11	12.8	82.6
	finished grade 9	5	5.8	88.4
	grade 9 < x < grade 12	3	3.5	91.9
	finished grade 12	7	8.1	100.0
	total	86	100.0	

SI 3-6 Dumbuto survey questions and responses

Question	*Frequency*	*Percentage*
Where is the farthest away from Dumbuto that you have lived?		
another village	35	39.3
I haven't lived outside	32	38.2
urban area	14	21.3
another West African country	1	1.1
Where is the farthest away from Dumbuto that people from your compound live?		
Europe or United States	41	51.7
urban area	31	34.8
I don't have relatives outside	7	7.9
another West African country	3	3.4
another village	2	2.2
Do people from your compound live in Kombo (the urban area of the capital)?		
yes	80	89.9
no	9	10.1
What Islamic studies have you completed?		
village study	61	74.2
none	17	19.1
advanced study	5	6.7
How many times a day do you pray?		
5	85	95.5
4	3	3.4
2	1	1.1
How often do you go to the mosque?		
more than once a day	35	39.3
daily	16	18.0
Fridays	16	18.0
never	15	16.9
multiple times a week	5	5.6
special occasions	2	2.2
How often do you go into the bush?		
daily	71	79.8
never	7	7.9
weekly	5	5.6
rarely	4	4.5
monthly	2	2.2

Question	*Frequency*	*Percentage*
For what purpose do you go to the bush?		
farming	69	77.5
doesn’t go to the bush	8	9.0
herding cows	5	5.6
firewood for household use	3	3.4
plants/fruit	2	2.2
park ranger	1	1.1
takes lunch to farmers	1	1.1
Are there (bad) places in the bush you will not go?		
yes, there are places I avoid	75	84.3
no, I will go everywhere	7	70
I don’t go to the bush	8	9.0
I don’t know the bad places	1	1.1
Why won’t you go there?		
I’m afraid	54	60.7
I don’t go to the bush	7	7.9
I don’t avoid places	6	6.7
elders/people told me not to go there	6	6.7
I don’t have time	4	4.5
it is far	3	3.4
I stay to places I know	3	3.4
dangerous animals/snakes	3	3.3
dragons	2	2.2
I don’t know	1	1.1
Have you heard of the *ninkananka*?		
yes	84	94.4
no	5	5.6
Is the *ninkananka* real?		
yes	72	80.9
I don't know	9	10.1
I haven't heard of the *ninkananka*	5	5.6
no	3	3.4
Do others believe it is real?		
Everyone belives it is real	34	38.2
Most people believe it is real	31	34.8
Some people believe it is real	11	12.4
I haven’t heard of the *ninkananka*	5	5.6

Question	*Frequency*	*Percentage*
Almost everyone believes it is real	3	3.4
No one believes is is real	2	2.2
I don't know	2	2.2
Many people believe it is real	1	1.1
How have you learned of it?		
old men	46	51.7
parents	17	19.1
elders	12	13.5
I haven't heard of the *ninkananka*	5	5.6
in the bush	2	2.2
book	2	2.2
teacher	1	1.1
local incident	1	1.1
boys	1	1.1
How old were you when you first learned about it?		
7-14	51	57.3
0-6	19	21.3
15-29	9	10.1
I haven't heard of the *ninkananka*	5	5.6
30-49	4	4.5
50+	1	1.1
Do you know where the *ninkananka* lives?		
yes	47	52.8
no	37	41.6
I haven't heard of the *ninkananka*	5	5.6
Have you been to that area?		
no	61	68.5
yes	23	25.8
I haven't heard of the *ninkananka*	5	5.6
Do other people go to that area?		
no	33	37.1
yes	23	25.8
few people go	15	16.9
I haven't heard of the *ninkananka*	5	5.6
most people go	4	4.5
people might enter accidentally	3	3.4
some people go	2	2.2

Question	*Frequency*	*Percentage*
Have you seen the *ninkananka*?		
no	82	92.1
I haven't heard of the *ninkananka*	5	5.6
yes	2	2.2
Do you know someone who has seen it?		
no	55	61.8
yes	29	32.6
I haven't heard of the *ninkananka*	5	5.6
What happens if you see the *ninkananka*?		
you die	46	51.7
sick or die	11	12.4
some are lucky, but some die	9	10.1
if you are scared, you become sick and/or die	5	5.6
I haven't heard of the *ninkananka*	5	5.6
nothing	3	3.4
I don't know	2	2.2
chases you and you run away	2	2.2
if you wait to tell of it then you will survive	2	2.2
you die if you are over 50 or if *ninkananka* sees you	1	1.1
you are scared, lucky see white *ninkananka*	1	1.1
you get sick	1	1.1
Have you heard stories about the *ninkananka*?		
yes	59	66.3
no	25	28.1
I haven't heard of the *ninkananka*	5	5.6
Do you know what it looks like?		
yes	64	71.9
no	20	22.4
I haven't heard of the *ninkananka*	5	5.6
like a snake	49	55.1
big	11	12.4
like a lamp or a mirror	7	7.9
it has different colors	6	6.7
like a python	4	4.5
like a goat or sheep	4	4.5

Question	*Frequency*	*Percentage*
it can change shape/animal	4	4.5
like a crocodile	3	3.4
starts small then gets big	3	3.4
it has big eyes	2	2.2
like an insect	2	2.2
it has scales	2	2.2
it is green	2	2.2
it is brown	2	2.2
if you see a white one, it is lucky	2	2.2
it breathes fire from the mouth	1	1.1
it makes a noise like clanging metal	1	1.1
it has a crested head/horn	1	1.1
it has legs	1	1.1
like a bird	1	1.1

SI 3-7 Correlation of demographic factors with belief in the *ninkananka*

Demographic Factor	Fisher's exact value	*p*-value
Gender	4.46	0.20
Age	7.42	0.55
Living outside village	1.61	0.77
Relatives outside village	2.02	0.58
Prayer frequency	5.09	1.00
Mosque visit frequency	22.29	0.19
Purpose for bush visits	19.37	0.60
Education	16.61	0.01*
Islamic Studies	17.65	0.03*
Frequency bush visits	21.30	0.03*

*Significance level < 0.05

SI 3-8 Belief in the *ninkananka* correlated with education level of respondents

		Is the *ninkananka* real?				
Education		no	yes	I don't know	I haven't heard of *ninkananka*	total
none	count	0	37	2	1	40
	% within education	0	92.5	5	2.5	100
	% within belief	0	51.39	22.22	20	44.94
some primary	count	0	19	3	2	24
	% within education	0	79.17	12.5	8.33	100
	% within belief	0	26.39	33.33	40	26.97
some junior secondary	count	1	11	1	2	15
	% within education	6.67	73.33	6.67	13.33	100
	% within belief	33.33	15.28	11.11	40	16.85
some senior secondary	count	2	5	3	0	10
	% within education	20	50	30	0	100
	% within belief	66.67	6.94	33.33	0	11.24
total	count	3	72	9	5	89
	% within education	3.37	80.9	10.11	5.62	100
	% within belief	100	100	100	100	100

SI 3-9 Islamic studies correlated with belief in the *ninkananka*

		Is the *ninkananka* real?				
Islamic studies		no	yes	I don't know	I haven't heard of *ninkananka*	total
none	count	0	17	0	0	17
	% within Islamic studies	0	100	0	0	100
	% within belief	0	23.6	0	0	19.1
village study	count	1	51	9	5	66
	% within Islamic studies	1.5	77.3	13.6	7.6	100
	% within belief	33.3	70.8	100	100	74.2
advanced study	count	2	4	0	0	6
	% within Islamic studies	33.3	66.7	0	0	100
	% within belief	66.7	5.6	0	0	6.7
total	count	3	72	9	5	89
	% within education	3.4	80.9	10.1	5.6	100
	% within belief	100	100	100	100	100

SI 3-10 Frequency of trips to the bush correlated with belief in the *ninkananka*

		Is the *ninkananka* real?				
Frequency of trips to the bush		no	yes	I don't know	I haven't heard of *ninkananka*	total
never	count	0	6	0	1	7
	% within bush frequency	0	85.7	0	14.3	100
	% within belief	0	8.3	0	20	7.9
rarely	count	0	2	2	0	4
	% within bush frequency	0	50.0	50.0	0	100
	% within belief	0	2.8	22.2	0	4.5
monthly	count	0	0	1	1	2
	% within bush frequency	0	0	50	50	100
	% within belief	0	0	11.1	20	2.2
weekly	count	0	4	0	1	5
	% within bush frequency	0	80	0	20	100
	% within belief	33.33	15.28	11.11	40	16.85
daily	count	3	60	6	2	71
	% within bush frequency	4.2	84.5	8.5	2.8	100
	% within belief	100	83.3	66.7	40	79.8
total	count	3	72	9	5	89
	% within bush frequency	3.4	80.9	10.1	5.6	100
	% within belief	100	100	100	100	100

SI 3-11 N, mean and standard error of the mean Normalized Difference Vegetation Index (NDVI) for area types by land cover

Mangroves			1984		1988		1991		1999		2002		2006		2009	
		n	Mean	s.e.m.	Mean	s.e.m.	Mean	s.e.m.	Mean	s.e.m.	Mean	s.e.m.	Mean	s.e.m.	Mean	s.e.m.
	Dragon Areas	3	0.30	0.01	0.55	0.01	0.31	0.02	0.46	0.02	0.53	0.01	0.49	0.02	0.49	0.03
	National Park	8	0.27	0.02	0.41	0.04	0.27	0.02	0.38	0.03	0.45	0.03	0.37	0.03	0.38	0.03
	Surrounding Areas	16	0.19	0.02	0.23	0.04	0.18	0.02	0.17	0.04	0.22	0.05	0.22	0.03	0.22	0.04
	Total	27														
Savanna woodland/woodland transition			1984		1988		1991		1999		2002		2006		2009	
		n	Mean	s.e.m.	Mean	s.e.m.	Mean	s.e.m.	Mean	s.e.m.	Mean	s.e.m.	Mean	s.e.m.	Mean	s.e.m.
	Dragon Areas	9	0.35	0.02	0.48	0.01	0.35	0.01	0.49	0.02	0.65	0.01	0.47	0.02	0.52	0.01
	Forest Parks	3	0.31	0.01	0.44	0.02	0.37	0.01	0.48	0.02	0.65	0.01	0.42	0.01	0.52	0.01
	National Park	12	0.34	0.01	0.43	0.01	0.31	0.01	0.48	0.01	0.59	0.01	0.43	0.01	0.49	0.01
	Surrounding Areas	20	0.30	0.01	0.44	0.01	0.36	0.01	0.44	0.01	0.61	0.02	0.41	0.01	0.48	0.02
	Total	44														
Riparian and fringing savanna woodlands/woodlands			1984		1988		1991		1999		2002		2006		2009	
		n	Mean	s.e.m.	Mean	s.e.m.	Mean	s.e.m.	Mean	s.e.m.	Mean	s.e.m.	Mean	s.e.m.	Mean	s.e.m.
	Dragon Areas	7	0.38	0.01	0.50	0.01	0.34	0.01	0.51	0.01	0.67	0.02	0.51	0.01	0.54	0.00
	Forest Parks	8	0.31	0.01	0.41	0.02	0.35	0.01	0.41	0.03	0.64	0.01	0.40	0.01	0.51	0.01
	National Park	7	0.35	0.01	0.46	0.01	0.33	0.01	0.48	0.01	0.62	0.02	0.46	0.01	0.49	0.01
	Surrounding Areas	22	0.33	0.01	0.42	0.01	0.32	0.01	0.43	0.01	0.57	0.01	0.40	0.01	0.44	0.01
	Total	44														

SI 3-12 Repeated measures ANOVA (1984, 1988, 1991, 1999, 2002, 2006, 2009) for NDVI of mangroves: pairwise comparisons of area types (Dragon areas n=3, National park n=8, Surrounding areas n=16, Total n=27), alpha value p=0.05*

Pairwise comparisons

(A) Area Type	(B) Area Type	Mean Difference (A-B)	Std. Error	p[a]	95% Confidence Interval for Difference[a]	
					Lower Bound	Upper Bound
Dragon Areas	National Park	.086	.077	.825	-.112	.284
	Surrounding Areas	.245*	.072	.007*	.060	.429
National Park	Dragon Areas	-.086	.077	.825	-.284	.112
	Surrounding Areas	.159*	.049	.011*	.032	.286

Based on estimated marginal means

a. Adjustment for multiple comparisons: Bonferroni

SI 3-13 Independent Samples Kruskal-Wallis Test for NDVI of area types in land covers (alpha level p=0.05, asymptotic significances displayed; All land covers: Dragon areas n=19, Forest parks n=11, National park n=27, Surrounding areas n=58, Total n=115; Savannah woodlands/woodland transition: Dragon areas n=9, Forest parks n=3, National park n=12, Surrounding areas n=20, Total n=44; Riparian and fringing savannah woodlands/woodlands: Dragon areas n=7, Forest parks n=8, National park n=7, Surrounding areas n=22, Total n=44)

Year	All land covers (p)	Savanna woodlands/woodland transition (p)	Riparian and fringing savanna woodlands/woodlands (p)
1984	.002*	.003*	.006*
1988	.000*	0.055	.001*
1991	.008*	.003*	0.001
1999	.000*	.049*	.000*
2002	.000*	.039*	.000*
2006	.000*	0.195	.000*
2009	.000*	0.231	.000*

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Chapter 4 Ethiopian church forests and pollination services across an agricultural landscape

As discussed in chapter one, forest patches serve as habitat and refugia for flora and fauna and increase connectivity in the landscape. Chapter three demonstrated that sacred forests, specifically dragon forests, can persist over time in the face of rapid land use change. Forest patches are also considered an important feature in the landscape due to the ecosystem services they can provide, which can contribute to poverty alleviation and local livelihoods (Schelhas and Greenberg, 1996, Sheridan and Nyamweru, 2008, Howe et al., 2013). This chapter presents the second of four papers of the thesis, and addresses research question 2) How do the location and distribution of sacred forests affect the provision of ecosystem services in diverse landscapes?

In agricultural landscapes, forest fragments can contain nesting habitat and forage resources suitable for pollinators that increase crop yields (Kremen et al., 2007, Klein et al., 2007, Ricketts et al., 2008), in addition to providing other valuable ecosystem services such as pest and weed control (Bianchi et al., 2006) and soil retention (Zhang et al., 2007). This paper maps the distribution of Ethiopian Orthodox Tewahido Church forests in an agricultural landscape in South Gondar, Amhara, northern Ethiopia, and estimates the pollination services to surrounding croplands by honeybees nesting and foraging in the church forests. At 1,461,537 ha, the study area and the district scale of analysis are the second smallest of the thesis. This paper assesses the second highest number of sacred forests of the study areas, 1,173 church forests, which are a form of sacred natural sites. The land tenure of this landscape is all state-owned, but in practice, the state sanctions church management of church lands.

Ethiopian Orthodox Tewahido churches, locally known as *debr* or *geddam*, are powerful local religious and social institutions that are up to 1500 years old. Churches operate autonomously with local priests and clergy. The total number of Ethiopian Orthodox Tewahido church forests is unknown; estimates range from a few thousand to 35,000 (Wassie et al., 2005, Cardelús et al., 2013). The forests surrounding the churches are often several centuries old ((McCann, 1997), and trees range from utilitarian species such as coffee or juniper (used for church construction) to revered old-age trees believed to house angels guarding the church (Wassie et al., 2005).

This study demonstrates how conservationists can apply the observations of custodians to available datasets to assess sacred natural sites in terms of ecosystem service provision. The ecosystem services that church forests provide, such as pollination for agricultural crops, may impact livelihoods and offer additional reasons for protection in cases where spiritual or religious values are pitted against livelihoods. For example, it may be helpful for priests to address grazing pressures on the edges of church forests with an additional economic argument: that as the last forest sites for nesting and forage for bees, the church forests improve crop harvests. The following chapter, chapter five, builds upon this idea and introduces case studies where similar ecological understanding has increased the social-ecological resilience of sacred forests over time.

4.1 Paper 2: Ethiopian church forests and pollination services across an agricultural landscape

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Journal: *Geoforum*

4.2 Abstract

Forest fragments provide ecosystem services in agricultural landscapes, from forage resources for pollinators to pest and weed control in croplands. Over the past three centuries, most Afromontane forest in Ethiopia's highlands has been converted for crops and grazing, with Ethiopian Orthodox Tewahido churches protecting the last forest remnants. A farmer in South Gondar noted that after his village cleared their church forest, crop yields decreased dramatically. We identified the crops grown and their pollination requirements, and obtained photographs of insects within the church forests. We compared the biodiversity of the church forests with bee forage. Finally, we identified the flowering calendars of bee forage species found in the church forests with crop planting calendars. Comparison of bee forage and crop flowering calendars indicated that in this agricultural landscape, crops are an insufficient source of forage and nesting resources for bees. Our review of regional data supported the hypothesis that church forest clearance could affect crop yields due to decreased visitation by pollinators. As South Gondar had such a stark contrast in land use, with the church forests appearing as green 'oases' in a brown agricultural 'desert', it offered a natural 'control' landscape for a study on how the distribution of church forests across the landscape may impact agricultural yields due to pollination services. We identified 1,173 Ethiopian church forests covering 7,235 hectares (0.5% of South Gondar, Amhara) and mapped surrounding pollination zones using honeybee foraging distance. Our results indicate church forests could support pollination service delivery by honeybees to up to 83% of South Gondar's cropland (and 19% of South Gondar overall). This study demonstrates how conservationists can apply the observations of custodians to available datasets to assess sacred natural sites in terms of ecosystem service provision and develop new research and conservation agendas in their landscapes.

4.3 Introduction

The Convention on Biological Diversity's Aichi Targets aim to increase the global land area conserved to 17% by 2020, including areas important for ecosystem services (Target 11) that contribute to the livelihoods and wellbeing of local communities, the poor and vulnerable (Target 14) (Secretariat of the Convention on Biological Diversity, 2011). There is an increasing awareness of the need for biodiversity conservation beyond protected areas, which comprise 87% of the Earth's terrestrial surface (Bhagwat and Rutte, 2006, UNEP-WCMC, 2012, Chazdon et al., 2009, Gardner et al., 2009). Forest patches have been identified as an important feature in the landscape due to the essential ecosystem services they can provide, which contribute to poverty alleviation, local livelihoods and human wellbeing (Schelhas and Greenberg, 1996, Sheridan and Nyamweru, 2008, Howe et al., 2013). In agricultural landscapes, forest fragments can contain nesting habitat and forage resources suitable for pollinators that increase crop yields (Kremen et al., 2007, Klein et al., 2007, Ricketts et al., 2008), in addition to providing other valuable ecosystem services such as pest and weed control (Bianchi et al., 2006) and soil retention (Zhang et al., 2007).

Forest patches surround places of worship (Bhagwat and Rutte, 2006, Verschuuren et al., 2010). For example, it has been estimated that in India there are 100,000-150,000 sacred groves (Malhotra et al., 2001), in Japan there are roughly 80,000 Shinto shrine forests (Jinja Honcho, 2011) and in Ethiopia there are as many as 35,000 Ethiopian Orthodox Tewahido church forests alone (Wassie et al., 2005). In addition to providing cultural ecosystem services, sacred natural sites serve as refugia for species and add ecological memory (Bengtsson et al., 2003) in the landscape (Mgumia and Oba, 2003a, Ntiamoa-Baidu, 2008, Bhagwat et al., 2005b). They also may increase landscape connectivity (Ishii et al., 2010) and provide ecosystem services such as pollination and seed dispersal critical for productive agroecosystems (Bodin et al., 2006, Tambat, 2005). In addition to ecological benefits and increased area for conservation networks, forest fragments (including sacred natural sites) can enhance livelihoods (Schelhas and Greenberg, 1996, Malhotra et al., 2001, Zhang et al., 2007). However, their contribution to rural agrarian communities has never been quantified on a landscape scale. This study therefore aims to determine the relative contribution of one ecosystem service, pollination, that small sacred natural sites make across agricultural landscapes.

We estimate pollination zones around Ethiopian church forests in South Gondar, Amhara, a geographical area prioritized for forest conservation and sustaining local livelihoods (zur Heide, 2012). We focus on pollination services provided by honeybees *(Apis mellifera)* as honeybees: 1) are ubiquitous in Ethiopia (Pauly and Hora, 2013), 2) serve as indicator species in many studies investigating pollination service delivery and distance from natural and semi-natural habitat patches (Ricketts et al., 2008), 3) are key pollinators for all crops grown in South Gondar that benefit from insect pollination (Central Statistical Agency of Ethiopia, 2012b, Klein et al., 2007, Admassu and Nuru, 1999) and 4) contribute directly to local livelihoods and the economy– honey is a major agricultural product in the region and Ethiopia is the top African exporter of honey and wax (Central Statistical Agency of Ethiopia, 2012a, Pauly and Hora, 2013). We ask, what is the extent of South Gondar cropland that falls within the pollination zones of church forests? How might pollination services provided by church forests contribute to local livelihoods?

4.3.1 Study area

This study was carried out in the South Gondar administrative zone of the Amhara region in northern Ethiopia. Lying to the east of Lake Tana (11°02’–12°33’N and 37°25’–38°41’E), South Gondar covers an area of 1,461,537 hectares with elevation ranging from

1500m to 4231m (Figure 4-1).

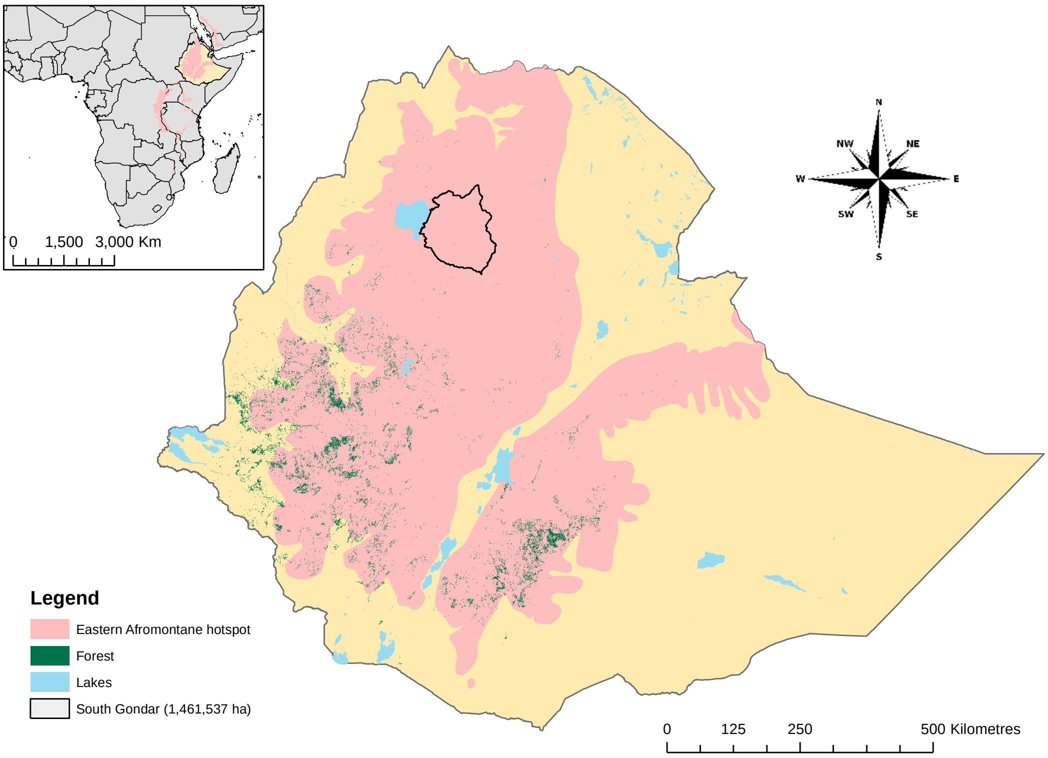


Figure 4-1 Forest cover of Ethiopia, part of the Eastern Afromontane hotspot and South Gondar administrative zone (study area). Only 1.2% of Ethiopia is forest and thousands of Ethiopian Orthodox Tewahido Church forests comprise the last remnants of Afromontane forest in the northern highlands (Wassie et al., 2005, European Space Agency, 2009, Conservation International, 2011, Global Administrative Areas, 2012, Cardelús et al., 2013, FAO, 2015).

A high intensity rainy season (June – August) is followed by a low intensity season (March – May); average annual rainfall ranges from 700 mm – 1300 m and average annual temperatures range from a minimum of 9.3°C to a maximum of 23.7°C (Wassie et al., 2010).

Ethiopia is the second most populous country in Africa, and subsistence-based livelihoods are dependent on agriculture and livestock. Over 95% of Ethiopia's agriculture is private peasant land holdings and <5% is commercial agriculture (Central Statistical Agency of Ethiopia, 2011). In Amhara region 43% of people live in extreme poverty (zur Heide, 2012) and in South Gondar administrative zone, private peasant land holdings average only 1.38 hectares (Central Statistical Agency of Ethiopia, 2012c).

Ethiopia is Africa's top exporter of honey and wax (Pauly and Hora, 2013)and Amhara's honey production comprises 22% of national production (Central Statistical Agency of Ethiopia, 2013). South Gondar hosts 10% of beehives in Amhara, producing 6.5% of Amhara's honey. Honey is predominantly collected from traditional beehives in the forest, which account for 95% of beehives in South Gondar and 97% of production, with the remainder collected from intermediate or modern beehives. In South Gondar, 54% of honey is sold, 44% is used for household consumption and 2% is used in other ways (Central Statistical Agency of Ethiopia, 2012a). Honey is an important complement to local diets as it keeps for periods of food scarcity, is served as a medicine or tonic, has cultural value as a festival drink of honey mead, or 'tej', and wax is used to make votive candles for religious ceremonies (Ejigu et al., 2009).

In addition to honey production, pollination by honeybees has been shown to improve yields of certain global food crops (Klein et al., 2007). In South Gondar, crops grown by private peasant holdings in the 2010-2012 meher season (harvested September – February) include self-pollinating cereals, which comprise 67-74% of crop area and 71-77% of production, and pulses and oilseeds, crops predominantly pollinated by bees and other insects, which comprise 12-20% and 4-6%, respectively, of crop area and 8-18% and 2-3% of total production (Central
Statistical Agency of Ethiopia, 2012b) (Tables 4-1 and 4-2).

Table 4-1 Production data for South Gondar (2012/13 is forecast) (Central Statistical Agency of Ethiopia, 2012b)

	Total Area (hectares)			Total Production (tonnes)			Yield (tonnes/ha)		
	2010/11	2011/12	2012/13	2010/11	2011/12	2012/13	2010/11	2011/12	2012/13
Cereals	388,627.73	362,468.53	399,582.74	63,657.24	604,659.23	717,829.61			
Eragrostis tef (Teff)	129,446.68	126,360.03	142,031.04	162,901.74	162,901.74	171,422.00	1.26	1.29	1.21
Hordeum vulgare L. (Barley)	35,861.26	27,617.33	62,150.84	47,437.27	47,437.27	36,192.00	1.32	1.72	0.58
Triticum spp. (Wheat)	78,880.22	72,549.66	85,161.09	135,203.04	135,203.04	123,416.62	1.71	1.86	1.45
Zea mays subsp. mays L. (Maize)	44,519.52	39,655.97	34,589.16	98,448.03	98,448.03	94,828.58	2.21	2.48	2.74
*Sorghum L. (*Sorghum)	37,856.93	41,794.11	15,877.48	63,415.80	63,415.80	67,502.65	1.68	1.52	4.25
Eleusine coracana (Finger Millet)	39,152.85	31,673.76	26,012.79	53,624.01	53,624.01	39,548.77	1.37	1.69	1.52
Oryza glaberrima (Rice)		22,757.80		71,656.13	71,656.13			3.15	
Pulses	86,919.55	109,138.30	63,555.28	119,998.27	149,512.03	77,528.60		1.37	
Vicia faba (Faba Beans)	12,449.30	14,708.42	20,435.70	13,254.70	17,079.56	25,857.59	1.06	1.16	1.27
Pisum sativum (Field Peas)	8,559.63	12,073.24	9,804.25	10,023.07	13,789.13	11,333.83	1.17	1.14	1.16
Phaseolus vulgaris (Haricot Beans)			13,127.75			14,937.17			1.14
Cicer arietinum (Chickpeas)	17,539.39	20,358.04	4,307.99	22,750.29	27,535.50	6,024.35	1.30	1.35	1.40
Lens culinaris (Lentils)	2,605.90	5,635.09	7,252.64		5,473.43	7,144.90	0.00	0.97	0.99
Lathyrus sativus (Grass Peas)	35,086.88	35,949.01	4,486.04	56,434.08	54,894.61	6,724.13	1.61	1.53	1.50

	Total Area (hectares)			Total Production (tonnes)			Yield (tonnes/ha)		
	2010/11	2011/12	2012/13	2010/11	2011/12	2012/13	2010/11	2011/12	2012/13
Trigonella foenum-graecum (Fenugreek)		236.55	197.01		204.57	170.90		0.86	0.87
Lupinus termis Forssk (Gibto)						5,335.74			
Oilseeds	22,051.19	31,737.40	32,682.60	14,793.92	26,303.54	27,470.99			
Guizotia abyssinica (Neug)	14,747.58	18,370.04	19,870.15	10,397.73	15,636.69	17,194.92	0.71	0.85	0.87
Linum usitatissimum (Linseed)	5,924.67	8,082.82	7,531.51	2,879.84	3,998.04	3,750.72	0.49	0.49	0.50
Brassica napus (Rapeseed)	1,064.32	4,655.73	4,417.12	1,347.16	6,138.74	5,852.20	1.27	1.32	1.32
Root Crops	6,550.57	5,827.26	10,422.80	49,876.58	44,338.89	79,213.60	7.61	7.61	7.60
Solanum tuberosum (Potatoes)	6,545.83	5,815.55	10,422.80	49,859.64	44,297.06	79,213.60	7.62	7.62	7.60

Table 4-2. Crops of South Gondar and level of yield increases from pollination by bees and other insects (Matiur et al., 1995, Admassu and Nuru, 1999, Klein et al., 2007, Central Statistical Agency of Ethiopia, 2012b)

	Insect pollination	Pollinators (bees in bold)
Cereals	Does not increase yields (Klein et al. 2007)	Self-pollinating
Pulses		
Vicia faba (Faba Beans)	10-40% increase in yields (Klein et al. 2007)	**Apis mellifera L., Bombus lapidarius L., Bombus pascuorum Scopoli, Bombus hortorum L.,** Anthophora plumipes Pallas, Eucera spp., **Megachile rotundata Fabricius**
Pisum sativum (Field Peas)	0-10% increase in yields (Klein et al. 2007)	**Apis spp., Bombus spp.**
Phaseolus vulgaris (Haricot Beans)	0-10% increase in yields (Klein et al. 2007)	**Apis florea Fabricius, Bombus spp.**, Thysanoptera
Cicer arietinum (Chickpeas)	Does not increase yields (Klein et al. 2007)	**Apis mellifera L., Megachilidae, Halictidae**
Lens culinaris (Lentils)	Does not increase yields (Klein et al. 2007)	**Apidae**
Lathyrus sativus (Grass Peas)	Insect pollination observed (Matiur et al., 1995)	**Apidae**
Trigonella foenum-graecum (Fenugreek)	Unknown	
Lupinus termis Forssk (Gibto)	Unknown	
Oilseeds		
Guizotia abyssinica (Neug or Niger Seed)	~43% increase in yields (Admassu and Nuru, 1999)	**Apis mellifera bandasii**[*]
Linum usitatissimum (Linseed)	0-10% increase in yields (Klein et al. 2007)	**Apis mellifera L., Bombus spp.**
Brassica napus (Rapeseed)	10-40% increase in yields (Klein et al. 2007)	**Apis mellifera L., Bombus spp.,** Andrena spp., Osmia cornifrons Radoszkowski, Osmia lignaria Say, **Halictus spp.,** Syrphidae
Root Crops		
Solanum tuberosum (Potatoes)	Increases seed production (Klein et al. 2007)	Unknown

[*] This species has recently been formally named Apis mellifera simensis PAULY, A. & HORA, Z. A. 2013. Apini and Meliponini from Ethiopia (Hymenoptera Apoidea Apidae Apinae).

Despite accounting for <20% of crop production in South Gondar, pulses and oilseeds are economically higher value crops than cereals and serve as critical local sources of 1) dietary protein, 2) animal fodder and 3) nitrogen fixation (Rashid et al., 2010). After coffee, oilseeds and pulses are the second and third largest export crops in Ethiopia, and the production of pulses has surged over the last decade. Ethiopia is the second largest producer of faba beans after China and one of the top ten honey and pulse-producing nations in the world (Rashid et al., 2010, FAO, 2015) Bees and other insects increase yields of pulses and oilseeds; especially notable in South Gondar are neug or niger seed (*Guizotia abyssinica*) (~43% increased yields), faba bean (*Vicia faba*) and rapeseed (*Brassica napus*) (10-40% increased yields) and field pea (*Pisum sativum*), haricot bean (*Phaseolus vulgaris*) and linseed (*Linum usitatissimum*) (0-10% increased yields) (Admassu and Nuru, 1999, Klein et al., 2007, Central Statistical Agency of Ethiopia, 2012b, Matiur et al., 1995).

Podocarpus-Juniperus forest once covered the Ethiopian highlands (Friis, 1992) and *Juniperus-Olea-Celtis* has dominated the northern highlands since the fifteenth century (Darbyshire et al., 2003). Over the past three centuries, this Afromontane forest has been converted to cropland and grazing land, with church forest fragments left as small islands in the agricultural landscape (Darbyshire et al., 2003, Cardelús et al., 2013). Only 1.2% of the present-day Ethiopian landscape is forest (FAO, 2015) and thousands of Ethiopian Orthodox Tewahido Church forests comprise these last remnants of Afromontane forest in the northern highlands (Wassie et al., 2005, Cardelús et al., 2013). Afromontane forest is prioritized for international conservation as part of the Eastern Afromontane biodiversity hotspot (Conservation International, 2011) and the Ethiopian montane grasslands and woodlands ecoregion (Mittermeier et al., 2004). In addition, three of the top ten watersheds globally prioritized for biodiversity and ecosystem services are found in Ethiopia (Luck et al., 2009). In the Lake Tana region, the Community-based Integrated Natural Resources Management Project aims to develop 650 watershed management plans by 2017 to increase agricultural productivity, including forests and fisheries (IFAD, 2013). The Lake Tana region is also under consideration as a biosphere reserve, with complementary goals of conservation and sustainable development (zur Heide, 2012).

Ethiopian Orthodox Tewahido churches, locally known as *debr* or *geddam*, are powerful local religious and social institutions that are up to 1500 years old. Churches operate autonomously and their total number is unknown; estimates range from a few thousand to 35,000 (Wassie et al., 2005, Cardelús et al., 2013). The forests surrounding the churches are often several centuries old (McCann, 1997); trees range from utilitarian species such as coffee or juniper (used for church construction) to revered old-age trees believed to house angels guarding the church (Wassie et al., 2005). In 28 church forests in South Gondar, Wassie et al. (2010) inventoried 168 woody species, 160 of which are indigenous. Seed banks for native plants, church forests store ecological memory in the agricultural landscape (Wassie and Teketay, 2006) and serve as refugia for flora and fauna that have largely disappeared from northern Ethiopia. However, these church forests are currently under threat. High demand for fuelwood and land in Ethiopia renders them vulnerable to exploitation and conversion to agriculture. They have been decreasing in vegetation density and in area over recent decades (Wassie et al., 2005, Cardelús et al., 2013).

One farmer in South Gondar noted that after his village cleared their church forest, crop yields decreased dramatically. In this paper, we consider the implications of church forest distribution for pollination services and agricultural yields on a landscape scale.

4.4 Methods

First we reviewed the literature on the biodiversity found in church forests in South Gondar, the region of the farmer who described decreased crop yields after church forest clearance. We identified the crops grown and their pollination requirements, and obtained photographs of insects within the church forests. We compared the biodiversity of the church forests with bee forage. Finally, we identified the flowering calendars of bee forage species found in the church forests with crop planting calendars. Comparison of bee forage and crop flowering calendars indicated that in this agricultural landscape, crops are an insufficient source of forage and nesting resources for bees. Our review of regional data supported the hypothesis that church forest clearance could affect crop yields due to decreased visitation by pollinators. As South Gondar had such a stark contrast in land use, with the church forests appearing as green ‘oases’ in a brown agricultural ‘desert’, it offered a natural ‘control’ landscape for a study on how the distribution of church forests across the landscape may impact agricultural yields due to pollination services.

To identify church forests in the South Gondar zone of Amhara region, northern Ethiopia, we systematically scanned Google Earth and Bing Maps imagery for church domes; the aerial view of silver or brightly painted church domes in patches of green Afromontane forest starkly contrasts with the surrounding brown agricultural landscape (Figure 4-2).

a)

b)

c)

Figure 4-2 Debresena Ethiopian Orthodox Tewahido Church forest, South Gondar; church dome surrounded by forest and an agricultural landscape, a) from the agricultural matrix (Phil Wittman) and b) aerial view (Google Earth), c) honeybee (*Apis mellifera)* in Gelawdiwos church forest in South Gondar (Phillip Harpootlian). Most church forests are quite small, with an average size of 6.16 (±0.54) hectares.

We created a point layer of church domes in ArcGIS v.10.0 and overlaid a vegetation cover layer we derived from an April 2013 Landsat 8 satellite image (30 m, <2% cloud cover (<1% in the study area), WGS 84, Africa Albers Equal Area Conic projection) by calculating the Normalized Difference Vegetation Index (NDVI) as: $\frac{near\text{-}infrared-red}{near\text{-}infrared+red}$ where near-infrared is band 5 (0.845-0.885 μm) and red is band 4 (0.630-0.680 μm) (Tucker, 1979). April is in the dry season in Ethiopia, so the contrast between agricultural land and forests is most pronounced. The locations of over 60 Afromontane forests in South Gondar and neighbouring zones were ground-truthed to verify our identification method. All points were confirmed as church forests save one, which was a public building. We further mapped 15 forests' perimeters using handheld GPS and cross-referenced these areas with our NDVI GIS layer, determining that Afromontane forest pixels largely exhibit NDVI>0.25. We performed a supervised classification of the South Gondar satellite image, identifying pixels with NDVI>0.25 as likely forest. Next, to map the church forests, we used the point layer of church domes and selected contiguous forest pixels within 1000 m of the church points. Ground-truthing indicated that forested pixels in South Gondar not identified as church forests were predominantly eucalyptus plantings. We calculated the area of church forests and performed spatial statistics on their distribution in South Gondar in ArcGIS (Average Nearest Neighbour, NNRatio: 0.80, NNZScore: -12.42, p=0.00). We mapped the cropland of South Gondar using GlobCover data (European Space Agency, 2009), removing forested pixels we identified in our analysis using the erase function in the overlay analysis tool in ArcGIS.

We catalogued the bee species observed in church forests in South Gondar in geolocated photographs taken by Phillip Hartpoolian and Phil Wittman as well as specimens collected by Erica McAlister 6-28 January 2012. Next we assessed the suitability of church forests in South Gondar as habitat for honeybees. Honeybees are central-place foragers, foraging floral resources in the landscape and returning to fixed nest sites in habitat patches (Kremen et al., 2007). *Apis mellifera* frequently nest in tree hollows, which are found in church forests due to prohibitions against tree clearance (Roubik, 1989, Wassie et al., 2005) and some communities practice traditional and modern beekeeping within church forests (zur Heide, 2012). Honeybee forage resources are plentiful in South Gondar from August to October with the *kiremt*, or big rains (June to September) which coincide with the *meher* crop season (crops harvested between September and February), and a second flowering period dominated by trees follows the spring rains, or *belg* (March to May), however forage resources are scarce from January to March following the dry season (November to February) (Fichtl and Adi, 1994, Bezabeh, 2006). We assessed the floral resources for pollinators in church forests by consulting species lists of vegetation recorded in church forest plots and examining the proportion of plant species known to be honeybee forage (Wassie et al., 2005, Fichtl and Adi, 1994, Bezabeh, 2006). We also mapped the seasonal availability of honeybee forage resources in South Gondar church forests using flowering period data, available for 39 of the 61 honeybee forage species in church forests (Fichtl and Adi, 1994).

We created pollination 'donuts' surrounding the church forests using the foraging distance of honeybees, which we derived via two methods. First, we considered a global meta-analysis of 23 studies by Ricketts et al. (2008) that employs Bayesian techniques to quantify the distance of 50% decay of pollinator visitation rates from habitat patches (Ricketts et al., 2008). Twenty of the studies included visitation rates of *Apis mellifera*. When these were included Ricketts et al. (2008) found a distance of 2,170 m (no range given) for the 50% decline of pollinator visitation. We applied this distance (2,170 m) to the edge of church forests to create pollination 'donuts' in ArcGIS v. 10.0 (Figure 4-3).

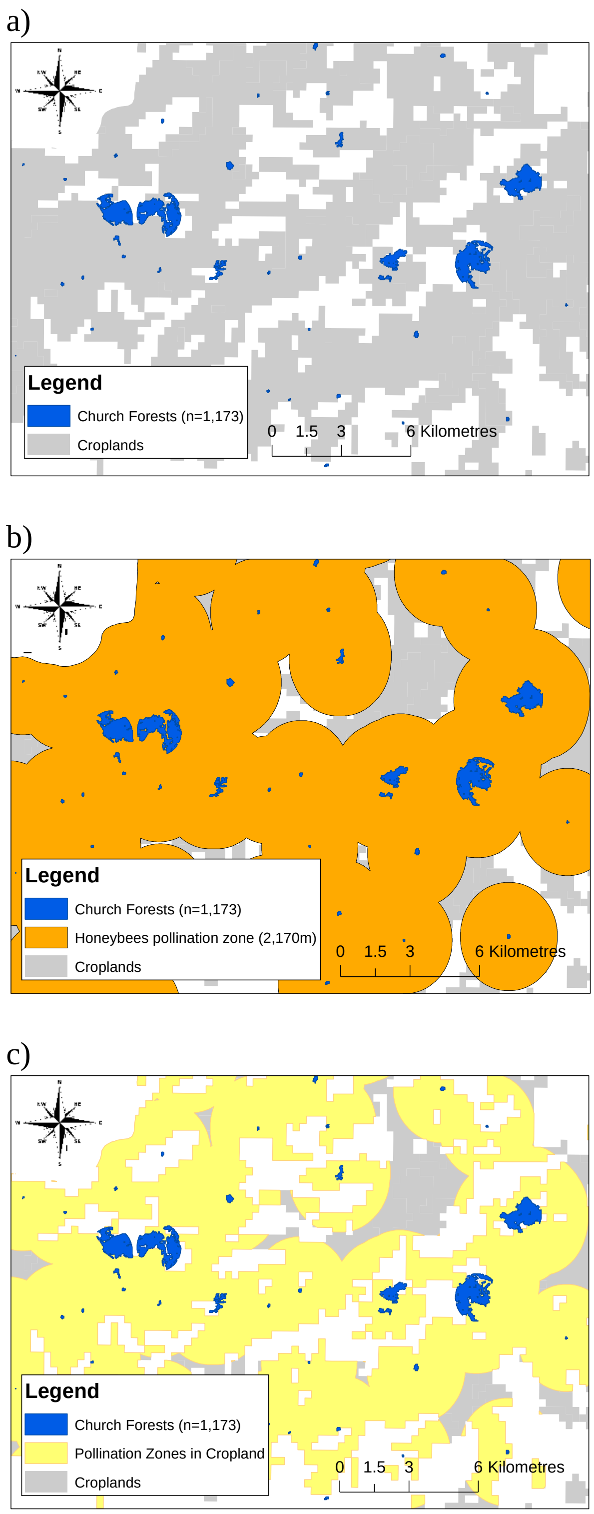


Figure 4-3 a) We overlaid church forests with croplands in ArcGIS v.10.0, b) created pollination ‘donuts’ surrounding church forests by measuring a distance of 2,170 m, the distance of 50% decay of pollinator visitation rates from habitat patches (Ricketts et al., 2008), outwards from the edges of the church forests and c) created pollination zones where the pollination ‘donuts’ overlapped with cropland (European Space Agency, 2009)

Using the buffer analysis tool in ArcGIS, we specified buffer distance: 2,170 m, side type: ‘outside only’ (excluding the church forests from the pollination zones), and dissolve type: ‘all’ (merging overlapping pollination zones together).

We applied a second method to ensure the distance of 2,170 m derived from the metadata was appropriate for South Gondar pollination zones. We calculated the foraging distance of South Gondar’s honeybee *Apis mellifera simensis* using the relationship between bee body size and foraging distance found by Greenleaf et al. (Greenleaf et al., 2007). We applied their logistical regression to the intertegular span measurement of South Gondar *Apis mellifera simensis* (3 mm) (Pauly and Hora, 2013), and calculated a predicted maximum feeding distance of 2,206 m (no range feasible to calculate) (Greenleaf et al., 2007). With this distance only 36 m greater than the distance derived from the global metadata on pollinator visitation rates, we are confident that global metadata is applicable in our case, if not slightly conservative.

Finally, to examine the potential of honeybees to provide pollination services from church forests to Ethiopian cropland, we employed the near function in the proximity analysis tool of ArcGIS to determine the number of church forests within 2,170 m of croplands. We overlaid the church forest pollination donuts with the croplands layer (derived from GlobCover data with forested pixels removed) (European Space Agency, 2009) via the intersect function in the overlay analysis tool in ArcGIS. We then calculated the area of church forest pollination zones that fall within South Gondar croplands.

4.4.1 Limitations

The landscape structure of South Gondar is quite homogenous, and is predominantly composed of a sea of agricultural land with islands of church forests. This simple landscape structure enabled us to estimate pollination services of sacred forests on a landscape scale. As previously mentioned, honeybee hives in South Gondar are predominantly traditional hives placed in forests. We assumed the church forests are the only location for hives, however there may be non-traditional hives kept by farmers outside of the church forests within the agricultural matrix. Our pollination services map therefore only covers potential pollination zones from hives in forest patches. Our church forest flowering season analysis indicated that at times of forage scarcity, church forests are the only source of food for bees in the landscape. If we consider church forests as sources of forage in times of scarcity as opposed to nesting resources, the maximum foraging distance of honeybees would be the same distance, but mapped to the church forest from the hives. In this case, the pollination services zones would cover an even greater area, making the church forests as nesting zones a more conservative estimate.

While the pollination zones indicate where pollination services could occur in the agricultural landscape of South Gondar, pollination service delivery is also strongly dependent on landscape structure, pollinator abundance, microclimate and the presence of competitors, predators, pathogens and parasites, and therefore pollinator services will be heterogeneous in these landscapes (Kremen et al., 2007). Performing this analysis with a map of crops planted would also be useful; our map has croplands that fall outside of the pollination areas, but as self-pollinating crops are dominant in this region, it is conceivable that farmers have altered where they plant their crops based on observed yields.

4.5 Results

We recorded 1,173 church forests in South Gondar, ranging in size from 0.09 to 254.94 hectares (Figure 4-4).

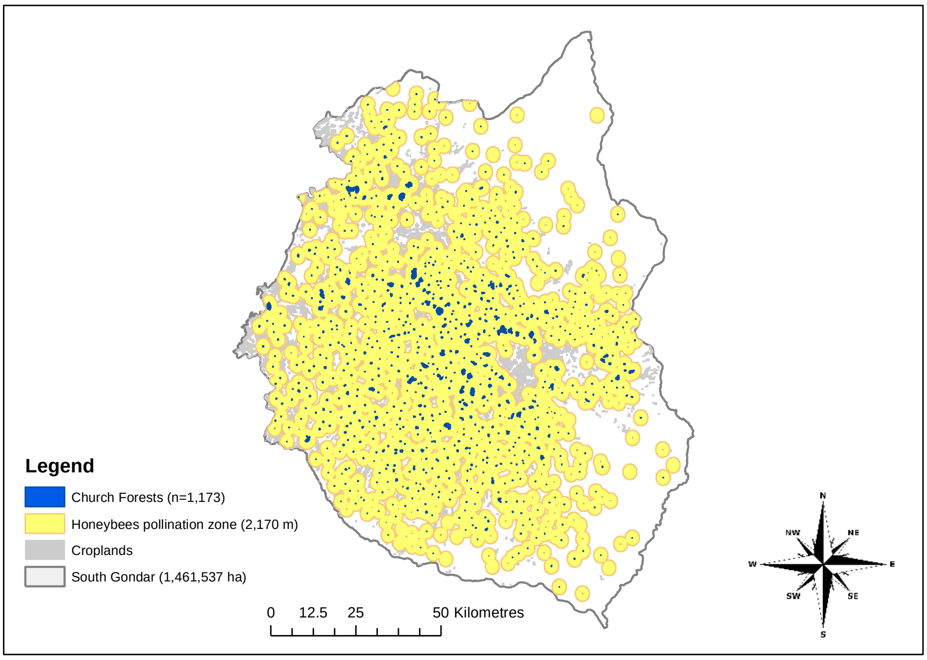


Figure 4-4 We recorded 1,173 church forests in South Gondar covering 7,235 hectares (covering 0.5% of South Gondar). Pollination zones with radii of 2,170m in South Gondar, Amhara, Ethiopia, were overlaid with croplands to determine that pollination zones of honeybees cover 292,866 ha, or 83%, of croplands (19% of South Gondar) (Ricketts et al., 2008, European Space Agency, 2009, 2012).

The largest forests likely reflect the capture of national forest, such as Alem Saga in central South Gondar, or eucalyptus plantations within 1000 m of church domes. Most church forests are quite small, however, with an average size of 6.16 (±0.54) hectares. In total the 1,173 church forests cover 7,235 hectares, or 0.5% of South Gondar. Spatial statistics show the observed mean distance between church forests in South Gondar is 1,503 m and there is less than 1% likelihood that the clustered pattern of church forests in South Gondar is due to random chance.

Honeybee and wild bee species were observed in South Gondar (Table 4-3).

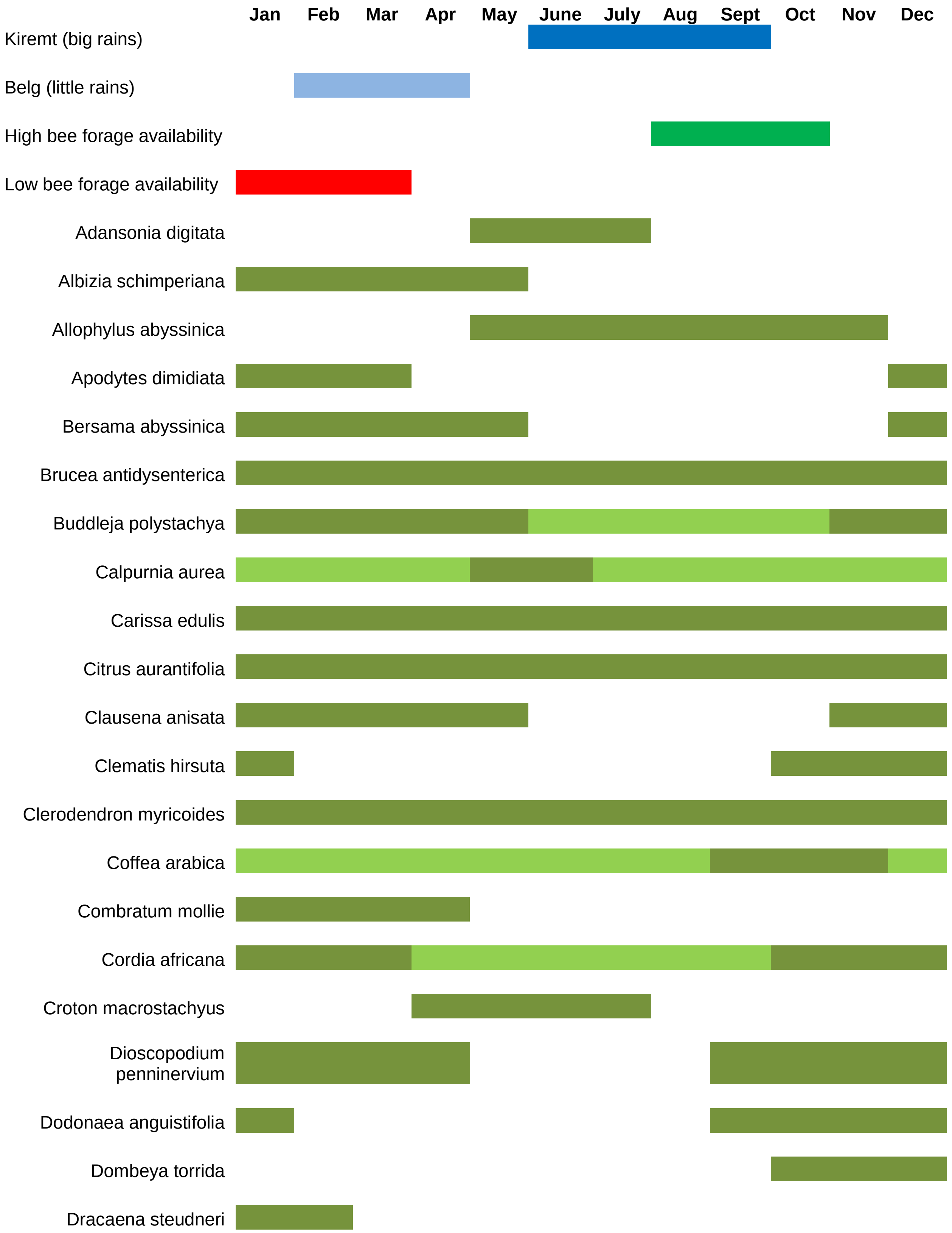
Table 4-3. Bee species observed (photographs or specimens) in South Gondar church forests.

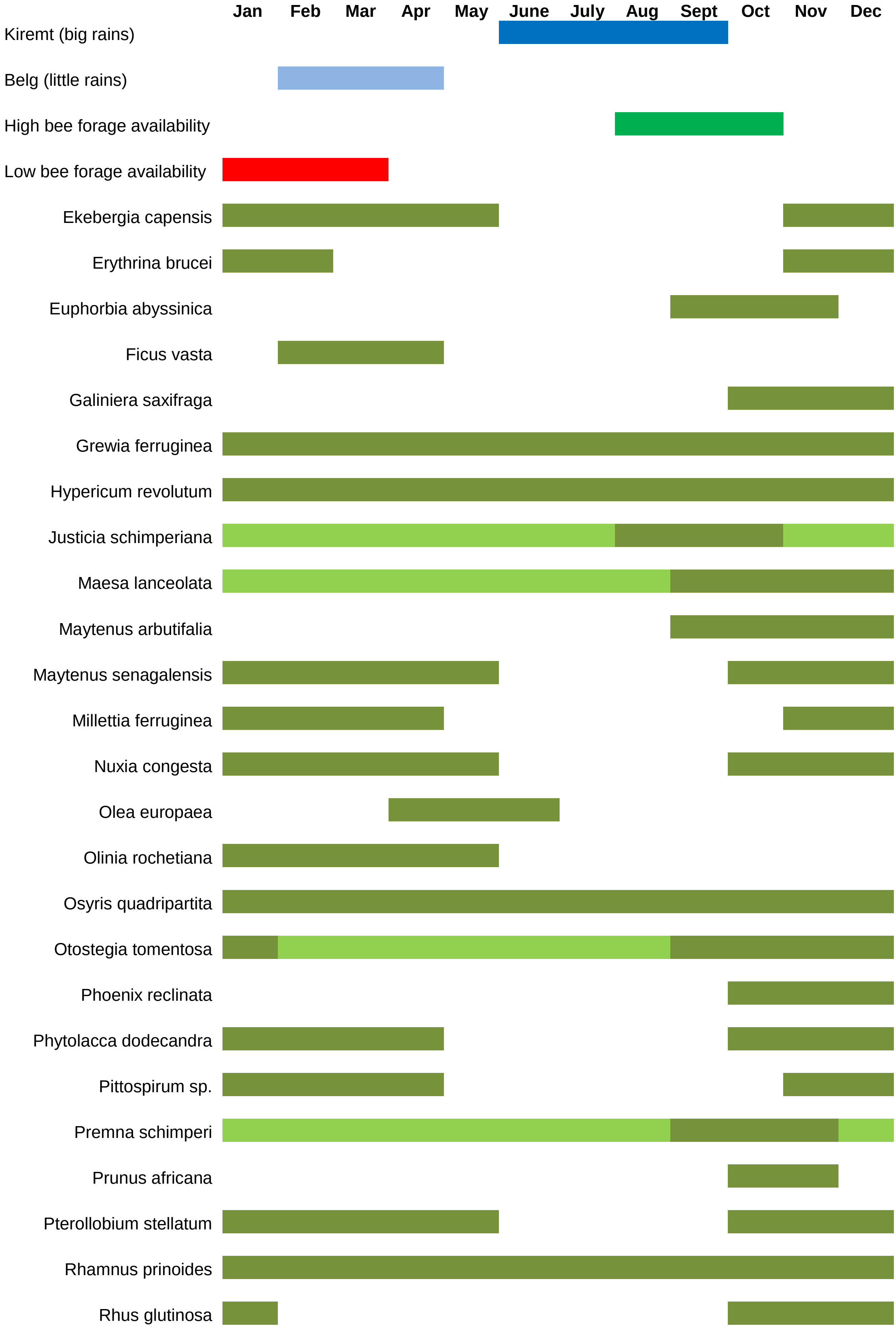
Bee species	Collection zone	Nesting (Roubik 1989)	Type	Latitude	Longitude
Apis mellifera (simensis)	Forest edge, Gelawdios	Tree hollows (frequently), caves, subterranean holes (occasionally), used nests, beetle burrows, foliage, exposed, ant nests, termitaria (rarely)	Photograph	11.64115	37.81227
Apis mellifera (simensis)	Forest edge, Gelawdios	Tree hollows (frequently), caves, subterranean holes (occasionally), used nests, beetle burrows, foliage, exposed, ant nests, termitaria (rarely)	Photograph	11.641863	37.812767
Apis mellifera (simensis)	Agricultural matrix	Tree hollows (frequently), caves, subterranean holes (occasionally), used nests, beetle burrows, foliage, exposed, ant nests, termitaria (rarely)	Photograph	11.59820454	38.07468301
Apis mellifera (simensis)	Forest edge	Tree hollows (frequently), caves, subterranean holes (occasionally), used nests, beetle burrows, foliage, exposed, ant nests, termitaria (rarely)	Photograph	11.853163	37.988731
Apis mellifera (simensis)	Village	Tree hollows (frequently), caves, subterranean holes (occasionally), used nests, beetle burrows, foliage, exposed, ant nests, termitaria (rarely)	Photograph	11.85732534	38.00484656
Apis mellifera (simensis)	Forest edge	Tree hollows (frequently), caves, subterranean holes (occasionally), used nests, beetle burrows, foliage, exposed, ant nests, termitaria (rarely)	Photograph	11.85302222	37.98921111
Lasioglossum (Afrodialictus) sp1	Forest core	Open ground (frequently), twigs, used nests, beetle burrows (rarely)	Specimen	11.85	37.983333
Lasioglossum (Afrodialictus) sp1	Forest edge, Gelawdios	Open ground (frequently), twigs, used nests, beetle burrows (rarely)	Specimen	11.633333	37.8
Lasioglossum (Afrodialictus) sp2	Forest edge, Gelawdios	Open ground (frequently), twigs, used nests, beetle burrows (rarely)	Specimen	11.633333	37.8
Lasioglossum (Afrodialictus) sp3	Forest core, Debresena	Open ground (frequently), twigs, used nests, beetle burrows (rarely)	Specimen	11.85	37.983333
Lasioglossum (Afrodialictus) sp3	Forest edge, Gelawdios	Open ground (frequently), twigs, used nests, beetle burrows (rarely)	Specimen	11.633333	37.8
Lasioglossum (Afrodialictus) sp3	Forest, Zhara	Open ground (frequently), twigs, used nests, beetle burrows (rarely)	Specimen	11.783333	37.566667
Lasioglossum (Afrodialictus) meruense	Forest edge, Debresena	Open ground (frequently), twigs, used nests, beetle burrows (rarely)	Specimen	11.85	37.983333
Lasioglossum (Ctenonomia) transvalense	Understory edge, Debresena	Open ground (frequently), twigs, used nests, beetle burrows (rarely)	Specimen	11.85	37.983333
Lasioglossum (Ctenonomia) scobe	Forest, Zhara	Open ground (frequently), twigs, used nests, beetle burrows (rarely)	Specimen	11.783333	37.55
Lasioglossum (Sellalictus) sp. 1	Forest edge, Galawdios	Open ground (frequently), twigs, used nests, beetle burrows (rarely)	Specimen	11.633333	37.8
Lasioglossum (Sellalictus) sp. 1	Forest edge, Debresena	Open ground (frequently), twigs, used nests, beetle burrows (rarely)	Specimen	11.85	37.983333
Lasioglossum (Ipomalictus) sp.	Forest edge, Zhara	Open ground (frequently), twigs, used nests, beetle burrows (rarely)	Photograph	11.7989695	37.5675988
Megachile sp.	Forest edge	Beetle burrows (frequently), twigs, used nests, open ground (occasionally), tree hollows, caves, subterranean holes, termitaria, exposed (rarely)	Photograph	11.588696	37.678753

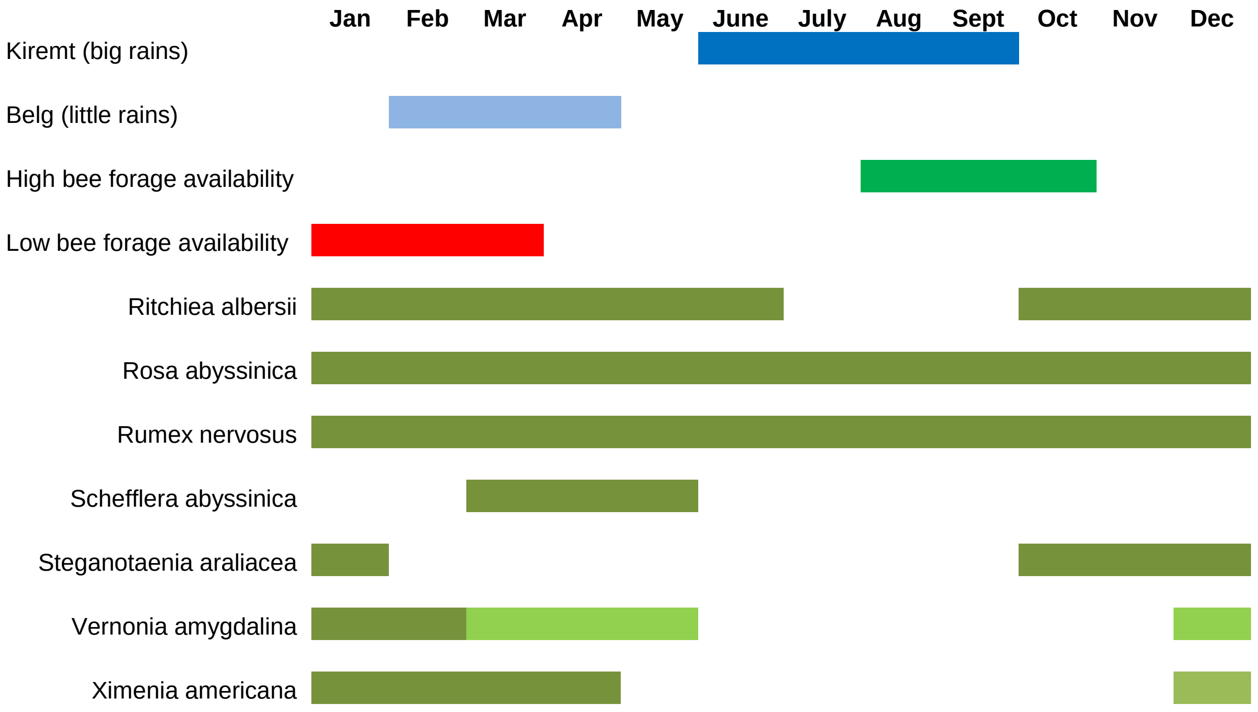
Bee species	Collection zone	Nesting (Roubik 1989)	Type	Latitude	Longitude
Meliponula beccarii	Forest edge	Tree hollows (frequently), caves, subterranean holes (occasionally), used nests, beetle burrows, foliage, exposed, ant nests, termitaria (rarely)	Photograph	11.50677833	37.63024167
Seladonia foana	Swept, Zhara	Open ground (frequently), twigs, used nests, beetle burrows (rarely)	Specimen	11.783333	37.566667
Seladonia sp.	Understory, Debesena	Open ground (frequently), twigs, used nests, beetle burrows (rarely)	Specimen	11.85	37.983333
Seladonia sp.	Agricultural matrix	Open ground (frequently), twigs, used nests, beetle burrows (rarely)	Photograph	11.59831267	38.07447212
Seladonia sp.	Forest edge	Open ground (frequently), twigs, used nests, beetle burrows (rarely)	Photograph	11.586018	37.679111
Xylocopa	Forest edge	Tree hollows (frequently), caves, subterranean holes (occasionally), used nests, beetle burrows, foliage, exposed, ant nests, termitaria (rarely)	Photograph	11.633796	37.529037
Xylocopa	Forest edge, Gelawdios	Tree hollows (frequently), caves, subterranean holes (occasionally), used nests, beetle burrows, foliage, exposed, ant nests, termitaria (rarely)	Photograph	11.641225	37.812809
Zonalictus sp. 1	Forest core, Gelawdios	Open ground (frequently), twigs, used nests, beetle burrows (rarely)	Specimen	11.633333	37.8
Zonalictus sp. 2	Swept, Zhara	Open ground (frequently), twigs, used nests, beetle burrows (rarely)	Specimen	11.783333	37.566667

Honeybee flora comprise 64% of vegetation species surveyed in church forests, many of which provide floral resources at various times of the year outside of the crop flowering period, when floral resources are scarce (Table 4-4).

Table 4-4 Flowering periods of honeybee flora in South Gondar church forests (light green indicates flowering, dark green indicates flowering profusely). Adapted from species lists of vegetation recorded in South Gondar church forest plots by Wassie et al. (2005) and honeybee flora of Ethiopia (Fichtl and Adi, 1994, Bezabeh, 2006).




Jan
Feb
Mar
Apr
May
June
July
Aug
Sept
Oct
Nov
Dec
Kiremt (big rains)
Belg (little rains)
High bee forage availability
Low bee forage availability
Ekebergia capensis
Erythrina brucei
Euphorbia abyssinica
Ficus vasta
Galiniera saxifraga
Grewia ferruginea
Hypericum revolutum
Justicia schimperiana
Maesa lanceolata
Maytenus arbutifalia
Maytenus senagalensis
Millettia ferruginea
Nuxia congesta
Olea europaea
Olinia rochetiana
Osyris quadripartita
Otostegia tomentosa
Phoenix reclinata
Phytolacca dodecandra
Pittospirum sp.
Premna schimperi
Prunus africana
Pterollobium stellatum
Rhamnus prinoides
Rhus glutinosa



Of the 1,173 church forests we recorded in South Gondar, 1,028, or 88% of them, are located within 2,170 m of croplands. Croplands cover 341,639 hectares, or 23% of South Gondar (European Space Agency, 2009). Our spatial analysis of cropland cover and the foraging distances of honeybees from the mapped church forests finds that pollination zones of honeybees surrounding church forests may cover up to 282,866 ha, or up to 83% of croplands and 19% of South Gondar.

4.6 Discussion

Even in agricultural landscapes where the pressure to convert forest to agricultural land can be great, remnant forest fragments are conserved due to underlying spiritual and religious values, including sacred natural sites such as the Ethiopian Orthodox Tewahido church forests of this study. Sacred natural sites can provide resources for direct use by local communities, i.e. fuel wood, medicinal plants and harvest of non-timber forest products. However, this study shows how seemingly small and individually managed sacred natural sites might also provide ecosystem services to a much greater area of the agricultural landscape beyond their footprints, for example, serving as pollination reservoirs for croplands, contributing significantly to local livelihoods in the process.

First we asked, what is the extent of South Gondar cropland that falls within the estimated pollination zones of church forests? We find that although church forests in South Gondar are quite small, covering a total of 7,235 ha, only 0.5% of South Gondar, the pollination zones that surround church forests in croplands could cover 282,866 ha, or 83% of South Gondar's croplands. In this case, pollination services provided by church forests would be delivered over an area nearly 42 times greater than the footprint of the church forests. Future work could build on this study to test pollination frequency across the landscape and geolocate hives, and apply this approach in landscapes where pollination science and crop mapping are more advanced.

The clustered distribution of church forests in South Gondar most likely occurs because church forests are embedded in populated agricultural landscapes and follow agricultural settlement patterns. This is underscored by our finding that 88% of the church forests we recorded in South Gondar are located within 2,170 m of croplands. There is a mean observed distance between church forests of 1,503 m – the proximity of this distance to the honeybee foraging distance of 2,170 m accounts for the widespread coverage of croplands by pollination zones. Cropland beyond pollination zones can be targeted by agricultural extension agents for the planting of pollination reservoirs to create additional habitat for pollinators (Brosi et al., 2008). Our findings support the assertions of Bodin et al. (2006) that the location of sacred forests are key determinants of pollination service delivery in the landscape (Bodin et al., 2006).

The vegetation species richness of church forests varies with altitude and grazing intensity (Wassie et al., 2010); thus the number of honeybee flora species in a given church forest will vary from our overall finding that 64% of vegetation species surveyed in church forests comprise honeybee flora. Our comparison of church forest vegetation species with honeybee flora flowering periods indicates that church forests provide honeybee forage resources throughout the year, including during dearth periods when resources are scarce. In the Ethiopian region of Tigray, to the north of Amhara, Teklay (2011) also finds the species diversity of honeybee flora significantly higher in closed forest in both wet and dry seasons than in homestead, pastureland and rain-fed croplands (Teklay, 2011). The provision of honeybee forage resources by church forests is important as the availability of honeybee forage impacts local honey production– Amhara beekeepers report a lack of suitable honeybee forage as their main constraint (Ejigu et al., 2009). In addition to church forests, eucalyptus plantations in the landscape provide honeybee forage throughout the year, but particularly after the *belg*, or spring rains, when trees are the predominant flowering vegetation (Bezabeh, 2006).

4.7 Conclusion

The bulk of the literature on the ecological role of sacred natural sites focuses on the biodiversity within the sites' boundaries. However, an increasing interest in ecosystem services and the implications of the conservation of sacred natural sites for the land uses outside of their boundaries highlights the imbalance of data for surrounding areas. This study demonstrates how conservationists can apply the observations of custodians to available datasets to assess sacred natural sites in terms of ecosystem service provision and develop new research and conservation agendas in their landscapes. Identification of ecosystem services such as pollination for agricultural crops can support custodians, for example, in efforts to secure land tenure for the last stands of forest in the landscape. The conservation of sacred natural sites in agricultural landscapes has the potential to contribute to the Convention on Biological Diversity's Aichi Targets for

2020, including areas important for ecosystem services (Target 11). Such areas can contribute to the livelihoods and wellbeing of local communities, the poor and vulnerable (Target 14) while respecting cultural practices that conserve biodiversity (Target 18) (Secretariat of the Convention on Biological Diversity, 2011).

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Chapter 5 Incorporating social-ecological systems into protected area networks: Indigenous and Community Conserved Areas (ICCAs) in Sabah, Malaysian Borneo

Chapter four considered the ecosystem services that sacred forests can provide beyond their boundaries to their custodians. In some cases, the identification of ecosystem services can help answer environmental questions based on observation, for example, the observation of a farmer in chapter four who noticed crop yields fell dramatically after the clearance of a church forest. Identifying a reason to support the management of sacred forests in addition to spiritual and religious values may prove benefical in times of social-ecological change, which is explored further in this chapter.

The development of conservation is linked to two different conceptual mechanisms– the ecological understanding model and the depletion crisis model. The ecological understanding model roots conservation in the slow accumulation of knowledge describing the human-environment relationship, including observations of changes in ecosystems and natural cycles, lessons from the past and other enviornments, observations of predator-prey interactions and migration cycles, monitoring resource use and ecosystem engineering by humans (Turner and Berkes, 2006). The depeletion crisis model posits that conservation behaviour is developed following a realization of resource scarcity. In this model, conservation is often the result of a resource crisis (Berkes and Turner, 2006). This chapter employs Gunderson and Holling's (2001) adaptive cycle to illustrate transformations of social-ecological systems over time, from resource exploitation (r) to conservation (k) in a bioculturally diverse landscape: Sabah, Malaysian Borneo.

The third largest island in the world (743,000 sq. km), Borneo is one of the most biodiverse places on Earth. Over 700 tree species have been recorded in a ten-hectare plot

— the number of tree species found in Canada and the United States combined (WWF Germany, 2005). Seventy percent of Sabah's population live in rural areas and conserve forests in a myriad of locally developed ways (Tongkul, 2002). Sabah has high rates of cultural diversity– indigenous people comprise 60% of Sabah's population, with over 30 ethnic groups speaking 50 languages and 80 dialects (Tongkul, 2002). Chazdon et al. (2009, p. 147) propose a research agenda in such landscapes, noting: "Designing successful conservation strategies requires an understanding of how and why local residents manage their landscapes and adapt to environmental changes". Pungetti et al. (2012:2) concur, arguing that conservation efforts should "only expect to achieve optimum results when undertaking an approach that involves and fully integrates cultural perspectives in nature conservation".

This chapter presents the third of four papers of the thesis, and addresses research question 3) How can conservationists engage with custodians of sacred forests in bioculturally diverse landscapes? We surveyed community representatives of 24 villages in the matrix of land uses beyond protected areas across Sabah about natural resource use, regulations, and forms of community-based conservation. At 7,363,100 ha, the study area and the scale of analysis, regional, are the second largest of the thesis. This paper considers the second fewest number of sacred forests of the study areas, 43 sacred forests, which include a mix of sacred groves, community forests, and forms of natural resource management using taboos. The land tenure of this landscape is all state-controlled. In practice, the common property resource is managed by village committees, who also apply for special status for their reserves, including Native Forest Reserves, to protect against interventions by state departments or state leases to commercial enterprises. One of the case studies of the chapter focuses on riverine management systems. Rivers are state resources overseen by the Department of Fisheries, with each section managed on the ground by the people (or company) occupying the land abutting that river section.

Tagal (or *bombon*) is a customary natural resource management system featuring spatial or temporal regulations on resource use in Sabah. In Kadazan, *tagal*, translated to English as ‘prohibition’, is one way that people sustainably use natural resources, practicing *gompi-guno*, meaning ‘protect and use’ (Vaz and Agama, 2013). In Kadazandusun *bombon* means ‘the controlled river’ (Vun and Yung, 2010). This chapter finds that the management of sacred forests and other forms of natural resource management by custodians is not static, but rather can be shifted by events including religious conversion, modernisation and the influence of outsiders on natural resource use. Communities may engage with the recognition process as a means of gaining land tenure, and ICCAs developed through the ecological understanding model may require additional facilitation and support. Successfully integrating ICCAs into the protected area network a few at a time can provide landscape-scale rewards if the ‘proof of concept’ engages neighbouring communities.

This chapter finds that just as protected area management has shifted towards adaptive management of ecological systems, ICCAs require adaptive governance of their social-ecological systems. Sacred forests and rivers can make valuable contributions in a new paradigm of community conservation– one that acknowledges conservation rooted in ecological understanding, supports conservation in the face of social and ecological changes, and recognizes the autonomy of local custodians in the process.

5.1 Paper 3: Incorporating social-ecological systems into protected area networks: Indigenous and Community Conserved Areas (ICCAs) in Sabah, Malaysian Borneo

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Journal: *Human Ecology*; Previous version of Gumantong case study published in *Society, Biology and Human Affairs* (Massey et al., 2011)

5.2 Abstract

In 2008 the World Commission on Protected Areas amended the governance types for protected areas to include indigenous and community conserved areas and territories (ICCAs). ICCAs have been proposed to improve the connectivity and expand the isolated and fragmented protected area network in Sabah, Malaysian Borneo, one of the most bioculturally diverse areas on earth. Here we ask, how can social-ecological processes beyond protected areas inform conservation policy and practice on a landscape scale? The research employed key informant interviews, oral and written questionnaires, and participant observation on-site and at conservation planning and capacity building workshops from October 2010 to April 2011, following a 6-week pilot trip in Sabah and Sarawak from June to August 2010. We surveyed community representatives of 24 villages in the matrix of land uses beyond protected areas across Sabah about natural

resource use, regulations, and forms of community-based conservation. We contextualized our survey findings with three case studies of community-based conservation, applying the adaptive cycle and ecological understanding/depletion models of conservation. We found that rural villages in Sabah employed village forest reserves, ‘spirit forests’, customary spatial and temporal resource use regulations and water catchment systems to conserve their natural resources. Conservation was practiced to safeguard ecosystem services (e.g. water catchment conservation), for aesthetic/moral reasons (e.g. to protect heritage sites in ancestral lands) and for spiritual reasons. Our research indicated that community-based forms of conservation are not static, but rather can be shifted by events including religious conversion, modernisation and the influence of outsiders on natural resource use. Communities may engage with the recognition process as a means of gaining land tenure, and ICCAs developed through the ecological understanding model may require additional facilitation and support. Successfully integrating ICCAs into the protected area network a few at a time could provide landscape-scale rewards if the ‘proof of concept’ engages neighbouring communities. Just as protected area management has shifted towards adaptive management of ecological systems, ICCAs require adaptive governance of their social-ecological systems. Sacred forests and rivers can make valuable contributions in a new paradigm of community conservation– one that acknowledges conservation rooted in ecological understanding, supports conservation in the face of social and ecological changes, and recognizes the autonomy of local custodians in the process.

5.3 Introduction

Protected areas comprise over 12% of the Earth’s terrestrial surface (UNEP-WCMC, 2012) and the Aichi Targets of the Convention on Biological Diversity (CBD) aim to expand this coverage to 17% by 2020 (Secretariat of the Convention on Biological Diversity, 2011). Increasing the coverage of protected area networks is challenging, however, as the 87% of the terrestrial surface beyond protected areas is a mosaic of land uses (Chazdon et al., 2009). Chazdon et al. (2009, p. 147) propose a research agenda in these landscapes, noting: “Designing successful conservation strategies requires an understanding of how and why local residents manage their landscapes and adapt to environmental changes”.

In the matrix of land uses beyond protected areas, community-based conservation (CBC) devolves natural resource management from national governments to local communities (Horwich and Lyon, 2007). ‘Community’ is a simplistic term used to denote self-regulating groups of natural resource users; the value of this term has been debated (Agrawal and Gibson, 1999). A systematic review of 146 CBC studies across 40 countries presents four definitions of CBC success that are alternatives to standard area-based protection targets: 1) attitudinal (positive changes in views of conservation goals), 2) behavioural (decreased off-take), 3) ecological (improved outcomes for the habitat or species of interest) and 4) economic (variety of livelihood benefits) (Brooks et al., 2012) (Table 5-1).

Table 5-1 Factors increasing the likelihood of successful community-based conservation: results of a systematic review of 146 studies across 40 countries (Brooks et al., 2012)

Type of success	Definition of success	Factors that increase likelihood of success
Attitudinal	Positive changes in views of conservation goals	Project creates or develops social capital
		Communities participate in project initiation, establishment and daily management
		Equity of benefits across community members
Behavioural	Decreased off-take	Project designs develop individual and institutional capacity
		Smaller communities
		Local engagement in cultural traditions and governance
Ecological	Improved outcomes for the habitat or species of interest	Local engagement in cultural traditions and governance
		Project designs develop individual and institutional capacity
		Communities participate in project initiation, establishment and daily management
Economic	Variety of livelihood benefits	Project designs develop individual and institutional capacity
		Communities with tenure rights

The multi-dimensional description of successful community-based conservation counterbalances conservation's focus on total protected area as the primary metric of conservation success. There is an increasing recognition that success of conservation efforts should not only be measured by the size of the area conserved, but also by the interaction between local communities and the environment. Brookes et al.'s (2012) systematic review indicates that if community members perceive an equity of benefits, for example, then their perceptions of conservation goals may be improved. Smaller communities have been found to be more likely to decrease off-take, a metric of successful conservation behaviour. Custodians who are active in governing the area and practicing their cultural traditions lead to ecological success for the target habitat or species of interest. Finally, land tenure can provide livelihood benefits, such as agricultural security, leading to economic benefits. Porodong et al. (2011:337) note: “Success of conservation efforts should not only be measured by the size of area we manage to conserve but also by how far we are willing to recognize the significance of the interaction between local communities and the environment”. Pungetti et al. (2012:2) concur, arguing that conservation efforts should “only expect to achieve optimum results when undertaking an approach that involves and fully integrates cultural perspectives in nature conservation”.

In 2008 the World Commission on Protected Areas amended the governance types for protected areas to include indigenous and community conserved areas and territories (Dudley, 2009). Indigenous and Community Conserved Areas (ICCAs) are “natural and/or modified ecosystems containing significant biodiversity values, ecological services and cultural values, voluntarily conserved by indigenous peoples and local communities, both sedentary and mobile, through customary laws or other effective means” (IUCN, 2003). The prevalence and extent of ICCAs is unknown, however the ICCA Consortium formed during the 2008 World Conservation Congress estimates their extent to equal that of protected areas (nearly 13% of Earth’s terrestrial surface) (ICCA Consortium, 2013).

A wide variety of sites qualify as ICCAs with their own distinctive local contexts, however the ICCA Consortium website notes three defining characteristics:

> “1) A strong relationship exists between indigenous or local communities (sedentary or mobile) and their physical environment (such as a given ecosystem, habitat, resource or species) as a result of cultural, social, economic and other reasons.
>
> 2) The concerned indigenous peoples or local community plays a key role in making decisions about the management of the ecosystem, area or species. The community possesses (in law or in practice) the power to make and enforce key management decisions regarding the territory and resources.
>
> 3) The voluntary management decisions and efforts of the concerned community lead to, or at least are well in the process of leading to, the conservation of

> biodiversity, habitats, species, ecological functions and associated cultural values, regardless of the original management objectives as perceived by the community" (ICCA Consortium, 2013).

The ICCA Consortium website's first defining characteristic of ICCAs describes social-ecological systems: "A strong relationship exists between indigenous or local communities (sedentary or mobile) and their physical environment (such as a given ecosystem, habitat, resource or species) as a result of cultural, social, economic and other reasons" (ICCA Consortium, 2013). Berkes and Turner (2006) attribute the development of conservation to two different conceptual mechanisms– the ecological understanding model and the depletion crisis model. The ecological understanding model roots conservation in the slow accumulation of knowledge describing the human-environment relationship, including observations of changes in ecosystems and natural cycles, lessons from the past and other enviornments, observations of predator-prey interactions and migration cycles, monitoring resource use and ecosystem engineering by humans (Turner and Berkes, 2006). The depeletion crisis model posits that conservation behaviour is developed following a realization of resource scarcity. In this model, conservation is often the result of a resource crisis (Berkes and Turner, 2006).

Gunderson and Holling's (2001) adaptive cycle illustrates transformations of social-ecological systems over time, from resource exploitation (r) to conservation (k) (Figure 5-1).

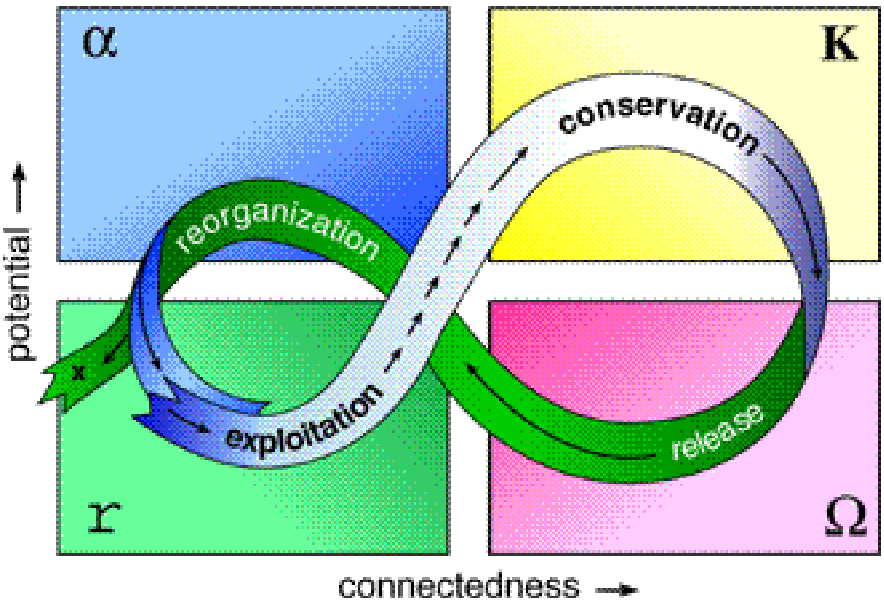


Figure 5-1 Transformations in social-ecological systems described by the adaptive cycle (Gunderson and Holling, 2001).

The shift from conservation (K) to release (Ω) is linked by a single long arrow and indicates a rapidly changing situation (e.g. disturbance via 'small and fast processes'). Once the effects of a disturbance are observed in the system in the release phase (Ω), there is potential for reorganization of the system (α) towards a new trajectory of exploitation (r) to conservation (K), or towards an alternative state (x). Berkes and Turner (2006) similarly describe this transformation with their ecological depletion model, where conservation occurs as a reatction to the observation of a sudden depletion of a resource.

Convesely, Berkes and Turner's (2006) ecological understanding model mirrors the multiple small arrows in the adaptive cyele between exploitation (r) and conservation (K), which represent a slowly changing situation (e.g. accumulation of ecological memory and social memory via 'large and slow' processes). Ecological memory is described by Bengtsson et al. (2003:389): "For ecosystems to reorganize after large-scale natural and human-induced disturbances, spatial resilience in the form of ecological memory is a prerequisite. The ecological memory is composed of the species, interactions and structures that make ecosystem reorganization possible, and its components may be found within disturbed patches as well in the surrounding landscape”. McIntosh (2000:142) notes that social memory “links the symbolic reservoir, that is, the authoritative set of symbols, metaphors, and myths that derive from core values (deep-time and unarticulated) fundamental to a society’s perception of the meaning of space and of its own place in nature and social action” and can be “likened to a calculus that allows society to reinvent responses to the environment in the face of environmental change”. Social-ecological memory is one form of adaptive governance of ICCAs, with the ‘remember’ function linking alternative states of the adaptive cycle (Figure 5-2).

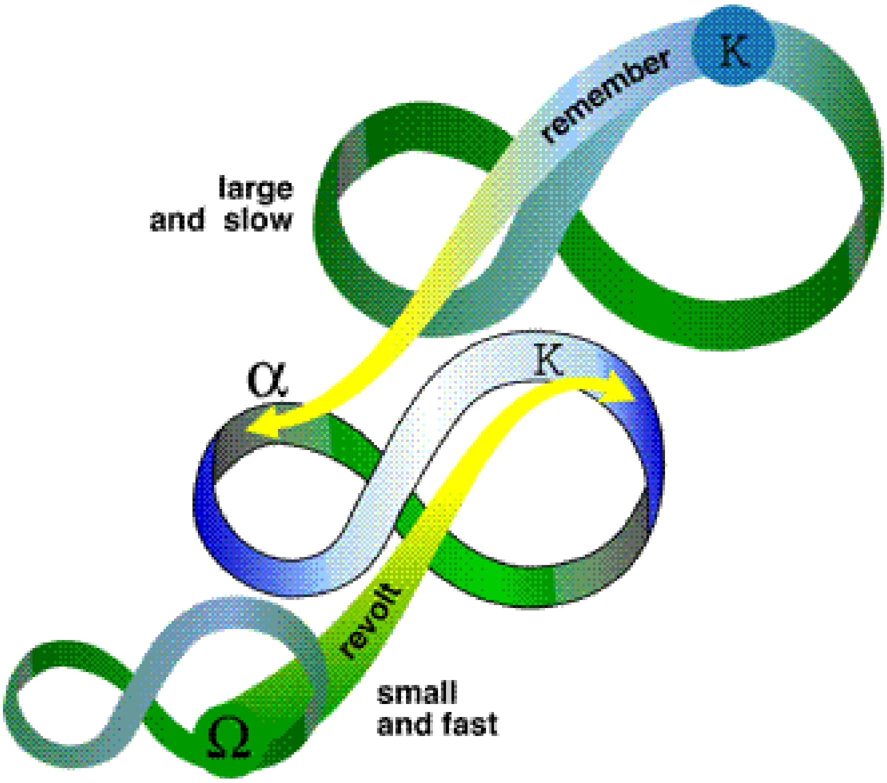


Figure 5-2 Social-ecological memory accumulated through ‘large and slow’ processes and innovation developed through ‘small and fast’ processes can shift an adaptive cycle to an alternative state (‘remember’ or ‘revolt’) (Gunderson and Holling, 2001).

Here we ask, how can social-ecological processes beyond protected areas inform conservation policy and practice on a landscape scale?

5.3.1 Study area

The third largest island in the world (743,000 sq. km), Borneo is one of the most biodiverse places on Earth. Over 700 tree species have been recorded in a ten-hectare plot — the number of tree species found in Canada and the United States combined (WWF Germany, 2005). Malaysian Borneo is comprised of the two states of Sarawak and Sabah, with the small country of Brunei between them in the northern part of the island and Indonesian Borneo to the south. Sabah covers 73,631 sq. km., less than ten percent of the island of Borneo (Reynolds et al., 2011). A variety of protected areas including forest reserves, virgin jungle reserves, wildlife reserves and state parks, cover over 13,500 km^2, or over 18% of Sabah, and Sabah plans to expand the protected network to cover 30% of the land mass over the next ten years (Sario, 2013) (Figure 5-3).

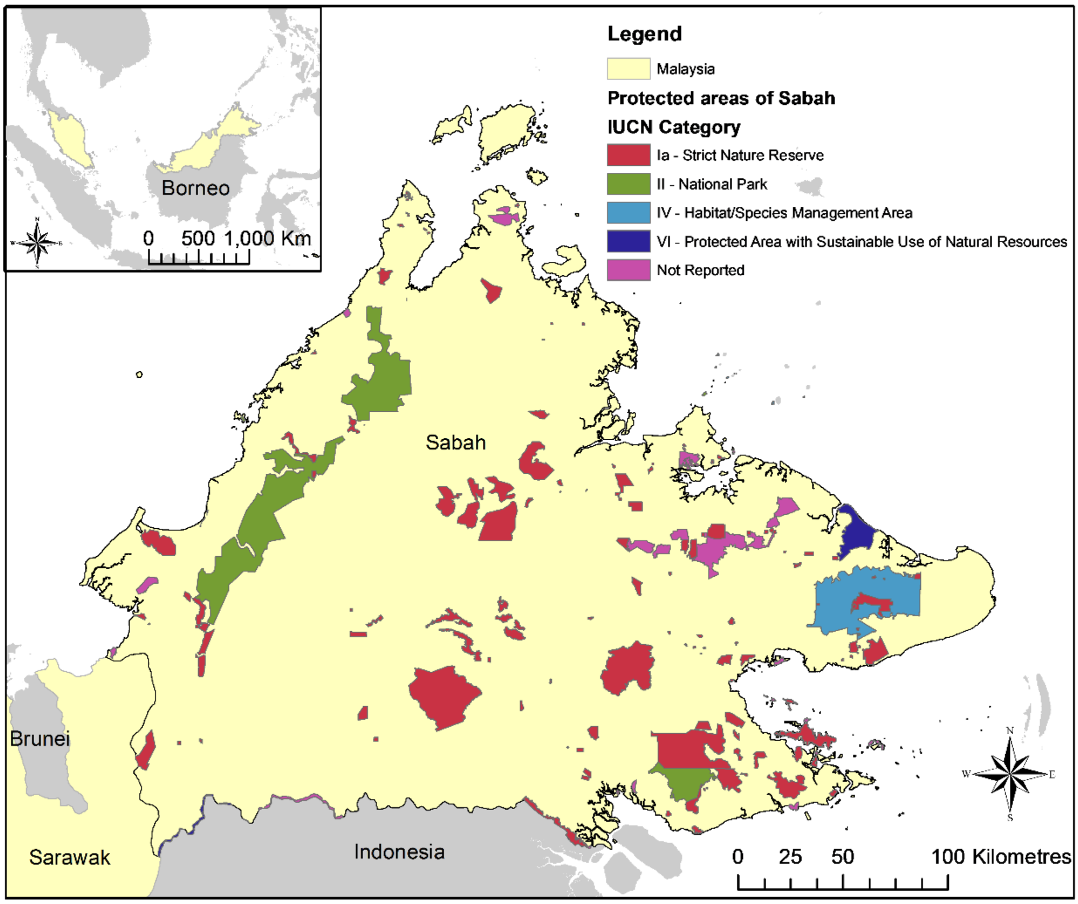


Figure 5-3 Protected areas in Sabah, Malaysia by IUCN category (Global Administrative Areas, 2012, UNEP-WCMC, 2012)

However, Borneo is undergoing widespread conversion of forests to oil palm plantations; oil palm expansion accounted for 86% of deforestation in Malaysian Borneo from 1995-2000 (WWF Germany, 2005) and the state of Sabah had near-complete clearance by 2010 of forest beyond Permanent Forest Reserves and State Parks (Reynolds et al., 2011).

The population of Sabah doubled from 1.34 million in 1987 to 3.12 million in 2010, with a population density around 40 people per sq. km. (Reynolds et al., 2011). Seventy percent of Sabah's population live in rural areas and conserve forests in a myriad of locally developed, culturally specific ways (Tongkul, 2002). Sabah has high rates of cultural diversity– indigenous people comprise 60% of Sabah's population, with over 30 ethnic groups speaking 50 languages and 80 dialects (Tongkul, 2002). Sabah is exploring the potential integration of indigenous and community conserved areas and territories

(ICCAs) with its fragmented protected area network, as demonstrated by the Sabah ICCA Review (Majid Cooke and Vaz, 2011, Vaz and Agama, 2013). In this study, we present survey results on natural resource use, regulations, and community-based conservation of respondents from 24 villages across Sabah and employ three case studies to contextualize these findings. Finally, we present a framework for conservation engagement using social-ecological systems theory (Folke et al., 2005) to make recommendations for the successful integration of ICCAs with protected area networks.

5.4 Methods

Fieldwork was conducted in Sabah, Malaysian Borneo, from October 2010 to April 2011, following a 6-week pilot trip in Sabah and Sarawak from June to August 2010. The research employed key informant interviews, oral and written questionnaires, and participant observation on-site and at conservation planning and capacity building workshops. Access was facilitated by researchers from Universiti Malaysia Sabah and the non-governmental organisations Global Diversity Foundation (GDF) and Partners of Community Organisations (PACOS).

PACOS serves as an umbrella organisation for community organisations in 116 villages in 23 of 25 Sabah districts and holds quarterly capacity-building workshops (i.e. Joint Technical Sessions) for community representatives. In addition to participant observation over eight months, we interviewed and surveyed participants at two PACOS workshops and an additional training (Joint Technical Session 18-19 November 2010, paralegal training for interior communities 23-25 November 2010 and Joint Technical Session 16-17 February 2011). Employing a Malay translator, we piloted an oral questionnaire with two respondents at the first PACOS workshop and an improved version with another five respondents at the second PACOS workshop. We further improved the structure and clarity of the questionnaire, decreased its length, and reformatted it as a written questionnaire in Malay with the assistance of our translator (SI 5-1 and 5-2).

We distributed 49 written questionnaires on the first day of the third workshop and 38 questionnaires were completed and returned to us on the second day. Some representatives did not return to the workshop for the second day due to other obligations, accounting for some of the incomplete surveys. Once the surveys were handed in, we distributed one-page brief follow-up surveys for respondents who had indicated their village had a current or former village forest reserve, spirit forest or *tagal/bombon* resource management system, respectively. *Tagal* (or *bombon*) is a customary natural resource management system featuring spatial or temporal regulations on resource use in Sabah. In Kadazan, *tagal*, translated to English as ‘prohibition’, is one way that people sustainably use natural resources, practicing *gompi-guno*, meaning ‘protect and use’ (Vaz and Agama, 2013). In Kadazandusun *bombon* means ‘the controlled river’ (Vun and Yung, 2010). Due to the extremely high cultural diversity in Sabah, we use ‘spirit forests’ to encompass forests where ancestors or other ‘spirits’ are found. We coded responses in statistical software SPSS v. 21 and removed duplicate respondents randomly. Duplicate respondents occurred when villages had sent two or more representatives to the workshop. After duplicate responses were removed, we had completed questionnaires from representatives of 24 villages, or 20.7% of PACOS villages in Sabah (n=116), from 10 of 25 rural districts (40%) (Figure 5-4).

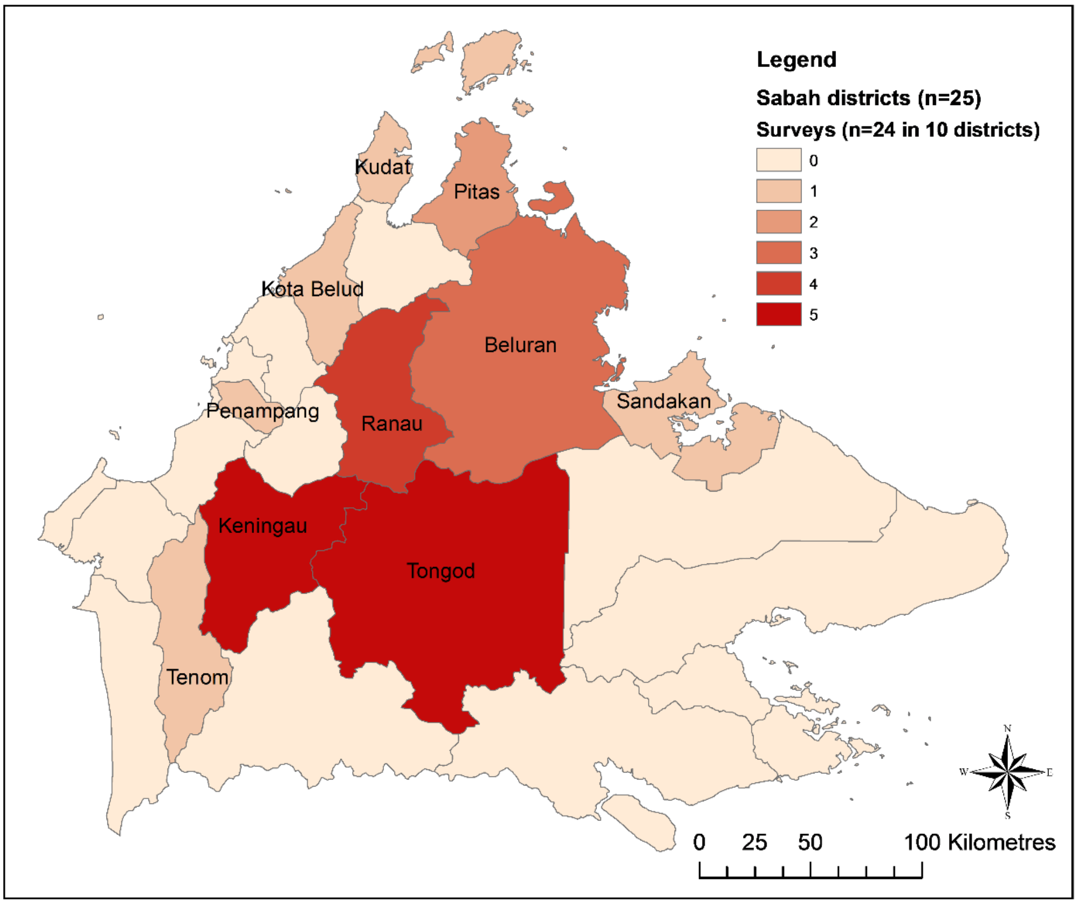


Figure 5-4 Districts of Sabah (n=25). Survey respondents represented 24 of 116 PACOS villages (20.7%) in 10 of 25 districts (40%) (Global Administrative Areas, 2012)

We identified cases studies of conservation of sacred forests and rivers beyond protected areas in Sabah: village forest reserves, 'spirit forests', and *tagal*. The selected case studies each featured high profile interactions with government agencies that regulated natural resource use in Sabah (i.e. Forest Department and Fisheries Department). The research employed key informant interviews, scientific and grey literature reviews, as well as ethnographic tools including participant observation on-site and at conservation planning and capacity building workshops. In addition to over six months of participant observation in Sabah, the primary data for the three case studies on village forest reserves (Bundu Tuhan), 'spirit forests' (Gumantong) and *tagal* (Luanti Baru) came from site visits and key informant interviews on 2-4 December 2010, 6 March 2011 and 23 January 2011, respectively (Figure 5-5).

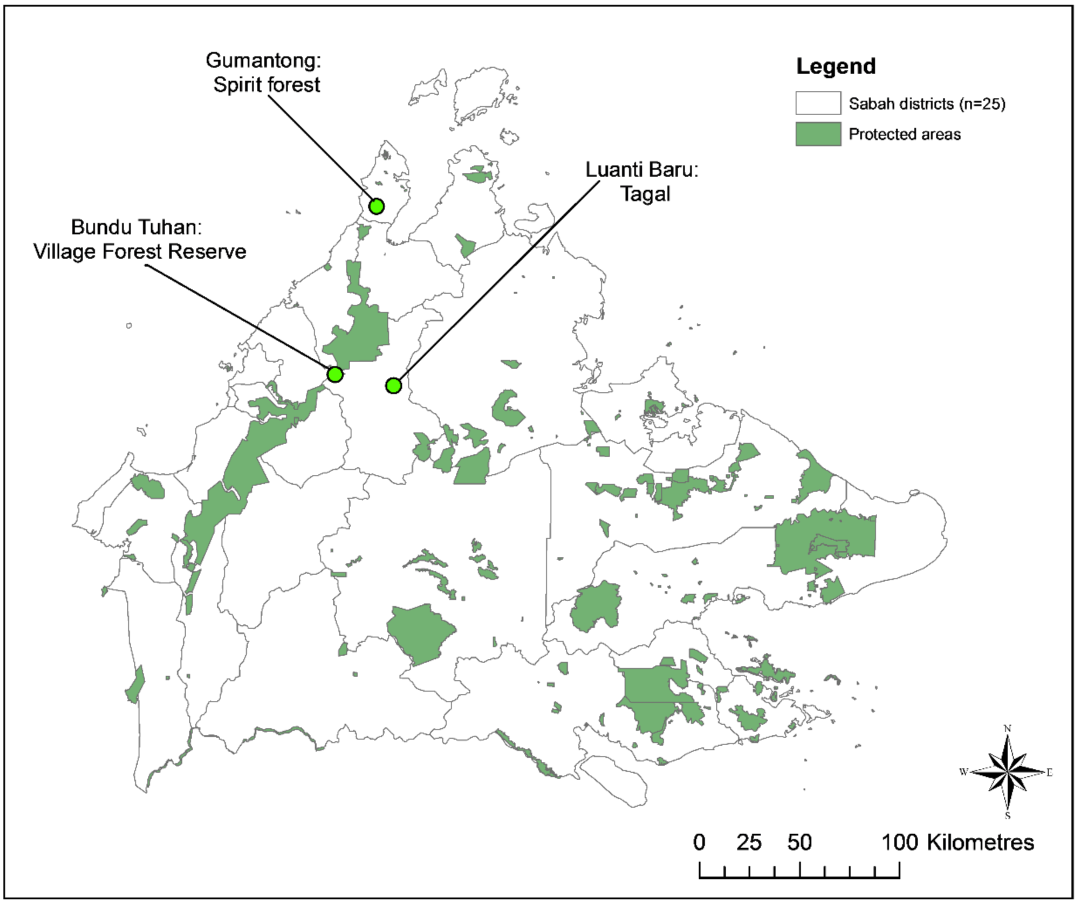


Figure 5-5 Case studies of the conservation of sacred forests and rivers in Sabah: Bundu Tuhan village forest reserve, Gumantong spirit forest and Luanti Baru tagal (Global Administrative Areas, 2012, UNEP-WCMC, 2012)

The primary data for the case study of Gumantong comes from an interview with Porodong Mogilin, Native Chief Representative of Matunggong Native Court in Bavanggazo, Kudat and meetings of community leaders from the 13 villages surrounding Gumantong. Dr. Paul Porodong facilitated access and served as a Rungus translator in Kudat. A well-respected native of Bavanggazo, one of the villages surrounding Gumantong, his close ties with the village and interviewee enabled frank discussion and minimized reporting error due to access and control issues and power inequalities between researcher and interviewees.

5.4.1 Limitations

The reporting of natural resource management strategies by PACOS village representatives and the three case studies may not form a representative sample of villages in Sabah. In terms of survey responses, the familiarity of respondents with the forms of natural resource management in their home areas may vary. Thus, it is important to note that questionnaire results may suffer from bias of omission and additional research in the home villages across Sabah may uncover other forms of biocultural conservation. The context of the quarterly PACOS meetings helped limit this bias; the representatives' regular representation of their villages at these meetings may have improved their awareness of conservation activities in their village.

5.5 Results

5.5.1 Questionnaire results

Respondents (Table 5-2)

Table 5-2 Characteristics of survey respondents (n=24)

Characteristic	Response	%	N
Gender	Male	70.8	17
	Female	29.2	7
Age	20-29	29.2	7
	30-39	29.2	7
	40-49	29.2	7
	50+	11.5	3
Education	No school	42.1	1
	Finished primary	20.8	5
	Finished secondary	66.7	16
	Finished form 6[8]	8.3	2
Ethnicity	Dusun putih, Dusun sokid, Kimaragang, Kedayan, Lundayeh, Makieng, Mangkaak, Murut, Nunuk Ragang, Tindal	4.2 each	1 each
	Dusun, Liwan, Lobu, Rumanau, Rungus, Sungai, Tombonuo	8.3 each	2 each
Religion	Christian	95.8	23
	Anglican	25	6
	Protestant Church in Sabah	8.3	2
	Roman Catholic	29.2	7
	Seventh Day Adventist	4.2	1
	Borneo Evangelical Church	25	6
	Gerakan Perkabaran Injil	4.2	1
	Muslim	4.2	1
Highest community role	Chairman of board	45.8	11
	Religious leader	25	6
	Village member	29.2	7

[8]Form 6 is a 1.5-year pre-university course undertaken upon completion of secondary school

Village characteristics (Table 5-3)

Table 5-3 Characteristics of survey respondents' villages (n=24)

Characteristic	Response	%	N
Access to village	Paved road	12.5	3
	Dirt road	87.5	21
Schools in village	Primary school	79.2	19
	Secondary school	8.3	2
Population	<250	12.5	3
	250-499	41.7	10
	500-749	33.3	8
	750-999	12.5	3
Ethnic groups	Bajau	4.2	1
	Bisaya	4.2	1
	Bugis	4.2	1
	Bundu	4.2	1
	Dusun	8.3	2
	Dusun Putih	4.2	1
	Dusun Sokid	4.2	1
	Kedayan	4.2	1
	Kimaragang	4.2	1
	Liwan	12.5	3
	Lobu	8.3	2
	Lundayeh	4.2	1
	Makaing	4.2	1
	Mangkaak	4.2	1
	Murut	8.3	2
	Nunuk Ragang	4.2	1
	Rumanau	12.5	3
	Rungus	8.3	2
	Sinobu	4.2	1
	Sungai	12.5	3
	Tausug	4.2	1
	Tidong	4.2	1
	Tindal	4.2	1
	Tombonuo	4.2	1
Religion	Christian	100	24
	Anglican	33.3	8
	Borneo Evangelical Church	25	6
	Gerakan Perkabaran Injil	4.2	1
	Protestant Church in Sabah	20.8	5
	Roman Catholic	20.8	5
	Seventh Day Adventist	8.3	2
	Muslim	25	6
	Animist	4.2	1

Natural resource use (Table 5-4)

Table 5-4 Natural resource use survey responses (n=24)

Question	Response	%	N
Why gather natural resources	For own use	100	24
	To sell at local markets	37.5	9
	To sell to middlemen	4.2	1
Where natural resources gathered	Forests	95.8	23
	Rivers	100	24
	Caves	37.5	9
	Sea	8.3	2
	Backyard farms	8.3	2
What natural resources gathered in forests	Wood for building	95.8	23
	Firewood	95.8	23
	Medicinal plants	91.7	22
	Fruits, vegetables and roots	87.5	21
	Hunting animals	91.7	22
What natural resources gathered in rivers	Fish	100	24
	Snails	70.8	17
	Shrimp	8.3	2
	Tortoises	4.2	1
	Eels	4.2	1
	Frogs	4.2	1
What natural resources gathered in caves	Birds nests	16.7	4
	Hunting animals	33.3	8
Land tenure of forests where natural resources are gathered	State land	12.5	3
	Forest Department land	41.7	10
	Native Reserve	29.2	7
	Native Titled	20.8	5
	Native Customary Rights	83.3	20
	Pending land claim	8.3	2

Regulating natural resource use (Table 5-5)

Table 5-5 Natural resource regulations survey responses (n=24)

Characteristic	Response	%	N
Spatial or temporal rules for natural resource management	Yes	41.7	10
	No	45.8	11
	Unknown	4.2	1
Who makes spatial and temporal regulations for natural resource use	Ketua Kampung (village head)	33.3	8
	JKKK (village committee)	20.8	5
	Religious leader	8.3	2
	Government	8.3	2
	Ancestors, inherited beliefs or customary law (adat)	8.3	2
Over the course of respondent's lifetime, regulations perceived to	Have stayed the same	37.5	9
	Have become stricter	8.3	2
	Have become less strict	16.7	4
Penalties exist for breaking regulations	Yes	45.8	11
Penalties enforced	Yes	45.8	11

Community-based Conservation (Table 5-6)

Table 5-6 Community-based conservation survey responses (n=24)

Conservation type	Time period	%	N
Village forest reserves	Current	66.7	16
	Past	70.8	17
'Spirit forests'[9]	Current	37.5	9
	Past	54.2	13
Tagal/bombon[10]	Current	33.3	8
	Past	16.7	4
Water catchment areas	Current	20.8	5
	Past	12.5	3
Village adat or regulations by JKKK	Current	8.3	2
None	Current	12.5	3
	Past	8.3	2

[10] *Tagal/bombon* is a resource management system that employs customary spatial and/or temporal regulations; it is a local form of taboo.

Village Forest Reserves (Table 5-7)

Table 5-7 Village forest reserves survey responses (n=24)

Characteristic	Response	%	N
Size (acres)	20	4.2	1
	30	4.2	1
	200	8.3	2
	300	8.3	2
	500	4.2	1
	1,200	4.2	1
	2,000	4.2	1
	5,000	4.2	1
	6,000	4.2	1
	10,000	4.2	1
Land tenure	Forest Department land	16.7	4
	Native Reserves	20.8	5
	Native Title	12.5	3
	Native Customary Rights	50	12
	Water catchment	12.5	3
Ecosystem services	Gathered natural resources	8.3	2
	Water source	70.8	17
Establishment	Pre-British rule	41.7	10
	WWII-Independence	8.3	2
	Independence-1980	8.3	2
	1980-2000	8.3	2
	2000-present	4.2	1
Clearance	British rule-WWII	4.2	1
	WWII-Independence	4.2	1
	Independence-1980	4.2	1
	2000-present	12.5	3
Why cleared	Religious change	21	5
	Converted to agriculture or government projects	8.3	2

'Spirit forests' (Table 5-8)

Table 5-8 'Spirit forests' survey responses (n=24)

Characteristic	Response	%	N
Size (acres)	3	4.2	1
	10	4.2	1
	15	4.2	1
	500	4.2	1
	1,000	4.2	1
	2,000	4.2	1
	10,000	8.3	2
Land tenure	Forest Department land	8.3	2
	Native Reserves	8.3	2
	Native Title	12.5	3
	Native Customary Rights	50	12
	Agricultural land, hunting areas and water catchment	4.2	1
Ecosystem services	Gathered natural resources	8.3	2
	Water source	45.8	11
Establishment	Pre-British rule	29.2	7
	British rule-WWII	4.2	1
	WWII-Independence	4.2	1
	Independence-1980	8.3	2
	1980-2000	4.2	1
State of belief	No one believes	20.8	5
	A few believe	16.7	4
	Most believe	12.5	3
Clearance	British rule-WWII	4.2	1
	2000-present	12.5	3
Why cleared	Religious change	21	5
	Lost land to Forest Department	4.2	1

Tagal/Bombon (Table 5-9)

Table 5-9 Tagal/bombon survey responses (n=24)

Characteristic	Response	%	N
Reason	Fish harvest	29.2	7
	Tourism	8.3	2
	Protect spawning grounds of fish	4.2	1
Fish harvest frequency	Twice a year	4.2	1
	Annually	12.5	3
	Every 2 years	8.3	2
	Every 3 years	4.2	1
Establishment[11]	1980-2000	4.2	1
	2000-present	29.2	7

5.5.2 Case Studies

The three case studies of village forest reserves, 'spirit forests', and *tagal* are located in the matrix beyond protected areas in Sabah in three distinct local contexts. As expected considering the high levels of diversity in Sabah's landscape (cultural, linguistic and biological), the case studies vary in a plethora of ways *inter alia* ethnicity, religion, village size and population, ecology, and forms of natural resource use. However, in all three of the case studies, resources conserved via biocultural conservation have been targeted by government agencies that regulate natural resource use, leading to local engagement, and in some cases, conflict. Government engagement has raised the profile of these case studies as potential ICCAs; we consider their environmental histories and apply social-ecological systems theory to develop a framework and recommendations for the inclusion of sacred forests and rivers in protected area networks as ICCAs.

Village Forest Reserve Case Study: Bundu Tuhan, Ranau

In 1968 boundary markers were placed for the Bundu Tuhan Native Reserve (approximately 1,263 ha), officially declared by the Chief Minister of Sabah in 1983

[11] None of the respondents said that the tagal/bombon had ended.

(Doolittle, 2001). This land included and surrounded the village and did not overlap with Kinabalu Park. However, in 1984 the Forest Department gazetted Tenompok Forest Reserve, with boundaries overlapping the Bundu Tuhan Native Reserve (Majid Cooke and Vaz, 2011). The community of Bundu Tuhan has prevented the Forest Department from measuring or mapping the contested area. The gazettement of Bundu Tuhan's Native Reserve legally fended off appropriation of land by external forces and incorporated a greater area than could have been procured by Native Title (individual land titles as opposed to communal). However, as the political economy of the region shifted, community members in Bundu Tuhan expressed frustration with land being locked up in the Native Reserve and unable to serve as credit or to be sold for profit (Doolittle, 2001). The Forest Department has presented a co-management proposal to the community, but community members express concern that the Forest Department might shift the reserve from class I to class II to allow logging (Majid Cooke and Vaz, 2011).

In 2005, community members observed that game populations were decreasing in their forest and a nearby community renowned for its vegetables, Kundasang, was suffering from soil dryness due to decreased river flow from the loss of its forest. Committees were formed to develop rules and policies for the Native Reserve using customary law (*adat*), including *Majlis Permuafakatan* (Community General Assembly), *Jawatankuasa Pemegang Amanah Hutan Simpan Bundu Tuhan* (Native Reserve Board of Trustees) and *Jawatankuasa Bombon* (conservation committees for forest and rivers) (Majid Cooke and Vaz, 2011) (Figure 5-6).

Figure 5-6 In 2005, Bundu Tuhan formed committees to develop rules and policies for their Native Reserve using customary law (*adat*), including *Majlis Permuafakatan* (Community General Assembly), *Jawatankuasa Pemegang Amanah Hutan Simpan Bundu Tuhan* (Native Reserve Board of Trustees) and *Jawatankuasa Bombon* (conservation committees for forest and rivers) (Majid Cooke and Vaz, 2011).

Bundu Tuhan has expressed interest in recognizing the ~60% of the Native Reserve conserved as a *hutan simpan* (protected forest) as a community-managed ICCA (Majid Cooke and Vaz, 2011).

Spirit Forest Case Study: Gumantong, Kudat

In Kudat, northern Malaysian Borneo, the Rungus people conserve *puru*, patches of forest approximately one hectare in size and inhabited by *rogon* (‘spirits’). Five villages surround the highest hill and large *puru*, Gumantong (Figure 5-7).

Figure 5-7 The mountaintop of Gumantong as seen from Tinangol, Kudat, northern Sabah.

‘Dancing animals’ are belived to reside on the mountaintop. These *kopizo* (‘omens’) are said to goad the interloper into laughing, and then dying upon his arrival at home (Mogilin, 2011) (Porodong, 2010) (Figure 5-8).

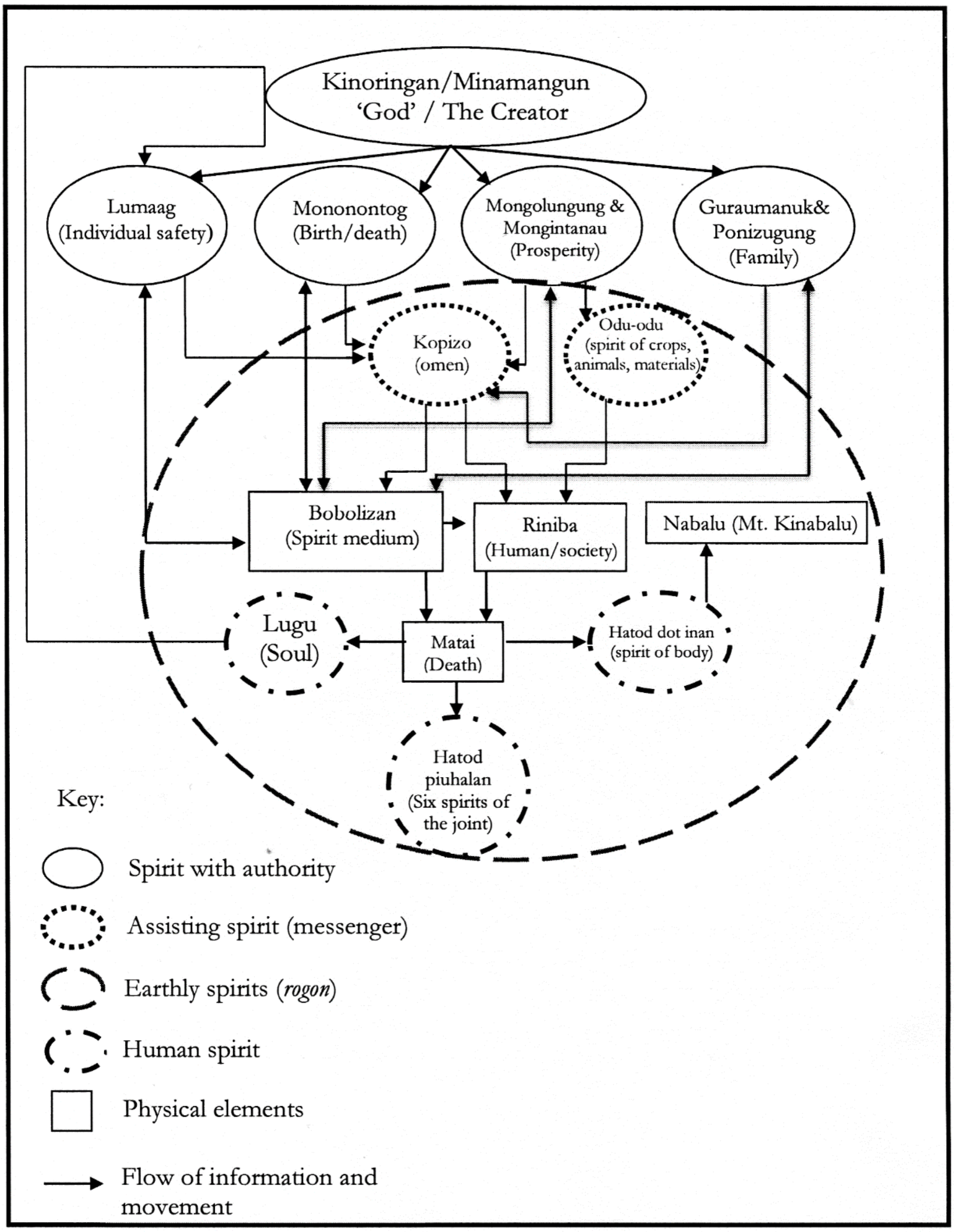


Figure 5-8 Rungus Spirit World (reproduced from Porodong, 2010)

This spiritual edict conserved the mountaintop in the first half of the 20th century. However, the effectiveness of this form of resource regulation was threatened by outsiders, specifically Iban members of a British survey team. The Iban area an indigenous ethnic group from the neighboring Malaysian state of Sarawak. While surveying the mountaintop, the Iban hunted animals, and the local Rungus believed they had hunted the ‘dancing animals’ out of Gumantung’s *puru*. Following their conversion to Christianity, the local Rungus people began to clear their *puru* for cropland. As a consequence of clearing these forest patches, the water table dropped to the point where the villages became reliant on the government for their water supply.

Although Kudat was formerly a mosaic of mature and fallow secondary rainforest, today the landscape of Kudat is primarily a monoculture of *Acacia mangium* due to its widespread planting in the 1980s by the Sabah Forestry Development Authority (SAFODA) for pulp production (Turnbull, Midgley and Cossalter, 1998, cited in Porodong, 2010, p.24-25). The spread of Acacia was enabled by the pervasive use of fire in swidden agriculture, as fire catalyzes the germination of buried *Acacia mangium* seeds. *Acacia mangium* has also been shown to out-compete native species such as *Melastoma* (Osunkoya, Farah and Rafhiah, 2005, cited in Porodong, 2010, p.24-25). At the end of the century, the Forest Department arrived to clear Gumantong’s mountaintop of native vegetation to plant the fast-growing exotic, *Acacia mangium* (Kothari, 2006). When protesting the proposed clearing of Gumantong for the planting of *Acacia mangium*, the communities surrounding Gumantong expressed concern that the exotic species would dry up their water source. By that point, the community had observed the connetion between the *puru* and water access, and they vehemently protested the Forest Department’s planned clearing of the mountatintop. Their action attracted the attention of the United Nations Development Programme (UNDP) on Climate Change, and the Rungus villages formed a partnership. In 2007, the Forest Department gazetted a 590-hectare area including Gumantong as a Forest Reserve Class 1 (Watershed) without informing the village chiefs or native court chiefs representing the 13 communities and 3,000 villagers. Again the villages protested the action, registering a complaint with the

Chief Minister of Sabah and proposing Gumantong be recognized as a Native Forest Reserve, a form of Indigenous Peoples' and Community Conserved Area (ICCA) that would provide land tenure (Sabah Publishing House, 2011).

Tagal Case Study: Luanti Baru

With modernization and urbanization impacting rural village communities in Sabah in the 1960s, harvesting practices shifted to include the use of explosives in fishing and the widespread logging of forests silted and polluted rivers. In 1997 a village in Penampang district successfully reinstated their customary *tagal* system to reintroduce spatial and temporal fishing regulations (Vaz and Agama, 2013). As news of the improved condition of Penampang's Babagon River spread, so did renewed interest in the revitalization of *tagal* systems in communities across Sabah.

In 2002 the Sabah Fisheries Department ran a 'Love your river' campaign. The village of Luanti Baru's river was full of litter, people washed their cars in it and it had become polluted and silted from logging upstream (Er et al., 2012). Community member Jeffrin Majangki remembered the many fish in the river of his childhood, and began work with his community to restore the river's fish population. The village approached the Fisheries Department for support to clean up the river; all rivers in Sabah were technically under governmental control. Resulting from that that collaboration, village, district and state level committees were formed. The zoning system adopted was a 'traffic light scheme', with red zones being no-take, yellow zones sometimes deemed fishable by the oversight committee, and green zones always fishable. Once large fish returned to the area, a tourism project was developed for fish massage, which was so successful that the community restricted fishing in all zones (Er et al., 2012) (Figure 5-9).

Figure 5-9 *Tagal*, customary spatial and temporal fishing regulations, a) are painted on a river rock as a reminder to villagers in Buayan (Photo: Nasiri Sabiah). b) Luanti Baru's *tagal* is hailed as one of the most successful examples of revitalization of *tagal* in Sabah; c) harvesting of fish has been abandoned to support a fish massage tourism project, which received 50,000 tourists in 2013 alone (2014).

Tourists visit the river and wade in, submerging their feet. Fish food is sprinkled on the water to attract fish and the fish come to eat the fish food, but also to take nibbles of dead skin on the feet. This ‘natural spa’ is especially popular with domestic tourists enjoying a weekend trip outside of the city. Luanti Baru received 50,000 tourists in 2013 alone (2014) Tourism funds are managed by a committee and fund community projects, such as children’s education. One challenge of *tagal* is that improved management practices in one section of the river do not necessarily buffer effects upstream. Even in the highly successful fish tourism project, logging upstream creates massive silt deposits that can stymie tourism until the river clears. The positive side of this challenge is that communities are incentivized to come together to advocate for more river-friendly practices upstream, which can clean up entire rivers instead of one zone.

The Sabah Fisheries Department conducted research on the effectiveness of *tagal*, and in 2003, *tagal* was codified in Sabah law in the Sabah Inland Fisheries and Aquaculture Enactment. Some villages with *tagal* projects had not formerly practiced *tagal*; its meaning has expanded to encompass a range of community-based fisheries projects, regardless of the links to customary law. Several villages have reportedly made annual tourism revenues between RM30,000 and RM50,000 (2016). *Tagal* systems have been (re)introduced by the Fisheries Department in 511 river zones across Sabah to date, with plans to add another 600 zones by 2016 (2014). *Tagal* has even been promoted in the neighbouring Malaysian state of Sarawak, which is inhabited by different ethnic groups with different customary practices (Vun and Yung, 2010, 2016).

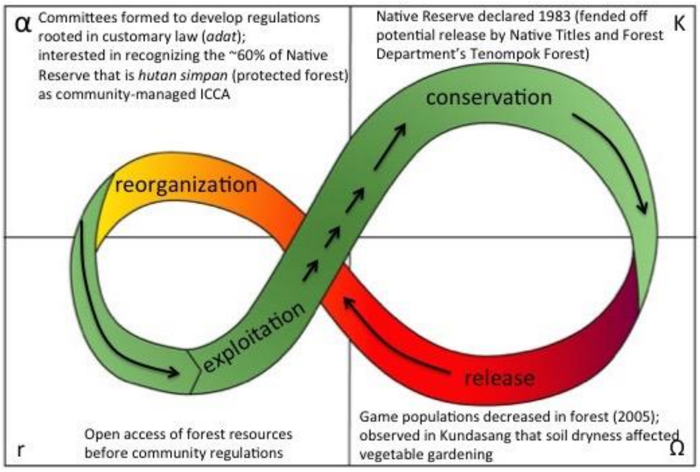
5.6 Discussion

Fragmented protected area networks seek to increase connectivity and incorporate the conservation practices of local communities in the human-modified landscapes comprising 87% of the Earth’s terrestrial surface (Chazdon et al., 2009). Countries are identifying Indigenous and Community Conserved Areas (ICCAs) to augment their protected area networks and ICCAs have recently been recognised as a form of IUCN protected area governance (Dudley, 2009). We surveyed natural resource use, regulations, and community-based conservation in bioculturally diverse Sabah, Malaysian Borneo, and identified factors impacting the successful integration of ICCAs into protected area networks.

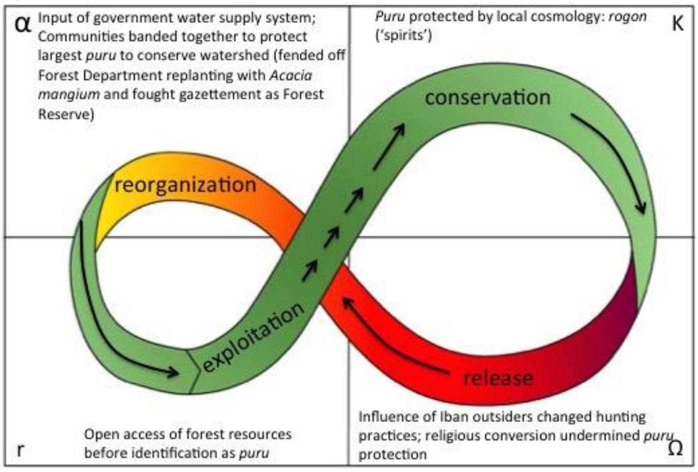
Our survey indicates that rural villages in Sabah employ *inter alia* village forest reserves (66.7%), 'spirit forests' (37.5%), *tagal*/*bombon* (33.3%), and water catchment systems (20.8%) to conserve their natural resources. Conservation is practiced to conserve ecosystem services including water sources (70.8%) and gathering natural resources (8.3%), which we also observed in the case studies (e.g. Gumantong's water catchment area and Luanti Baru's fish massage tourism), for aesthetic/moral reasons (e.g. to protect heritage sites in ancestral lands) and for spiritual reasons as in 'spirit forests' (37.5%), (e.g. Gumantong's 'dancing animals' or *rogon* ('spirits') in *puru*). Our research indicates that the conservation of sacred forests and rivers are not static, but rather can be shifted by events such as religious conversion (the reason cited for village forest or spirit forest clearance by 21% of respondents, e.g. Gumantong's clearance of *puru* upon conversion to Christianity), modernisation (e.g. Luanti Baru's introduction of plastics and car washing polluting the river) and the influence of outsiders on natural resource use (e.g. Gumantong's Iban hunting of 'dancing animals', Bundu Tuhan's observance of Kundasang's soil aridity following forest clearance, and the adoption of *tagal* by communities who had not traditionally practiced it). Communities can respond to these shifts by practicing adaptive management of the social-ecological system, such as protecting the Gumantong hilltop by collaborating with the UNDP climate change program. The transformations observed in community-based conservation in Sabah are indicative of the human-environment couplings of social-ecological systems, which we will proceed to discuss in greater detail.

In the Gumantong case study, the influence of outsiders, i.e. changing hunting practices and religious conversion, disturbed the social-ecological system. The clearance of *puru* decreased the level of the water table, shifting the social-ecological system from conservation (K) to release (Ω). The input of a government water supply system was the first stage of reorganization (α) and then a 'revolt' occurred as communities banded together to protect their largest *puru* in order to conserve their watershed (K) in an alternative state. Inherent in this adaptive process was the recognition of the link between forest clearance and the drop in the water table, which enabled the 'small and fast' shift towards conservation of Gumantong (Figure 5-10).

a)



b)



c)

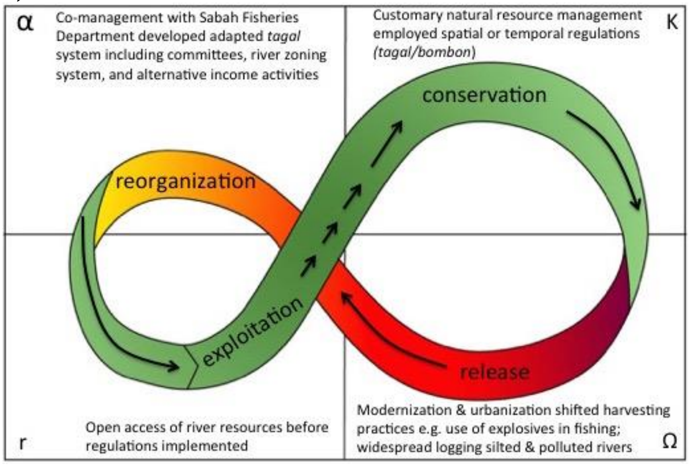


Figure 5-10 The case studies of a) a village forest reserve b) 'spirit forest' and c) *tagal/bombon* in Sabah pass through the phases of the adaptive cycle.

Adaptive governance enabled the means of conservation (the *how* and *why*) to shift to an alternative adaptive cycle, from ‘spirit forests’ (‘dancing animals’ and *rogon*) to water catchments providing ecosystem services (water conservation). This is evident in our survey, where we observed the decreased use of village forest reserves (70.8% in past to 66.7% in present) and ‘spirit forests’ (54.2% in past to 37.5% in present) over time, but also an increase in the use of water catchment areas (12.5% in past to 20.8% in present) and *tagal/bombon* (16.7% in past to 33.3% in present).

Religious conversion does not in itself result in the clearance of sacred forests, as occurred with the conversion to Christianity and the clearance of *puru*. While none of our survey respondents self-identified as Animist and only one respondent noted Animism was practiced in his or her village, 37.5% of respondents said they had ‘spirit forests’, 12.5% said most people believe in the ‘spirit forests’, 16.7% said a few people believe in them and 8.3% said ancestors, inherited beliefs or customary law (*adat*) set regulations for natural resource use. In other parts of Southeast Asia, conservation of sacred forests have been maintained in the face of religious conversion, with the reasons underpinning conservation shifting to aesthetic/moral reasons (Keyes, 1996). In Indonesia, Protestant Christianity incorporated many of the structures of local *adat* governance systems (Cooley, 1967). Although we do not observe similar syncretism of area-based conservation measures in Sabah, religious leaders were cited as rule-makers regarding natural resource use in 7.7% of our survey villages and faith leaders convened community conservation meetings in Lokos, a village we observed over the course of our research. Collaboration with religious leaders who interpret environmental stewardship as part of their religious teachings has been successful in many contexts (Palmer and Finlay, 2003, Hitzhusen and Tucker, 2013) and can retain the functionality of the social-ecological system despite the disturbance of religious conversion. The motivations underpinning conservation can be reframed to accommodate the new belief system, for example, protecting forest patches as a moral duty as opposed to the veneration of ancestral 'spirits'. The process of religious conversion occurred at the village level in Sabah, and the degree of acceptance of animist beliefs and integration with the conversion religion varied by missionary, even within the same branch of religion. Therefore, the clearance of the *puru* by the Rungus can not be attributed solely to their religious conversion, but may be due to the interplay of multiple simultaneous shifts, including the method of religious conversion, modernization, and increased market access.

As communities reorganized their social-ecological systems to address polluted river zones, traditional forms of natural resource management (*tagal/bombon*) were revitalized and adapted to the current system. An observed shift in the ecological system to an undesirable state can spur conservation actions ('revolt' developed via 'small and fast' processes) or formerly successful interventions can be revitalized and adapted (the 'remember' function developed via 'large and slow' processes).

In addition, it is important to note that social-ecological systems (here we focus on ICCAs) do not occur in a vacuum, bur rather observation of other communities' experiences (i.e. other adaptive cycles) can spur preventative conservation action before an undesirable state is reached. In our Sabah case studies, this is observed in Bundu Tuhan's observation of Kundasang and in the rollout of *tagal* to river zones across Sabah (e.g. only 16.7% of our survey noted *tagal/bombon* systems were in place in the past but 33.3% of respondents had current *tagal/bombon* systems). Participatory capacity-building workshops bringing together community representatives with a range of experiences, like those we observed with PACOS and the Global Diversity Foundation, can facilitate exchanges that foster 'communal memory', that is, cumulative 'social memory' at the community level.

The stage of the adaptive cycle for identifying ICCAs to integrate into the protected area network is conservation (K). Formal recognition, such as co-management with a governmental agency or the determination of an IUCN protected area category and inclusion in the World Database on Protected Areas, would ideally contribute to the process indicated by the multiple small arrows linking exploitation (r) to conservation (K). As such, formal recognition would be one of many social processes accumulated over time to conserve the resource base. However, it must be noted that formally recognising an area as an ICCA can also act as a disturbance to the system, shifting it from conservation (K) to release (Ω) (Dove, 2011). Negative social impacts of imposing conservation on local communities have included the restriction of land use and the loss of management rights (West and Brockington, 2006). Even in cases where land use and management rights are unchanged, formally describing an area as 'conserved' may alter local perceptions of rights and ownership (Pathak, 2006). The process of recognizing and supporting ICCAs must acknowledge that communities may have had negative experiences or hold preconceptions of formal conservation and must include safeguards to ensure the autonomy of local custodians (Kothari, 2006).

The United Nations Declaration of Principles on the Rights of Indigenous Peoples (UNDRIP) says that, "Indigenous Nations and Peoples are entitled to the permanent enjoyment of their aboriginal ancestral historical territories. This includes air space, surface and subsurface rights, inland and coastal waters, sea ice, renewable and non-renewable resources, and the economies based on these resources" (United Nations, 2007). If ICCAs include the shift in land tenure from the government to indigenous peoples, UNDRIP principles state that the custodians have decision-making power, including the rights to forest clearance, mineral extraction, etc. Shifting decision-making to the community level for conservation does not therefore ensure that conservation will always be their choice, but rather, that they will be the ones making that choice. The concern that custodians will choose economic development through mineral extraction over conservation has stymied the full transfer of decision-making power to communities in favor of co-management or participatory government-led decision-making processes. The large majority of the world's biodiversity is found in indigenous peoples' areas and territories, a fact that is oft cited to demonstrate indigenous people's successful envrionmental management to date (Stevens, 2014). It is also important to note that protected areas are not immune to similar threats such as mineral extraction. Protected area downgrading, downsizing, and degazzettment (PADDD) is widespread; a study of protected areas in Africa, Asia, Latin America and the Caribbean from 1900-2010 found that natural resource extraction (oil and gas, forestry, mining, industrial agricultural, industrialization, and infrastructure) accounted for 37.5% of the 282 PADDD events (Mascia et al., 2014). Protected area networks are also at risk during periods of national instability. Following the 2009 coup d'état in Madagascar, illegal rosewood harvesting in Masoala and Marojejy National Parks spiked, with $130,000,000 of illegal exports from January to April alone (Schuurman and Lowry, 2009).

Some communities in Sabah have expressed interest in the ICCA concept as a means to circumvent their inability to acquire tenure of farmland with slopes greater than 25 degrees. Sabah's Forest Enactment 1968 (Sabah En. 268) forbids the clearance of vegetation on slopes greater than 25 degrees, barring community land claims for agricultural use of their steep ancestral lands. However, Sabahans perceive this environmental regulation to be loosely enforced when it comes to commercial interests (Figure 5-11).


Figure 5-11 Commercial oil palm plantation as seen from the A4 roadway in Sabah. Forest clearance on the steep hillside has led to erosion and siltation of the water below.

Enforcement relies on 13 officers for over 300 projects and fines (maximum RM20,000) are significantly less than the short-term economic benefits of non-compliance (Wyn, 2013). This is an important distinction: land tenure may be a prerequisite for successful community-based conservation (Brooks et al., 2012) but is not in itself sufficient. ICCAs that exhibit the attributes of successful community-based conservation espoused by Brooks et al. (2012) may be more resilient to disturbances. Of particular note to protected area network planners are the factors that increase the likelihood of ecological success (that is, improved outcomes for the habitat or species of interest): 1) project designs develop individual and institutional capacity, 2) smaller communities and 3) local engagement in cultural traditions and governance (Chazdon et al., 2009, Brooks et al., 2012).

Local governance comprises the second defining characteristic of ICCAs: “The concerned indigenous peoples or local community plays a key role in making decisions about the management of the ecosystem, area or species. The community possesses (in law or in practice) the power to make and enforce key management decisions regarding the territory and resources" (ICCA Consortium, 2013). The survey showed that regulations of natural resource use were set by the Ketua Kampung (village head) (33.3%), the JKKK (village committee) (20.8%), religious leaders (8.3%), ancestors, inherited beliefs or customary law (*adat*) (8.3%) and by the government (8.3%). Our research found that *how* and *why* a community conserves its resources changes over time; 8.3% of survey respondents perceived natural resource use regulations to have become stricter and 16.7% perceived them as becoming less strict over the course of their lifetimes. Just as protected area management has shifted towards adaptive management of ecological systems, protected areas that include people should also include adaptive governance of social systems (Dove, 2011, Scoones, 1999). ICCAs are inclusive of systems where conservation has developed over time through an ecological understanding model. The ICCA Consortium describes such systems, noting, "The voluntary management decisions and efforts of the concerned community lead to, or at least are well in the process of leading to, the conservation of biodiversity, habitats, species, ecological functions and associated cultural values, regardless of the original management objectives as perceived by the community" (ICCA Consortium, 2013).

Communities may engage with the ICCA recognition process to gain land tenure, and ICCAs developed through the ecological understanding model may require additional facilitation and support. Successfully integrating ICCAs into the protected area network a few at a time could provide landscape-scale rewards if the 'proof of concept' engages neighbouring communities, as we found in the case studies in Luanti Baru (*tagal*) and Bundu Tuhan (village forest reserve).

5.7 Conclusion

As alternative existing forms of conservation in the landscape, Indigenous and Community Conserved Areas (ICCAs) are of interest as conservation expands into the mosaic of land uses beyond protected areas. ICCAs take a myriad of forms, from 'spirit forests' to village forest reserves, church forests and seasonal or temporal river resource regulations. The breadth of local conservation approaches and their dynamic nature over time can be challenging for conservation planning. However, sacred forests and rivers can make valuable contributions in a new paradigm of community conservation– one that acknowledges conservation rooted in ecological understanding, supports conservation in the face of social and ecological changes, and recognizes the autonomy of local custodians in the process. Just as the adaptive management of protected areas formerly viewed as static ecological systems has become best practice, so shall adaptive governance of sacred forests and rivers by local communities beyond protected areas.

5.8 Supplementary Information

SI 7-1 Questionnaire distributed to PACOS community representatives at Joint Technical Session 16-17 February 2011 (Malay)

Sila isikan borang kaji selidik ini dengan selengkapnya. [Researcher name and institution]. Kini dia sedang bekerjasama dengan Universiti Malaysia Sabah (UMS) untuk mengkaji mengenai pengurusan sumber alam tempatan di seluruh Sabah. Terima kasih!

BAHAGIAN A. JTS Maklumat Wakil

1. Nama: ______________________________________ 2. Umur: _____

3. Jantina: ☐ Lelaki
☐ Wanita

4. Nombor telefon: ______________________________

5. Pendidikan (sila tanda satu):
☐ tidak pernah ke sekolah
☐ tamat sekolah rendah
☐ tamat sekolah menengah
☐ tamat tingkatan enam
☐ tamat universiti

6.Keturunan (sila tanda semua yang berkaitan):

☐ Bajau	☐ Kedayan	☐ Malapi	☐ Pingas	☐ Tausug
☐ Bisaya	☐ Kimagarang	☐ Malay-Brunei	☐ Rumanau	☐ Tidong
☐ Bonggi	☐ Kolobuan	☐ Malaysian Chinese	☐ Rungus	☐ Tindal
☐ Bugis	☐ Kuijau	☐ Mangkaak	☐ Sinobu	☐ Tobilung
☐ Bundu	☐ Lingkabau	☐ Minokok	☐ Sinorupu	☐ Tolinting
☐ Dumpas	☐ Liwan	☐ Murut	☐ Sonsogon	☐ Tombonuo
☐ Gana	☐ Lobu	☐ Ngabai	☐ Sukang	☐ Tuhawon
☐ Garo	☐ Lotud	☐ Nunuk Ragang	☐ Sungai	☐ Tutung
☐ Idaan	☐ Lundayeh	☐ Orang Cocos	☐ Tatana	☐ Sandayoh
☐ Illanun	☐ Makiang	☐ Paitan	☐ Tangara	

☐ Lain-lain: ____________________________

7. Agama (sila tanda semua yang berkaitan):
☐ Animist
☐ Kristen - Anglican
☐ Kristen - Baptist
☐ Kristen - Borneo Evangelical
☐ Kristen - Brethren
☐ Kristen - Lutheran
☐ Kristen - Methodist
☐ Kristen - Presbyterian
☐ Kristen - Protestant Church Sabah (PCS)
☐ Kristen - Roman Katolik (RC)
☐ Kristen - Sidang Injil Borneo (SIB)
☐ Kristen - Seventh-day Adventist
☐ Muslim ☐ Lain-lain: __________________________

8. Saya adalah (sila tanda semua yang berkaitan):

☐ Penduduk kampung

☐ Mempunyai jawatan JKKK: ____

☐ Pemimpin agama di dalam kampung: ____________________________________

☐ Mempunyai jawatan kepimpinan lain dalam komuniti: _____________________

BAHAGIAN B. Maklumat Kampung

9. Nama kampung: ________________________________

11. Daerah: _______________________________________

12. Bandar yang terdekat daripada kampung ialah ___________dan terletak sejauh ___________ km daripada kampung

10. Zon PACOS:

☐ Utara

☐ Kinabalu

☐ Penampang

☐ Pendalaman Atas

☐ Pendalaman Bawah

☐ Tongod

☐ Pantai Timur

13. Semua jalan di dalam kampung bertar?

☐ Ya

☐ Tidak, jalan raya bertar adalah _____________ km daripada kampung.

.

14. Jika jalan raya bertar tidak sampai ke kampung anda, adakah jalan tanah sampai ke kampung anda?

☐ Ya

☐ Tidak, jalan tanah adalah __________ km daripada kampung.

15. Apakah ada sekolah rendah di dalam kampung?

☐ Tidak ada, sekolah rendah terletak___ km daripada kampung.

☐ Ya, sekolah rendah di dalam kampung dibina:

☐ Semasa kedatangan British - Perang

☐ Perang - Merdeka

☐ Merdeka - 1980

☐ Tahun 1980 - 2000

☐ Tahun 2000 – Sekarang

16. Apakah ada sekolah menengah di dalam kampung ?

☐ Tidak ada, sekolah menengah terletak ______________ km daripada kampung.

☐ Ya, sekolah menengah di dalam kampung dibina:

☐ Semasa kedatangan British - Perang

☐ Perang - Merdeka

☐ Merdeka - 1980

☐ Tahun 1980 - 2000

☐ Tahun 2000 – Sekarang

17. Berapakah jumlah penduduk di dalam kampung ?

☐ Kurang dari 250 orang

☐ 250-499 orang

☐ 500-749 orang

☐ 750-999 orang

☐ 1000-1249 orang

☐ 1250-1499 orang

☐ 1500-1749 orang

☐ 1750-2000 orang

☐ Lebih dari 2000 orang

18. Keturunan (Sila tanda semua yang berkaitan dan BULATKAN keturunan yang paling ramai di dalam kampung):

☐ Bajau	☐ Kedayan	☐ Malapi	☐ Pingas	☐ Tausug
☐ Bisaya	☐ Kimagarang	☐ Melayu-Brunei	☐ Rumanau	☐ Tidong
☐ Bonggi	☐ Kolobuan	☐ Melayu-Cina	☐ Rungus	☐ Tindal
☐ Bugis	☐ Kuijau	☐ Mangkaak	☐ Sinobu	☐ Tobilung
☐ Bundu	☐ Lingkabau	☐ Minokok	☐ Sinorupu	☐ Tolinting
☐ Dumpas	☐ Liwan	☐ Murut	☐ Sonsogon	☐ Tombonuo
☐ Gana	☐ Lobu	☐ Ngabai	☐ Sukang	☐ Tuhawon
☐ Garo	☐ Lotud	☐ Nunuk Ragang	☐ Sungai	☐ Tutung
☐ Idaan	☐ Lundayeh	☐ Orang Cocos	☐ Tatana	☐ Sandayoh
☐ Illanun	☐ Makiang	☐ Paitan	☐ Tangara	

☐ Lain-lain: ____

19. Agama (Sila tanda semua yang berkaitan BULATKAN agama yang paling ramai penganut di dalam kampung):

☐ Animist
☐ Kristen - Anglican
☐ Kristen - Baptist
☐ Kristen - Borneo Evangelical
☐ Kristen - Brethren
☐ Kristen - Lutheran
☐ Kristen - Methodist
☐ Kristen - Presbyterian
☐ Kristen - Protestant Church Sabah (PCS)
☐ Kristen - Roman Katolik (RC)
☐ Kristen - Sidang Injil Borneo (SIB)
☐ Kristen - Seventh-day Adventist
☐ Muslim
☐ Lain-lain: ______________________

BAHAGIAN C Pengurusan Sumber Alam Tempatan

20. Adakah penduduk kampung mengambil sumber alam?

☐ Ya
☐ Tidak (sila lompat ke soalan 27)
☐ Saya tidak tahu

Sekiranya ya, adakah semua sumber alam yang didapati adalah untuk (sila tanda semua yang berkaitan):

☐ kegunaan sendiri
☐ di jual di tamu
☐ di jual kepada orang tengah

21. Sekiranya ya,di mana penduduk kampung pergi untuk mengumpul sumber alam dan apa yang di ambil?

☐ Hutan, iaitu (Sila tanda semua yang berkaitan):

☐ Kayu untuk pembinaan
☐ Kayu api
☐ Tumbuh-tumbuhan untuk kegunaan perubatan
☐ Buah-buahan hutan, tumbuh-tumbuhan, akar kayu
☐ Memburu binatang
☐ Lain-lain: ___________________________________

Hutan di mana penduduk kampung mendapatkan sumber alam adalah:

☐ Tanah negara (State land)
☐ Tanah Jabatan Hutan (Forest department land)
☐ Tanah simpanan asal (Native Reserve)
☐ Tanah simpanan yang mempunyai pemilik (Native titled)
☐ Tanah adat (Native Customary Right, NCR)
☐ Pengunaan bawah tanah (Under land application)
☐ Lain-lain: ______________________________

☐ Sungai, iaitu (Sila tanda semua yang berkaitan):

☐ Ikan
☐ Siput sungai
☐ Lain-lain: _____________________________________

☐ Gua, iaitu (Sila tanda semua yang berkaitan):

☐ Sarang burung
☐ Memburu binatang
☐ Lain-lain: _____________________________________

☐ Tempat selain hutan, sungai, dan gua di mana penduduk kampung pergi untuk mengumpul sumber alam (iaitu, laut):

Kami pergi ke: _____________________ dan mengumpulkan: ________________

22. Adakah terdapat peraturan mengenai di mana atau bila penduduk boleh mengumpulkan sumber alam?

☐ Ya, ada peraturan
☐ Tidak, tidak ada peraturan (sila lompat ke soalan 27)
☐ Saya tidak tahu

23. Siapa yang membuat peraturan mengenai bila dan di mana penduduk boleh mengumpulkan sumber alam?
(sila tanda semua yang berkaitan)

☐ Ketua kampung
☐ JKKK
☐ Pemimpin agama
☐ Bobolizan/Dukun
☐ Jabatan kerajaan: ____
☐ Lain-lain: ____

24. Apakah ada hukuman bagi yang melanggar peraturan tersebut?

☐ Ya
☐ Tidak
☐ Saya tidak tahu

25. Adakah hukuman tersebut dikuatkuasakan?

☐ Ya
☐ Tidak
☐ Saya tidak tahu

26. Selama hidup anda, adakah peraturan-peraturan ini:

☐ Masih tetap sama
☐ Menjadi lebih ketat
☐ Menjadi kurang ketat

27. Sekarang, adakah kampung anda mempunyai (sila tanda semua yang berkaitan):
- ☐ Hutan simpan kampung
- ☐ Hutan yang mempunyai roh atau semangat hutan
- ☐ Tagal/Bombon
- ☐ Sistem pengurusan sumber alam tempatan yang lain: ____________________
- ☐ Sekarang, kampung tidak mempunyai sebarang sistem pengurusan sumber alam tempatan.

28. Sebelum ini, adakah kampung mempunyai (sila tanda semua yang berkaitan):
- ☐ Hutan simpan kampung
- ☐ Hutan yang mempunyai roh atau semangat hutan
- ☐ Tagal/Bombon
- ☐ Sistem pengurusan sumber alam tempatan yang lain: ____________________
- ☐ Sekarang, kampung tidak mempunyai sebarang sistem pengurusan sumber alam tempatan.

BAHAGIAN D. Persetujuan dan maklumat tambahan

Bolehkah [Researcher] menulis nama anda dan kampung dengan maklumat yang telah anda berikan dalam kajian ini dalam pekerjaannya? (sila tandakan salah satu)
- ☐ Ya, [Researcher] boleh menulis nama saya dan kampung.
- ☐ [Researcher] boleh menulis maklumat dan kampung, tetapi bukan nama saya.
- ☐ [Researcher] boleh menggunakan maklumat tersebut, tetapi tidak boleh menulis nama saya atau kampung.

Tanda tangan: ____

TERIMA KASIH!

HUTAN SIMPAN KAMPUNG
Jika sekiranya baru-baru ini atau sebelum ini kampung ada menyimpan hutan simpan kampung,

1. Berapa ekarkah itu? ________ ekar

2. Apakah jenis tanah yang digunakan bagi hutan simpan tersebut?
   - ☐ Tanah negara
   - ☐ Tanah Jabatan Hutan
   - ☐ Tanah simpanan asal
   - ☐ Tanah simpanan yang mempunyai pemilik
   - ☐ Tanah adat
   - ☐ Pengunaan bawah tanah
   - ☐ Lain-lain: ____

3. Bolehkah penduduk kampung mengambil sumber alam di hutan simpan kampung tersebut?
   - ☐ Ya
   - ☐ Tidak
   - ☐ Saya tidak tahu

4. Adakah terdapat sumber air di dalam kawasan hutan simpan kampung?
   - ☐ Ya
   - ☐ Tidak
   - ☐ Saya tidak tahu

5. Bilakah ia menjadi hutan simpan kampung?
   - ☐ Sebelum kedatangan British
   - ☐ Semasa kedatangan British – Perang
   - ☐ Perang - Merdeka
   - ☐ Merdeka – 1980
   - ☐ Tahun 1980 – 2000
   - ☐ Tahun 2000 – Sekarang

6. Jika sekiranya hutan simpan itu tidak wujud lagi, pada waktu bilakah kampung berhenti untuk menyimpannya?
   - ☐ Sebelum kedatangan British
   - ☐ Semasa kedatangan British - Perang
   - ☐ Perang – Merdeka
   - ☐ Merdeka – 1980
   - ☐ Tahun 1980 – 2000
   - ☐ Tahun 2000 – Sekarang

7. Jika sekiranya hutan yang mempunyai roh atau semangat hutan itu tidak wujud lagi, mengapakah kampung berhenti untuk menyimpannya?

____

____

SEMANGAT HUTAN
Jika sekiranya baru-baru ini atau sebelum ini kampung ada menyimpan hutan yang mempunyai roh atau semangat hutan,

1. Berapa ekarkah itu? ________

2. Apakah jenis tanah yang digunakan untuk hutan yang mempunyai roh atau semangat hutan tersebut?
   - ☐ Tanah negara
   - ☐ Tanah Jabatan Hutan
   - ☐ Tanah simpanan asal
   - ☐ Tanah simpanan yang mempunyai pemilik
   - ☐ Tanah adat
   - ☐ Pengunaan bawah tanah
   - ☐ Lain-lain: ______________________________

3. Bolehkah penduduk mengumpulkan sumber alam di dalam hutan yang mempunyai roh atau semangat hutan itu?
   - ☐ Ya
   - ☐ Tidak
   - ☐ Saya tidak tahu

4. Sekarang, adakah penduduk kampung percaya dengan semangat hutan yang terdapat di dalam hutan yang mempunyai roh atau semangat hutan tersebu?
   - ☐ Tiada seorang pun yang percaya
   - ☐ Sedikit orang sahaja yang percaya
   - ☐ Hampir semua orang percaya
   - ☐ Semua orang percaya

5. Adakah terdapat sumber air di dalam hutan yang mempunyai roh atau semangat hutan itu?
   - ☐ Ya
   - ☐ Tidak
   - ☐ Saya tidak tahu

6. Bilakah ia diisytiharkan sebagai hutan yang mempunyai roh atau semangat hutan ?
   - ☐ Sebelum kedatangan British
   - ☐ Semasa kedatangan British – Perang
   - ☐ Perang – Merdeka
   - ☐ Merdeka – 1980
   - ☐ Tahun 1980 – 2000
   - ☐ Tahun 2000 – Sekarang

7. Jika sekiranya hutan yang mempunyai roh atau semangat hutan itu tidak wujud lagi, pada waktu bilakah kampung berhenti untuk menyimpannya?
   - ☐ Sebelum kedatangan British
   - ☐ Semasa kedatangan British – Perang
   - ☐ Perang – Merdeka
   - ☐ Merdeka – 1980
   - ☐ Tahun 1980 – 2000
   - ☐ Tahun 2000 – Sekarang

8. Jika sekiranya semengat hutan itu tidak wujud lagi, mengapakah kampung berhenti untuk menyimpannya?

TAGAL/BOMBON
Jika sekiranya baru-baru ini atau sebelum ini kampung ada mengamalkan aktiviti Tagal / Bombon,

1. Adakah tagal/bombon yang digunakan untuk (sila tanda semua yang berkaitan):

   ☐ Menuai ikan → Berapa kalikah dalam satu tahun? __________
   ☐ Pelancongan
   ☐ Lain-lain: ______________________________

2. Bila tagal/bombon bermula?
   ☐ Sebelum kedatangan British
   ☐ Semasa kedatangan British – Perang
   ☐ Perang – Merdeka
   ☐ Merdeka – 1980
   ☐ Tahun 1980 – 2000
   ☐ Tahun 2000 – Sekarang

3. Jika sudah berhenti, pada waktu bilakah kampung berhenti untuk mengamalkan tagal/bombon?
   ☐ Sebelum kedatangan British
   ☐ Semasa kedatangan British - Perang
   ☐ Perang - Merdeka
   ☐ Merdeka - 1980
   ☐ Tahun 1980 - 2000
   ☐ Tahun 2000 – Sekarang

4. Jika sudah berhenti, mengapakah kampung berhenti untuk mengamalkannya?

____

____

SI 7-2 Reference copy of questionnaire distributed to PACOS community representatives at Joint Technical Session 16-17 February 2011 (English)

Please fill out the following survey as completely as possible. [Researcher name and institution] affiliated with Universiti Malaysia Sabah (UMS) studying local natural resource management across Sabah. Thank you!

PART A. JTS Representative Information

1. Name: ______________________________________ 2. Age: _______

3. Sex: ☐ Male ☐ Female

4. Phone number: ________________________________

5. Education (please check one):
   - ☐ I did not go to school
   - ☐ I finished primary
   - ☐ I finished secondary
   - ☐ I finished form 6
   - ☐ I finished university

6. Ethnicity (please check all that apply):

☐ Bajau	☐ Kedayan	☐ Malapi	☐ Pingas	☐ Tausug
☐ Bisaya	☐ Kimagarang	☐ Malay-Brunei	☐ Rumanau	☐ Tidong
☐ Bonggi	☐ Kolobuan	☐ Malaysian Chinese	☐ Rungus	☐ Tindal
☐ Bugis	☐ Kuijau	☐ Mangkaak	☐ Sinobu	☐ Tobilung
☐ Bundu	☐ Lingkabau	☐ Minokok	☐ Sinorupu	☐ Tolinting
☐ Dumpas	☐ Liwan	☐ Murut	☐ Sonsogon	☐ Tombonuo
☐ Gana	☐ Lobu	☐ Ngabai	☐ Sukang	☐ Tuhawon
☐ Garo	☐ Lotud	☐ Nunuk Ragang	☐ Sungai	☐ Tutung
☐ Idaan	☐ Lundayeh	☐ Orang Cocos	☐ Tatana	☐ Sandayoh
☐ Illanun	☐ Makiang	☐ Paitan	☐ Tangara	

☐ Other: ________________________________

7. Religion (Please check all that apply):
   - ☐ Animist
   - ☐ Christian- Anglican
   - ☐ Christian- Baptist
   - ☐ Christian- Borneo Evangelical
   - ☐ Christian- Brethren
   - ☐ Christian- Lutheran
   - ☐ Christian- Methodist
   - ☐ Christian- Presbyterian
   - ☐ Christian- Protestant Church Sabah (PCS)
   - ☐ Christian- Roman Catholic (RC)
   - ☐ Christian- Sidang Injil Borneo (SIB)
   - ☐ Christian- Seventh-day Adventist
   - ☐ Muslim
   - ☐ Other: ________________________

8. I am (please check all that apply):

☐ A member of the village

☐ A JKKK member: ____

☐ A religious leader in the village: _______________________________

☐ Another type of community leader: _____________________________

PART B. Village Information

9. Name of village: ______________________________

10. PACOS Zone:

☐ Utara
☐ Kinabalu
☐ Penampang
☐ Pendalaman Atas
☐ Pendalaman Bawah
☐ Tongod
☐ Pantai Timur

11. District: _____________________________________

12. Closest city to village is ________________________,
which is _________ km away from the village.

13. Does the paved road go to your village?

☐ Yes
☐ No, the paved road stops __________ km away from my village.

14. If a paved road does not go to your village, does a dirt road go to your village?

☐ Yes
☐ No, dirt road stops_________ km away from my village.

15. Is there a primary school in the village?

☐ No, the primary school is__________ km away from the village
☐ Yes, primary school was built in village:
- ☐ Before British
- ☐ British - War
- ☐ War - Independence
- ☐ Independence - 1980
- ☐ 1980 - 2000
- ☐ 2000 – present

16. Is there a secondary school in village?

☐ No, secondary school is____________ km away from my village
☐ Yes, secondary school was built in village:
- ☐ Before British
- ☐ British - War
- ☐ War - Independence
- ☐ Independence - 1980
- ☐ 1980 - 2000
- ☐ 2000 – present

17. How many people are in the village?

☐ Less than 250
☐ 250-499
☐ 500-749
☐ 750-999
☐ 1000-1249
☐ 1250-1499
☐ 1500-1749
☐ 1750-2000
☐ More than 2000

18. Ethnicities in the village (Check all that apply and CIRCLE the ethnicities of the MOST people in the village):

☐ Bajau	☐ Kedayan	☐ Malapi	☐ Pingas	☐ Tausug
☐ Bisaya	☐ Kimagarang	☐ Malay-Brunei	☐ Rumanau	☐ Tidong
☐ Bonggi	☐ Kolobuan	☐ Malaysian Chinese	☐ Rungus	☐ Tindal
☐ Bugis	☐ Kuijau	☐ Mangkaak	☐ Sinobu	☐ Tobilung
☐ Bundu	☐ Lingkabau	☐ Minokok	☐ Sinorupu	☐ Tolinting
☐ Dumpas	☐ Liwan	☐ Murut	☐ Sonsogon	☐ Tombonuo
☐ Gana	☐ Lobu	☐ Ngabai	☐ Sukang	☐ Tuhawon
☐ Garo	☐ Lotud	☐ Nunuk Ragang	☐ Sungai	☐ Tutung
☐ Idaan	☐ Lundayeh	☐ Orang Cocos	☐ Tatana	☐ Sandayoh
☐ Illanun	☐ Makiang	☐ Paitan	☐ Tangara	

☐ Other: ____

19. Religion (Check all that apply and CIRCLE the religions of the MOST people in the village):

☐ Animist
☐ Christian- Anglican
☐ Christian- Baptist
☐ Christian- Borneo Evangelical
☐ Christian- Brethren
☐ Christian- Lutheran
☐ Christian- Methodist
☐ Christian- Presbyterian
☐ Christian- Protestant Church Sabah (PCS)
☐ Christian- Roman Catholic (RC)
☐ Christian- Sidang Injil Borneo (SIB)
☐ Christian- Seventh-day Adventist
☐ Muslim
☐ Other: ________________________

PART C. Local natural resource management

20. Do people in the village gather natural resources?

☐ Yes
☐ No (Skip to question #27)
☐ I don’t know

If yes, do people gather natural resources for (check all that apply):

☐ Own use
☐ Sell in tamu
☐ Sell to middlemen

21. If yes, where do people go to gather natural resources and what do they take?

☐ Forest, taking: (Check all that apply)

☐ Wood for building
☐ Firewood
☐ Medicinal plants
☐ Forest fruits, vegetables, roots
☐ Hunting animals
☐ Others: ____________________________________

The forest where people gather resources is:
☐ State land
☐ Forest department land
☐ Native Reserve
☐ Native titled
☐ Native Customary Right (NCR)
☐ Under land application
☐ Others: ________________________________

☐ River, taking: (Check all that apply)
☐ Fish
☐ River snails
☐ Others: _______________________________________

☐ Caves, taking: (Check all that apply)
☐ Bird nests
☐ Hunting animals
☐ Others: _______________________________________

☐ Other places beside forests, rivers, and caves people go to gather natural resources (ex: ocean).
They go to: _______________________________ and take: ___________________

22. Are there any rules about where or when people can gather natural resources?
☐ Yes, there are rules
☐ No, there are no rules (Skip to question #27)
☐ I don't know

23. If yes, who makes the rules about when and where people can gather natural resources? Check all that apply.
☐ Ketua kampung
☐ JKKK
☐ Religious leaders
☐ Bobolizan/Dukun
☐ Government department: ______________________________________
☐ Others: ____

24. Are there penalties for breaking the rules? ☐ Yes
☐ No
☐ I don't know

25. Are these penalties enforced? ☐ Yes
☐ No
☐ I don't know

26. During your lifetime, have these rules: ☐ Stayed the same
☐ Become more strict
☐ Become less strict

27. Now, does the village have (please check all that apply):
☐ Village forest reserve
☐ Spirit forest
☐ Tagal/Bombon
☐ Other local natural resource management system: ________________________
☐ The village doesn't have any local natural resource management systems.

28. In the past, did the village have:

☐ Village forest reserve
☐ Spirit forest
☐ Tagal/Bombon
☐ Other local natural resource management system: ________________________
☐ The village didn't have any local natural resource management systems

PART D. Consent and additional information

May [Researcher] write your name and village with the information you have given in this survey in his/her work?

(please choose one)
☐ Yes, [Researcher] may use my name and village
☐ [Researcher] may use the information and village, but not my name
☐ [Researcher] may use the information, but not write my name or village

Signature: ____

THANK YOU!

VILLAGE FOREST RESERVE

If the village currently keeps or previously kept a village forest reserve:

1. How many acres is/was it? _________

2. What type of land is/was the village forest reserve on?
   - ☐ State land
   - ☐ Forest department land
   - ☐ Native Reserve
   - ☐ Native titled
   - ☐ Native Customary Right (NCR)
   - ☐ Under land application

   - ☐ Others: ________________________________

3. Can/could people gather resources in the village forest reserve?
   - ☐ Yes
   - ☐ No
   - ☐ I don't know

4. Is/was there a water source in the village forest reserve?
   - ☐ Yes
   - ☐ No
   - ☐ I don't know

5. When did it become a village forest reserve?
   - ☐ Before British
   - ☐ British – War
   - ☐ War – Independence
   - ☐ Independence – 1980
   - ☐ 1980 – 2000
   - ☐ 2000 – present

6. If it's gone, when did the village stop keeping it:
   - ☐ Before British
   - ☐ British – War
   - ☐ War – Independence
   - ☐ Independence – 1980
   - ☐ 1980 – 2000
   - ☐ 2000 – present

7. Why did the village stop keeping it? ___________________________________

   ____

   ____

SPIRIT FOREST
If the village keeps or previously kept spirit forest:

1. How many acres is/was it? _______________

2. What type of land is/was the spirit forest on?
   - ☐ State land
   - ☐ Forest department land
   - ☐ Native Reserve
   - ☐ Native titled
   - ☐ Native Customary Right (NCR)
   - ☐ Under land application
   - ☐ Others: ______________________________

3. Can/could people gather resources in the spirit forest?
   - ☐ Yes
   - ☐ No
   - ☐ I don't know

4. Today, do people in the village believe in the spirit in the spirit forest?
   - ☐ No one believes
   - ☐ A few people believe
   - ☐ Most people believe
   - ☐ Everyone believes

5. Is/was there a water source in the spirit forest?
   - ☐ Yes
   - ☐ No
   - ☐ I don't know

6. When did it become a spirit forest?
   - ☐ Before British
   - ☐ British – War
   - ☐ War – Independence
   - ☐ Independence – 1980
   - ☐ 1980 – 2000
   - ☐ 2000 – present

7. If it's gone, when did the village stop keeping it:
   - ☐ Before British
   - ☐ British – War
   - ☐ War – Independence
   - ☐ Independence – 1980
   - ☐ 1980 – 2000
   - ☐ 2000 – present

8. If it's gone, why did the village stop keeping it? ________________________

____

____

TAGAL/BOMBON

If the village currently practices or previously practiced Tagal / Bombon,

1. Is/was the tagal / bombon used for (please check all that apply):

☐ Fish harvest → How many times per year? _______________
☐ Tourism
☐ Other:____

2. When was tagal / bombon started?
☐ Before British
☐ British – War
☐ War – Independence
☐ Independence - 1980
☐ 1980 – 2000
☐ 2000 – present

3. If stopped, when did the village stop tagal/bombon:
☐ Before British
☐ British - War
☐ War – Independence
☐ Independence – 1980
☐ 1980 – 2000
☐ 2000 - present

4. If stopped, why did the village stop tagal / bombon? ____________________________

____

____

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Chapter 6 Shinto shrine forests and happiness in Japan

Chapter four considered the distribution of Ethiopian Orthodox Tewahido Church forests and the ecosystem service of pollination in an agricultural landscape. This chapter considers the distribution of Japanese Shinto shrine forests and cultural ecosystem services in a highly urbanized landscape. While the contexts of the two studies are different, the identification and assessment of contextually relevant ecosystem services on a landscape scale, assessed in terms of sacred forest distribution are similar. This chapter explores the distribution of Japanese Shinto shrine forests and cultural ecosystem services on a national scale. Cultural ecosystem services provided by forest patches, including sacred natural sites such as Japanese Shinto shrine forests, are difficult to quantify and incorporate in ecosystem service assessments, especially at the landscape scale. As introduced in chapter one, the Millennium Ecosystem Assessment defines ecosystem services as the "benefits people obtain from ecosystems" and cultural ecosystem services as including cultural diversity, spiritual and religious values, recreation and ecotourism, aesthetic values, and knowledge systems (Millenium Ecosystem Assessment, 2005:v). The development of non-monetary methods of valuing cultural ecosystem services is a research priority (Daily et al., 2009). This chapter presents the last of four papers of the thesis, and addresses research question 2) How do the location and distribution of sacred forests affect the provision of ecosystem services in diverse landscapes?

This paper considers the relationship between Shinto shrine forests and happiness at a national scale in Japan. At 37,800,000 ha, the study area and the national scale of analysis are the largest of the thesis. This paper assesses the largest number of sacred forests of the study areas, 57,742 Shinto shrine forests, which are a form of sacred natural sites. Shinto shrine land tenure emerged alongside the Imperial Court's claim to lands and is thus one of the oldest forms of state land tenure in Japan. Shinto shrines are autonomous in that they are individually managed by Shinto priests and priestesses, but they are also supported by an umbrella network, Jinja Honcho, the Association of Shinto Shrines.

Shinto shrine forests persist across the country to welcome and honour *kami*, or ‘Shinto gods’, and to lend a ‘dignified’ atmosphere to shrine buildings (Domenig, 1997). Shinto shrine forests range in size from less than a hectare to the 5,400 ha Grand Shrine of Ise which is 2000 years old and includes stands of primeval forest (Shikinen-Sengu, 2010, Ishii et al., 2010, Manabe, 2008). The concept of sacred forests in Japan as the meeting place for men and gods dates back to Jomon times (10,000 to 300 BC) (Tsukada, 2005). Stress relief and the social connection that Shintoism fosters are both forms of cultural ecosystem services that Shinto shrine forests provide.

This chapter considers the implications of sacred forest distribution for cultural ecosystem services. While religious and spiritual values are described as cultural ecosystem services, this paper demonstrates that they are, rather, processes that provide services such as social cohesion and stress relief. As non-monetary indices are developed to measure ecosystem services, such as happiness indices developed by countries as an alternative metric to GDP, calls in the literature for non-monetary valuations of ecosystem services on a landscape scale may soon be answered. This paper is a first look at such an approach, and shows that finer scales of data hold additional promise for more definitively linking sacred forests with ecosystem services assessments. This chapter, along with chapter four, also demonstrate that ecosystem services vary with the context of the study area. In these two chapters, ecosystem services were identified that would be of potentially high value or interest to the custodians in the landscape beyond the sacred forests.

6.1 Paper 4: Shinto shrine forests and happiness in Japan

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6.2 Abstract

Over half of the world's population lives in urban areas and 67.2% of the world's population is projected to live in urban areas by 2050. The effects of urban expansion and decreased daily interaction with the natural world have considerable impact on human wellbeing and happiness. However, urban green space has been shown to decrease stress, improve health and people report increased happiness in green spaces. In addition to governmental urban planning, sacred natural sites persist despite urban growth, conserved by religions as churchyards, shrine forests and cemeteries. In Japan, Shinto shrine forests form an integral component of the landscape. Rooted in the literature describing the cultural ecosystem services of social cohesion and stress relief that Shinto shrine forests provide, this study asks, what is the relationship between the distribution of Shinto shrine forests across Japan and happiness? We found that Shinto shrine forests were prevalent in urban areas where green space is scarce; over half of the prefectures had densities of at least one Shinto shrine forest for every 2 km^2 in both core and surrounding urban areas. We also found that the number of Shinto shrine forests per capita is positively correlated with the 'Happiness Ranking' for the 47 prefectures in Japan. While national happiness indexes have only recently emerged, this paper is a first step towards assessing spatial

datasets using non-monetary valuation tools for cultural ecosystem services on a national scale. Our study also raises an important research question for future work, do the spiritual and religious values underpinning sacred natural sites, their cultural ecosystem processes, enable cultural ecosystem services that differ from 'secular' green space?

6.3 Introduction

Cultural ecosystem services provided by forest patches, including sacred natural sites such as Japanese Shinto shrine forests, are difficult to quantify and incorporate in ecosystem service assessments, especially at the landscape scale. The Millennium Ecosystem Assessment defines ecosystem services as the "benefits people obtain from ecosystems" and cultural ecosystem services as including cultural diversity, spiritual and religious values, recreation and ecotourism, aesthetic values, and knowledge systems (Millenium Ecosystem Assessment, 2005:v). The development of non-monetary methods of valuing cultural ecosystem services is a research priority (Daily et al., 2009). The Millennium Ecosystem Assessment's definition of ecosystem services is an oversimplification of the human-environment relationship, as humans not only receive benefits from ecosystems, they shape the natural world based on their values. Wallace's (2007:237) review of ecosystem services classification suggests that like pollination or water regulation, spiritual and religious values are ecosystem processes rather than ecosystem services, in that they are "not ends that the manager will seek in their own right". This paper maps Shinto shrine forests across Japan, considers the implications of Shinto shrine forests' distribution for the provision of cultural ecosystem services, and investigates the relationship between Shinto shrine forests and happiness.

Over half of the world's population lives in urban areas (52.1% in 2011) and 67.2% of the world's population is projected to live in urban areas by 2050. In more developed regions[12], 77.7% of people live in cities with projections of 85.9% by 2050 (Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat, 2010/11). The effects of urbanization and citizens' decreased daily interactions with the natural world have been called the 'Extinction of Experience', with ramifications for wellbeing (Miller, 2005, Pyle, 2003) and happiness (MacKerron and Mourato, 2013). Overweight and obesity, abnormal and excessive fat accumulation that may impair health, respectively, are increasing in emerging economies, especially in urban areas; over 30% of preschool children in emerging economies are overweight or obese (World Health Organization, 2014). Globally 35% of adults aged 20+ were overweight and 12% were obese in 2008 (World Health Organization, 2014). Urbanization is also associated with an increase in mental disorders as people are exposed to overcrowding, pollution, violence and decreased social support (Srivastava, 2009). Mental and substance use disorders are the leading cause of non-fatal disease globally, with depression accounting for 40.5%, followed by anxiety (14.6%), drug and alcohol use (10.9% and 9.6%) (Whiteford et al.).

Green spaces in urban areas decrease stress and improve wellbeing; research to date focuses on high-income countries: The United States, United Kingdom, European countries and Japan (Wolf et al., 2012). Li et al. (2008) note that residents of Japanese prefectures with less forest cover have higher standardized mortality ratios from cancer than those living in prefectures with greater forest cover. Another study in Dundee, United Kingdom found that people who live near trees and parks have less cortisol, a stress hormone, in their saliva than those who live in areas with less green space (Ward

[12] The United Nations defines 'more developed regions' as all regions of Europe, Northern America, Australia/New Zealand and Japan. POPULATION DIVISION OF THE DEPARTMENT OF ECONOMIC AND SOCIAL AFFAIRS OF THE UNITED NATIONS SECRETARIAT 2010/11. World Population Prospects: The 2010 Revision and World Urbanization Prospects: The 2011 Revision.

Thompson et al., 2012). Even brief experiences in urban green space have measurable health benefits (Kaplan and Kaplan, 1989); hospital patients whose windows overlook trees have been found to heal faster than those with views of a brick wall (Ulrich, 1984) and brain waves of walkers show mental quietness when they walk through parks as opposed to busy urban environments (Aspinall et al., 2013).

A study of people living in deprived communities in Dundee, Scotland, found that people who live near trees and parks have less cortisol, a stress hormone, in their saliva than those who live in areas with less green space (Ward Thompson et al., 2012). The study's twenty-five participants measured their salivary cortisol and self-reported measures of stress and well-being. The study found significant relationships between self-reported stress, the circadian cortisol cycle, and quantity of green space. The percentage of green space near their homes and self-reported physical activity were each independent significant predictors of circadian cortisol cycle. Similarly, a study in Toronto, Canada found that people living with trees on the street perceived their health as better and had significantly less cardio-metabolic conditions (controlling for socio-economic and demographic factors); they found that an average of 10 more trees on a block increased perception of health similar to a $10,000 increase in personal income (Kardan et al., 2015).

In addition to health benefits, emerging research indicates that green space can improve happiness. Over 20,000 people in the United Kingdom participated in a study where they would respond to a smartphone survey request with their current level of happiness. Matching their responses with GPS and land cover data and controlling for weather, daylight, activity, companionship, location type, time, day and response trends, participants reported increased happiness when in green spaces rather than in urban environments (MacKerron and Mourato, 2013). Following the Kingdom of Bhutan's reporting of ‘Gross National Happiness’ (GNH) as an alternative to Gross Domestic Product (GDP), measuring happiness on a national scale has recently gained traction in numerous countries including China, France, Austria, the United Kingdom and Japan (AtKisson, 2012). It is important to consider the cultural context underscoring happiness. For example, in East Asian cultural contexts, happiness is defined in terms of social interpersonal connectedness (Uchida et al., 2004).

6.3.1 Study Area

Considering the trajectory towards urbanization globally, this study focuses on sacred natural sites in the highly urbanised nation of Japan; 91.3% of Japan’s population lives in urban areas (Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat, 2010/11). Sacred natural sites are “areas of land or water having special spiritual significance to peoples and communities” (Oviedo and Jeanrenaud, 2007:79) and range in size from a small cemetery abutting a church to large stands of urban forest. Large swathes of forest in Japan have been cleared for urban development and green space per capita in Japanese urban areas is notably less than metropolitan areas in other Asian countries and in other high-income countries around the world (Domenig, 1997, Yamamoto, 2010, Fuller and Gaston, 2009). Asian cities average 39 m^2 green space per capita, African cities 79 m^2 green space per capita and Latin American cities 255 m^2 green space per capita (Kuchelmeister, 1998, Economist Intelligence Unit, 2012); the World Health Organization recommends cities have a minimum of 9 m^2 green space per capita (Kuchelmeister, 1998). In Japan, Tokyo has 5.8 m^2 green space per capita, Osaka has 4.5 m^2 green space per capita and in Aichi prefecture, 26 of 32 cities have green space per capita below the of 9 m^2 green space per capita WHO threshold (Economist Intelligence Unit, 2012, Yamamoto, 2010, Tokyo Metropolitan Government Bureau of Construction, 2012). Although Shintoism was once regarded as a rural Japanese religion, Shinto shrines, or '*jinja*', persist despite urban growth. The Shinto shrine forests that surround them, or *'chinju no mori*' are one form of green space in Japanese cities (Figure 6-1).

a)

b)

Figure 6-1 Meiji shrine in Tokyo, Japan as depicted in a) a 1920 map (Geographicus, 1920) and in b) an aerial view photograph in 2010 (2010)

Land use regulations in Japan are weak and as such, green space is more susceptible to development than in other nations (Yamamoto, 2010:84). Shinto shrines, or '*jinja*', and the forests that surround them are designated as state land in the first land classification category, 'Land belonging to the Imperial Court, and land belonging to Shinto shrines' (Nōshōmushō, 1904). Shinto shrine land tenure emerged alongside the Imperial Court's claim to lands and is thus one of the oldest forms of land tenure in Japan.

During the Meiji Era (1868-1912), the government decreed Shintoism the national religion and claimed the divine rights of the Emperor were rooted in Shinto. This ideological use of Shintoism by the government is referred to as State Shinto. By restricting state funds to one *jinja*, or ‘shrine’, per village, the government attempted to consolidate and nationalise Shinto practice. During this period, the number of shrines in Japan decreased from 200,000 to 120,000 (Susumu et al., 2009). Today, Shintoism is practiced by 79.2% of Japan’s population, many of whom also practice Buddhism (Central Intelligence Agency (US), 2014).

While State Shinto was heavy-handed in its attempt to financially influence autonomous shrines run by Shinto priests and priestesses, it also linked Shintoism with Japanese nationalism. Another essentialist view is described as ‘ethnic’, and conceives that a connection with nature is part of being Japanese:

> “Two-thirds of Japan is forested, but throughout the archipelago, from the subarctic to the subtropical zones, virgin forest accounts for only 1 percent of the trees. One could say that the basis of Japan’s culture and spirituality lies in these forests. The deep woods, sacred places into which men do not lightly tread, evoked reverence and stirred the imagination. As if it were embedded in our DNA, awe of sacred trees still dwells in the hearts of modern Japanese” (Editorial Staff, 2005:1).

Essentialist conceptions of Shintosim have been extensively critiqued, yet Shinto is still described through a variety of alternative paradigms, including ahistoric, an imperial non-religion, environmental, as asserting otherness, local, universal, and spiritual (Rots, 2013). Thus, it is important to note that this paper is not claiming Shinto to be an ‘environmental’ religion, even though we focus on the distribution of Shinto shrine forests in the landscape.

Shinto shrine forests persist across the country to welcome and honour *kami*, or ‘Shinto gods’, and to lend a ‘dignified’ atmosphere to shrine buildings (Domenig, 1997). Shinto shrine forests range in size from less than a hectare to the 5,400 ha Grand Shrine of Ise which is 2000 years old and includes stands of primeval forest (Shikinen-Sengu, 2010, Ishii et al., 2010, Manabe, 2008). The concept of sacred forests in Japan as the meeting place for men and gods dates back to Jomon times (10,000 to 300 BC) (Tsukada, 2005). Masaaki Ueda, former chairman of the Shaso Gakkai, a society for sacred natural sites in Japan, said,

> “The Japanese viewed giant trees and pillers as yoshiro– meaning ‘a place whre gods draw near.’ Even as they cut down the forests to develop rice paddies and towns, there was a sense of taboo, that if you felled a tree in a sacred forest, you would be cursed. As a result they preserved woods with original flora. Although established as forbidden forests that people were not supposed to enter, the sacred woods became the center of village community because people could gather around them and offer performances of dance and music to the gods” (Tsukada, 2005:1).

Festivals, or *‘matsuri’*, with dance and music still regulary occur at Shinto shrines, and in the modern era, have been scheduled for Saturdays and Sundays to align with the Japanese work week (Nelson, 1996). Local music groups and dance troupes perform their routines with colourful matching attire and flags (Figure 6-2).

Figure 6-2 Festival at Meiji Shrine, Tokyo, 2016

These large gatherings bring people together and promote a sense of social cohesion. In this vein, people visit the shrines on many special days, including to celebrate New Year, bless their newborns a few weeks after birth, for ‘*setsubun*’– chasing away evil spirits at the start of spring, celebrating the harvest, ‘*obon*’– visits from the ancestors, and for ‘*shichi-go-san*’– girls aged three and seven and boys aged three and five dress in kimonos and receive prayers for their health and development (Jinja Honcho, 2011). Entering a shrine on a typical day without a festival is a markedly different experience, and they have a quiet and peaceful atmosphere. Wooden torii gates form the entrances to Shinto shrines – open archways that separate the secular world from the *kami*, but allow the public to access the shrine at any time. While this paper at times refers to Shinto shrines or Shinto shrine forests to match the literature discussing them, it is important to note that shrine visitors are enveloped in forest upon entering the Shinto shrine. While separate terms are used to specify shrine buildings or offerings, in practice, visiting a Shinto shrine is a forest experience. After passing through the torii gates, visitors walk down an entrance path lined with trees and into the shrine precincts with sacred trees (Figure 6-3).

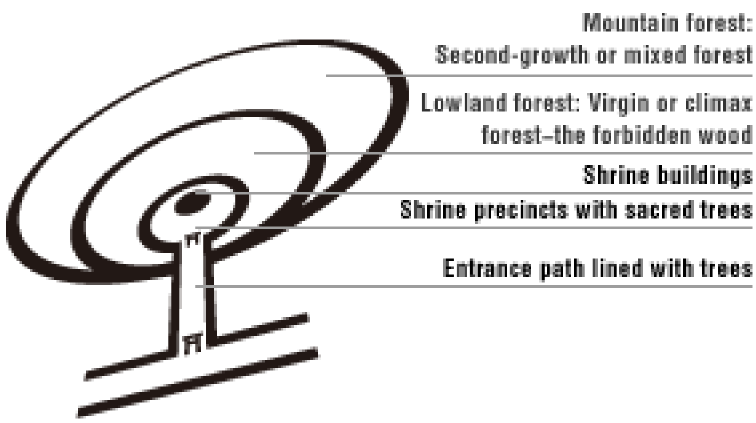


Figure 6-3 The layout of Shinto shrines, and their associated shrine forest, is depicted in the symbol of Shaso Gakkai, a Japanese society for sacred natural sites (Tsukada, 2005)

Visitors wash their hands and mouths at the purification trough before making offerings and prayers at the offering hall. There are also places to leave wishes on wooden plates, ‘*ema*’, and in some shrines, receive fortune telling paper slips, ‘*omikuji*’. Sacred trees, stones, etc. are marked with a straw rope with zigzag paper strips, '*shimenawa*' (Figure 6-4).

Figure 6-4 Meiji shrine, Tokyo from top left, clockwise: Entering through torii gate, three women in festival wear walking down the entrance path lined with trees, purification trough, sacred trees marked with '*shimenawa*'

Shintoism provides a feeling of connection with friends, family, Japanese identity, and the natural world. This has implications for happiness in Japan. Happiness is a relative concept, and in Japan, happiness is constructed as the realization of social harmony (Kitayama et al., 2000). Evans (2002:ii) notes, "In Shinto, each individual stands on a vertical line connecting the kami, [his] ancestors and [his] descendents, past and future. Additionally, each person is also on a horizontal line that connects [him] with [his] neighbor, [his] friends, society, country, and with foreign nations". Social trust has been found to have significant positive effects on subjective assessments of happiness in Japan, as reported by the 14,538 respondents of the Japanese General Social Survey (Kuroki, 2011).

In addition to the sense of connection and social trust that Shinto provides, the natural atmosphere of Shinto shrine forests contributes to a sense of interconnectedness with the natural world. Shintoism emphasizes practice, or *jissen*, over theology or doctrine, and the "practice of Shinto leads [its practitioners] to live in harmony with *Dai Shizen no rneguri*, the ceaseless cycle of Great Nature" (Evans, 2002:ii). Kishimoto (1968:126) describes how Shinto shrine forests enrich the lives of urban residents:

> "At a corner of a busy district of a city a Jinja is quietly situated. The precint of the sanctuary is full of green covered by huge old trees… At due time and season, rituals are observed as they were in ancient days. The performance produces in the participants a certain kind of sacred feeling… Stepping into the precinct, into its quietude, a visitor rediscovers his inner self having been lost all the while in the busy life of the city… To have a brief moment like this a few times a week for a lay member of a Jinja, means an immeasurable enriching of his life. The Jinja becomes the oasis of urban life."

Empirical research in Japan has investigated the physiological benefits of *shinrin-yoku*, or 'taking in the forest atmosphere or forest bathing' (Tsunetsugu et al., 2010, Park et al., 2010, Li, 2010). Over 25% of respondents in a 2003 survey engaged in *shinrin-yoku* in the past year and over 66% of respondents were interested in *shinrin-yoku* for the health benefits (Cabinet Office of Government of Japan, 2004). The Council of the 3 Cities on the Waterfront (Sawara, Itako, and Kashima) website notes to potential shrine visitors, "You can saunter among the mighty trees that have been guarding the sacred precincts of the shrines all through time. You can experience a feeling of relief from your worldly stress by touching clean and pure air exhaled from 'sacredness'" (The Council of 3 Cities on the Waterfront, 2008-2010). The stress relief that spending time in Shinto shrine forests has been empirically shown to provide is of interest in light of the high rates of stress in the Japanese workforce coupled with a relatively low incidence of green space in Japanese urban areas. According to government surveys, 58% of workers in Japan report stress at work, and there is even a Japanese term, *karoshi*, for 'death from overwork' (Ministry of Health Labour and Welfare (Japan), 2008).

Shinrin-yoku may also reduce the risk of psychosocial stress-related diseases (Morita et al., 2007). Diabetic patients who engaged in *shinrin-yoku* nine times over a six-year period decreased their blood glucose levels after 30 minutes of walking in the forest, more than diabetic subjects using cycle ergometers, walking on treadmills, or swimming in hot spring pools (Ohtsuka et al., 1998). Li (2010) found that office workers in Nagano prefecture who stayed in the forest for 3-day/2-night retreats decreased stress levels and exhibited improved immune activity up to a week, and in some cases over a month, later. Morita et al. (2007) found that stress relief occurs upon arriving at the forest, and the type of forest, size, and time spent in the forest do not determine health benefits (Morita et al., 2007). Bodin's (2006) study in Madagascar, where the location of sacred forests was found to be more important in ecosystem service provision than patch size. The Millennium Ecosystem Assessment defines ecosystem services as the "benefits people obtain from ecosystems" (Millenium Ecosystem Assessment, 2005:v). Stress relief and the social connection that Shintoism fosters are both forms of ecosystem services that Shinto shrine forests provide. This study considers the implications of Shinto shrine forest distribution for cultural ecosystem service provision. Across the 47 prefectures of Japan, we explore the relationship between the density of Shinto shrine forests and happiness, based on a national happiness index.

6.4 Methodology

We selected Japan as 1) it's a highly urbanised nation (91.3% of population lives in urban areas) (Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat, 2010/11), 2) 79.2% of Japanese people practice Shintoism and Shinto shrine forests, *chinju no mori*, persist across the country, forming an integral component of the landscape and national Imperial identity (Central Intelligence Agency (US), 2014, Fukamachi et al., 2001, White 曜社 Co., unknown), and 3) a significant body of research explores the benefits of Shinto shrine forests for physical and mental health (Tsunetsugu et al., 2010, Park et al., 2010, Li, 2010, Morita et al., 2007, Kawakami and Haratani, 1999, Ohtsuka et al., 1998).

To examine the distribution of Shinto shrine forests in relation to other forest types, we created a forest map layer for Japan in ArcMap GIS software using GlobCover satellite data (European Space Agency, 2009). We identified forest as pixels of 1) closed to open (>15%) broadleaved evergreen or semi-deciduous forest (>5m), 2) closed (>40%) broadleaved deciduous forest (>5m), 3) open (15-40%) broadleaved deciduous forest/woodland (>5m), 4) closed (>40%) needleleaved evergreen forest (>5m), 5) open (15-40%) needleleaved deciduous or evergreen forest (>5m), 6) closed to open (>15%) mixed broadleaved and needleleaved forest (>5m), 7) closed to open (>15%) broadleaved forest regularly flooded (semi-permanently or temporarily) – fresh or brackish water and 8) closed (>40%) broadleaved forest or shrubland permanently flooded – saline or brackish water (European Space Agency, 2009). Next we created a map layer of core urban areas, using GlobCover's designation of artificial surfaces and associated areas (European Space Agency, 2009). Finally, we created a map layer of surrounding urban areas (areas of dense human habitation beyond the core urban areas) developed from 2002-2003 MODIS satellite data at 1 km resolution (Schneider et al., 2003). To avoid errors of commission, in ArcMap we overlapped our layers of forest and core urban areas with the MODIS urban areas layer and removed any intersecting pixels to create our surrounding urban areas layer. Then we calculated the total area of Japan covered by forest, core urban areas and surrounding urban areas, respectively.

Prefectural boundaries of Japan were obtained from the Global Administrative Areas database and overlaid in ArcMap (Global Administrative Areas, 2012). The areas of prefectures were calculated as well as the areas of forest, core urban areas and urban areas in each prefecture. We calculated the percentage of forest area, core urban areas and surrounding urban areas in each prefecture. The population data per prefecture was obtained from the 2005 Population Census (Statistics Bureau of Japan, 2005) and we calculated the population density of each prefecture using the prefectural areas we calculated in ArcMap. Next we tested our data for percentage forest cover, percentage core urban areas, percentage surrounding areas and population density for the 47 prefectures for normality via the Shapiro-Wilk test in SPSS v. 21. We conducted a bivariate correlation of percentage forest cover and population density using Spearman's Test for non-normal variables.

Geographically referenced point data of 80,000 Shinto shrines (Geographic coordinate system WGS-1984) were downloaded from a Shinto shrine database (White 曜社 Co., unknown), mapped in ArcMap v.10.0 and geographical duplicates removed to avoid errors of commission. Duplicates' headings included 'shrine office' and other demarcations of individual buildings on a shrine site. The Shinto shrine forest data in our study, while extensive (n=57,742) and geographically expansive, constrains our analysis as point data. The future availability of boundary data for sacred natural sites will enable additional analyses.

First, we assessed the average observed distance between Shinto shrine forests using the Average Nearest Neighbour tool in ArcMap. Then we calculated the number of Shinto shrine forests per prefecture by intersecting the Shinto shrine forest layer with the prefectural boundary layer, and using the area of the prefectures, we calculated the Shinto shrine forest density per prefecture. Finally, to compare Shinto shrine forest density with percentage forest area, population, and population density of the prefectures, we tested the data for normality in SPSS and as the data was non-normal, we performed bivariate correlations using Spearman's Test. For each prefecture we calculated green space per capita, as it is the preferred metric of urban green space guidelines to ensure that green space provision keeps pace with population growth (World Health Organization, 2012, Kuchelmeister, 1998).

Next we calculated the number of Shinto shrine forests in forest areas, core urban areas, and urban areas in each prefecture by intersecting the Shinto shrine forest layer with the respective forest and urban layers. We divided the number of Shinto shrine forests found in each land cover type (forest, core urban areas, and surrounding urban areas) by the area of the respective land cover type to calculate the Shinto shrine forest density in each prefecture's forest, core urban areas and surrounding urban areas. To determine if there was a statistically significant difference between Shinto shrine forest density in forest vs. core urban areas across the 47 prefectures of Japan, first we tested our shrine forest density data for normality via the Shapiro-Wilk test in SPSS v. 21 and then as our data was non-normal, we conducted a Related Samples Wilcoxon Signed Rank Test. We performed a second Related Samples Wilcoxon Signed Rank Test to compare Shinto shrine forest density in forest vs. surrounding urban areas.

To test the nearness of Shinto shrine forests in urban areas, we assigned 4,400 random points within the core urban areas layer using the "create random points" tool in ArcMap, specifying 100 points per prefecture (n=44). We repeated this process to assign 4,700 random points within the surrounding urban areas layer, also with 100 points per prefecture (n=47). Next we calculated the Euclidean distance from each random point to the nearest Shinto shrine forest employing the 'near' tool in ArcMap. We tested our two random point distance datasets (distance from core urban area random points and distance from surrounding urban area points to nearest Shinto shrine forests) for normality in SPSS. We performed an Independent Samples Kruskal-Wallis Test to determine if there was a significant difference between the prefectures for distances from the random points in core urban areas to the nearest Shinto shrine forests. We performed a second Independent Samples Kruskal-Wallis Test to determine if there was a significant difference between the prefectures for distances from the random points in surrounding urban areas to the nearest Shinto shrine forests. To compare the accessibility of Shinto shrine forests in core urban areas compared to surrounding urban areas, we compared the data for the 44 prefectures with core urban areas via a Related Samples Wilcoxon Signed Rank Test.

Finally, we employed a Japanese national happiness index as a coarse non-monetary method of measuring cultural ecosystem services on a national scale. To test for a relationship between Shinto shrine forests and happiness, we compared the number of Shinto shrine forests per 1000 people and Shinto shrine forest density (number of Shinto shrine forests per km) with Sakamoto's wellbeing index for the 47 prefectures of Japan. Sakamoto's 'Happiness Ranking' is comprised of 40 objective indicators within the categories of 1) life and family issues, 2) labour issues, 3) safety and security issues, and 4) medical care and health issues (Sakamoto, 2011). We chose to use Sakamoto's 'Happiness Ranking' as it is a national happiness index developed by Japanese researchers who selected indicators for happiness in a Japanese context. We tested the Sakamoto Index, Shinto shrine forests per 1000 people and Shinto shrine forest density data for normality in SPSS v.20 and as the data was non-normal, we performed bivariate correlations using Spearman Tests. We similarly tested the relationship between Sakamoto's 'Happiness Ranking' with population and population density.

It is important to note that there are numerous factors influencing a prefecture's happiness and the number of Shinto shrine forests per capita, that is to say, correlation does not mean causation. For example, this study also found that the population of a prefecture negatively influenced its happiness, which may be due to the negative aspects of urban living, e.g. pollution, crowding, obesity, etc. and/or the challenges associated with governing more people, e.g. the stretching of prefectural resources. The number of Shinto shrine forests per capita may be the result of factors that affect happiness, for example good local governance, as in the case of Fukui, or historical political processes, as in the case of Okinawa.

6.5 Results

We identified 57,742 Shinto shrine forests across the 47 prefectures of Japan; there is an observed mean distance of 913.82 m between Shinto shrine forests (Average Nearest Neighbour, NNRatio: 0.23, NNZScore: -351.91, p=0.00). We found 66% of Japan is comprised of forest, 1% is core urban areas, and 14% is surrounding urban areas; the remaining 19% of Japan is dominated by other land cover types (Figure 6-5).

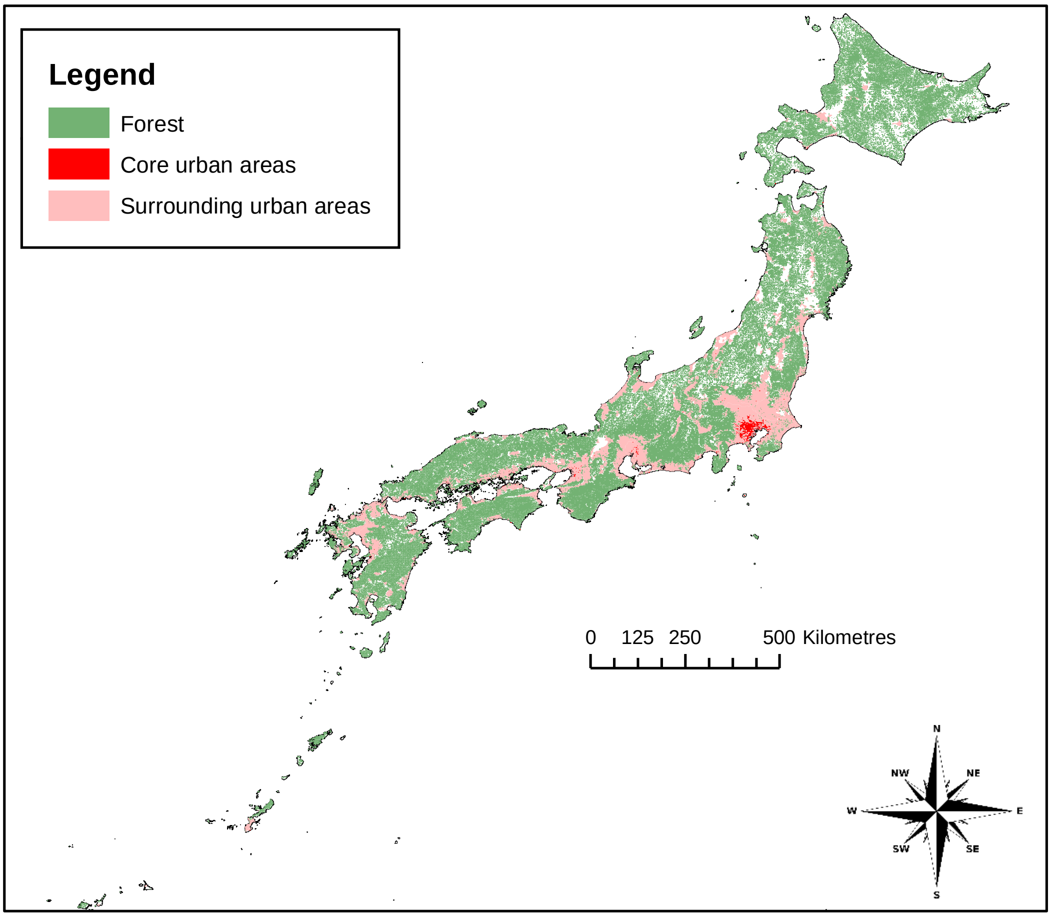


Figure 6-5 Forest cover (66%), core urban areas (1%), and surrounding urban areas (14%) of Japan (European Space Agency, 2009, White 曜社 Co., unknown, Schneider et al., 2003, Kitayama et al., 2000)

We found that 12,935, or ~22%, of Shinto shrine forests are located in forested areas, 30,423, or ~53%, in surrounding urban areas and 1,512, or ~3%, in core urban areas. The remaining 12,872 Shinto shrine forests, or ~22%, are located in the other land cover types. The density of Shinto shrine forests in forested areas across Japan is 0.05 Shinto shrine forests/sq. km, in core urban areas there are 0.75 Shinto shrine forests/sq. km and in surrounding urban areas there are 0.57 Shinto shrine forests/sq.km. We found significant differences between the Shinto shrine forest density in forest versus core urban areas (Related Samples Wilcoxon Signed Rank Test, n=44, p=0.000) and between the Shinto shrine forest density in forest versus surrounding urban areas (Related Samples Wilcoxon Signed Rank Test, n=47, p=0.000).

Across the 47 prefectures, percentage forest area ranges from 28.23% to 90.01% with an average of 60.47 ± 2.43%, percentage core urban areas in the prefectures ranges from 0% to 43.72% with an average of 1.7 ± 9.95%, and percentage surrounding urban areas in the prefectures range from 1.72% to 63.84%, with an average of 21.07 ± 2.46%. The percentage forest area of the 47 prefectures is negatively correlated with Shinto shrine forest density (across all land cover types) (Spearman correlation, n=47, p=0.006, two-tailed, correlation coefficient=-0.392) (Figure 6-6).

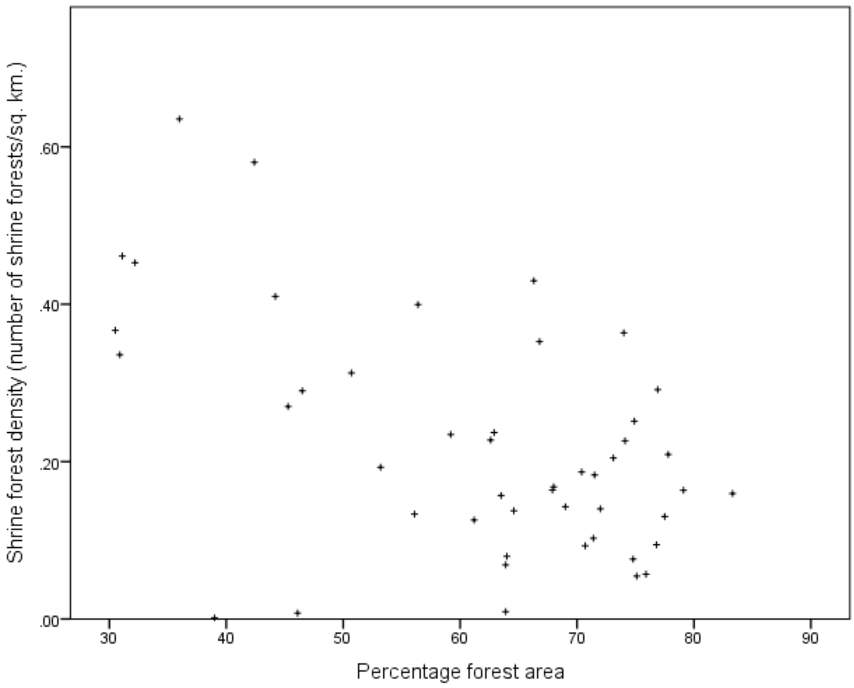


Figure 6-6 Percentage forest area is negatively correlated with Shinto shrine forest density (number of Shinto shrine forests/km^2) for the 47 prefectures of Japan (Spearman correlation, n=47, p=0.006, two-tailed, correlation coefficient=-0.392).

This means that Shinto shrine forests are more densely distributed in prefectures with less forest. This makes sense as Shinto shrine forests were also found to be more densely distributed in core urban areas and surrounding urban areas than in forest.

Percentage forest area is negatively correlated with population density for the 47 prefectures of Japan (Spearman correlation, n=47, p=0.000, two-tailed, correlation coefficient=-0.603) (Figure 6-7).

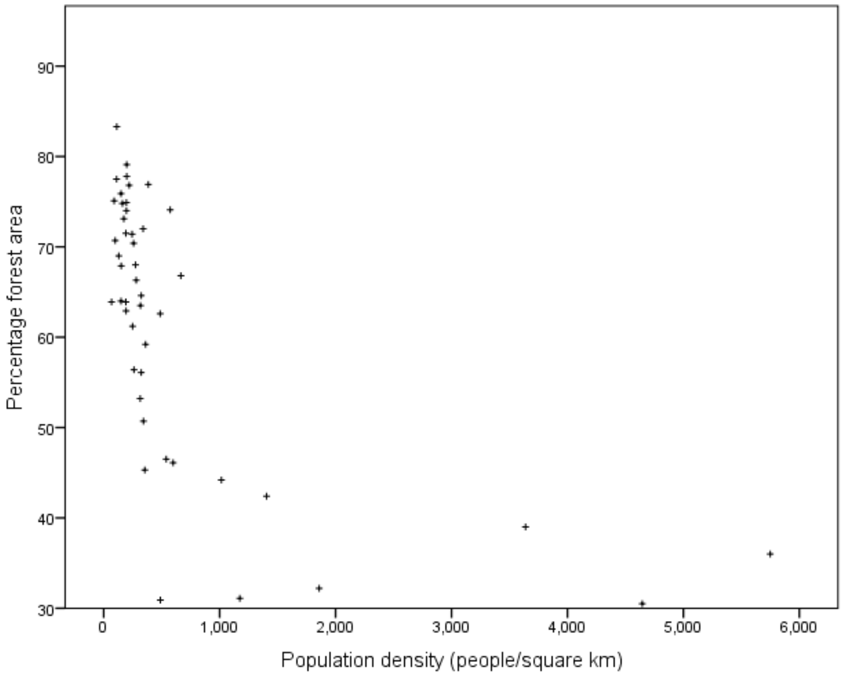


Figure 6-7 Percentage forest area is negatively correlated with population density (Spearman correlation, n=47, p=0.000, two-tailed, correlation coefficient = -0.603) for the 47 prefectures of Japan (2005, Ministry of Health Labour and Welfare (Japan), 2012)

Percentage core urban areas and percentage surrounding urban areas are positively correlated with population density (Spearman correlations, n=44, p=0.000. two-tailed, correlation coefficient=0.687 for core urban areas, and n=47, p=0.000, two-tailed, correlation coefficient=0.851 for surrounding urban areas).

In the prefecture of Tokyo, home to the most populated city in Japan (Tokyo: 36.5 million people) (CIA, 2014), core urban areas comprise 43.73% of the prefecture, however 63.96% of Shinto shrine forests in the prefecture are found in core urban areas, with another 27.55% of Shinto shrine forests found in surrounding urban areas (Figure 6-8).

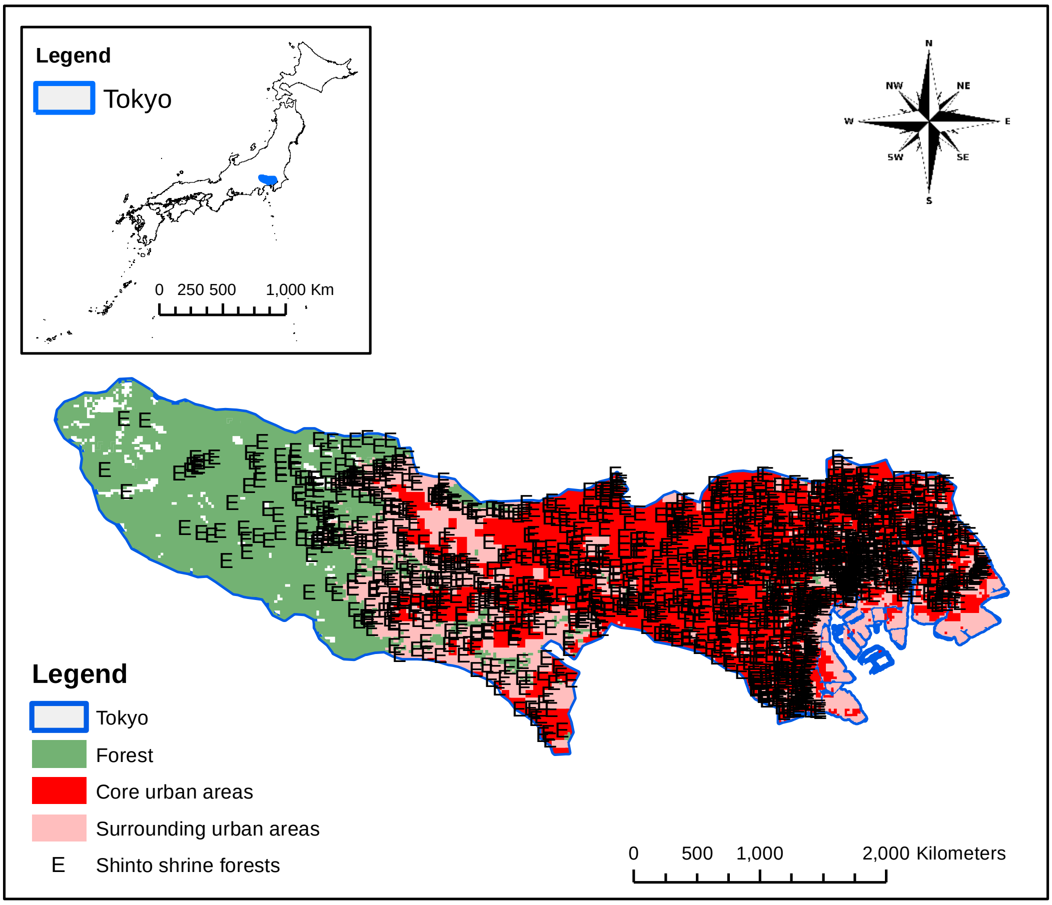


Figure 6-8 Shinto shrine forests in the prefecture of Tokyo, Japan (European Space Agency, 2009, White 曜社 Co., unknown, Schneider et al., 2003, Kitayama et al., 2000)

At 889, Tokyo has the most Shinto shrine forests in core urban areas of any prefecture, 689 more than the second-most Saitama at 200. However, Tokyo's core urban areas are more expansive than other prefectures' core urban areas, thus the Shinto shrine forest density is higher in eight other prefectures than Tokyo's 1.13 Shinto shrine forests/km^2; the highest being Shimane with 5.45 Shinto shrine forests/km^2. When the number of Shinto shrine forests in Tokyo is added to the total number of "secular" green spaces reported by the Tokyo Metropolitan Government Bureau of Construction (e.g. metropolitan and municipal parks, national gardens and nature parks), Shinto shrine forests in Tokyo prefecture's 53 districts comprise on average 14.15 ± 1.85% (range:

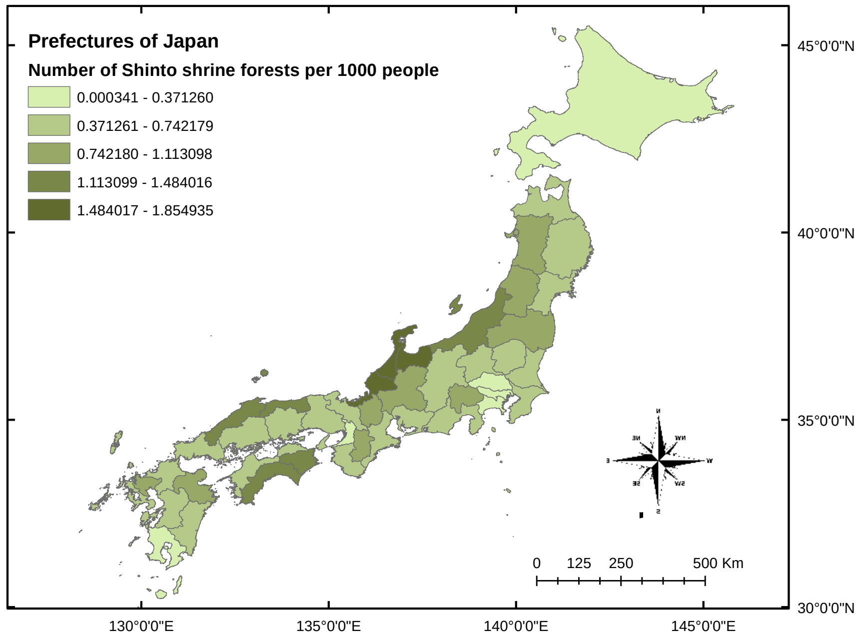
2.65-86.36%, median 9.95%) of overall green space (Tokyo Metropolitan Government Bureau of Construction, 2012).

Of the 44 prefectures with core urban areas, 11 prefectures have a Shinto shrine forest density of >1 Shinto shrine forest/ km^2 and 23 have a Shinto shrine forest density of >0.5 Shinto shrine forest/ km^2. Of the 47 prefectures with surrounding urban areas, 4 have a Shinto shrine forest density of >1 Shinto shrine forest/ km^2 and 27 have a Shinto shrine forest density of >0.5 Shinto shrine forest/ km^2.

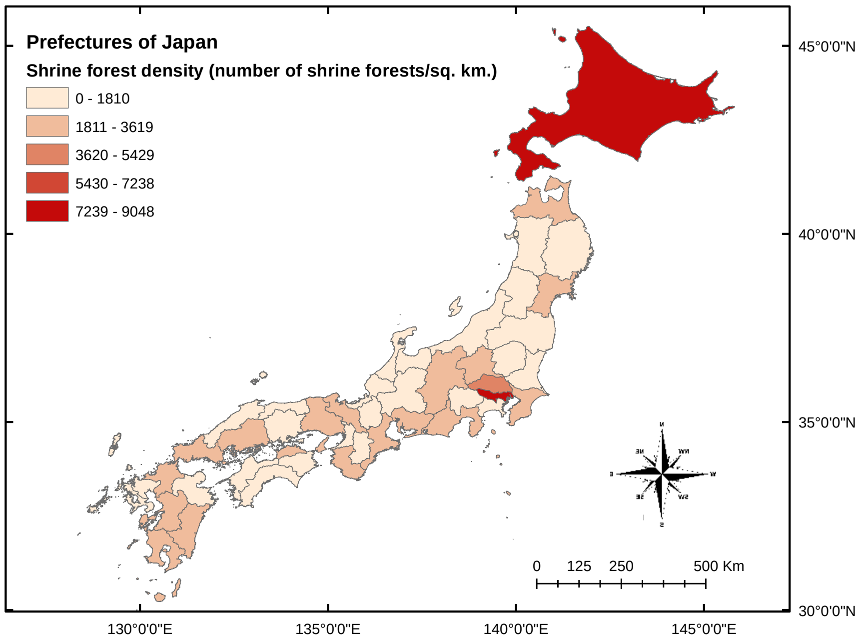
The distances from our 4,400 random points in core urban areas to the nearest Shinto shrine forest range from 13.48 to 301,081.98 m. The median distance is 666.81 m and the mean distance is 4,345.52 ± 403.32 m. There is a significant difference between the 44 prefectures for the distances from random points in core urban areas to the nearest Shinto shrine forests (Independent Samples Kruskal-Wallis Test, n=4,400, p=0.000). The distances from our 4,700 random points in surrounding urban areas to the nearest Shinto shrine forest range from 13.18 to 121,395.73 m. The median distance is 700.30 m and the mean distance is 1,342.51 ± 65.02 m. There is also a significant difference between the 47 prefectures for the distances from random points in surrounding urban areas to the nearest Shinto shrine forests (Independent Samples Kruskal-Wallis Test, n=4,400, p=0.000). We found no significant difference between the distance to the nearest Shinto shrine forest from our random points in core urban areas compared to our points in surrounding urban areas (Related Samples Wilcoxon Signed Rank Test, n=4,400, p=0.083).

The number of Shinto shrine forests per 1000 people is positively correlated with Sakamoto’s ‘Happiness Ranking’ for the 47 prefectures of Japan (Spearman correlation, n=47, p=0.000, two-tailed, correlation coefficient=0.591) (Figures 6-9 and 6-10) (Table 6-1).

a)


Prefectures of Japan
Number of Shinto shrine forests per 1000 people
0.000341 - 0.371260
0.371261 - 0.742179
0.742180 - 1.113098
1.113099 - 1.484016
1.484017 - 1.854935
0 125 250 500 Km
45°0'0"N
40°0'0"N
35°0'0"N
30°0'0"N
130°0'0"E
135°0'0"E
140°0'0"E
145°0'0"E

b)


Prefectures of Japan
Shrine forest density (number of shrine forests/sq. km.)
0 - 1810
1811 - 3619
3620 - 5429
5430 - 7238
7239 - 9048
0 125 250 500 Km
45°0'0"N
40°0'0"N
35°0'0"N
30°0'0"N
130°0'0"E
135°0'0"E
140°0'0"E
145°0'0"E

c)

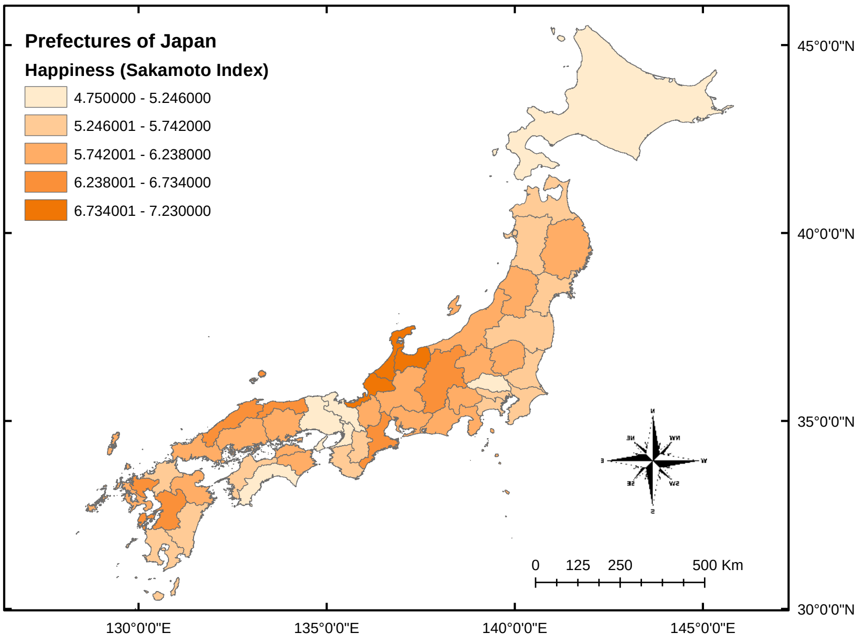


Figure 6-9 a) Number of Shinto shrine forests per 1000 people, b) Shinto shrine forest density (number of shrine forests per km) and c) happiness (Sakamoto Index) for the 47 prefectures of Japan

Table 6-1 Number of Shinto shrine forests per 1000 people and happiness (Sakamoto Index) for the 47 prefectures of Japan

Prefecture	Number Shinto shrine forests	Number Shinto shrine forests/1000 people	and rank	Happiness (Sakamoto Index) and rank	
Fukui-ken	1524	1.85	1	7.23	1
Ishikawa-ken	1799	1.53	2	6.9	3
Toyama-ken	1697	1.53	3	7.2	2
Kōchi-ken	1130	1.42	4	5	46
Tokushima-ken	1042	1.29	5	6	17
Niigata-ken	2982	1.23	6	6.18	10
Tottori-ken	718	1.18	7	6.63	4
Shimane-ken	873	1.18	8	6.35	8
Yamagata-ken	1329	1.09	9	5.93	19
Fukushima-ken	2258	1.08	10	5.73	27
Yamanashi-ken	934	1.06	11	6.05	14
Ōita-ken	1160	0.96	12	6.05	15
Akita-ken	1080	0.94	13	5.4	37
Shiga-ken	1256	0.91	14	6.13	11
Gifu-ken	1738	0.82	15	6.08	13
Saga-ken	659	0.76	16	6.55	5
Nara-ken	1076	0.76	17	5.65	31
Ehime-ken	1060	0.72	18	5.73	28
Ibaraki-ken	2047	0.69	19	5.68	30
Nagasaki-ken	962	0.65	20	5.88	23
Tochigi-ken	1236	0.61	21	5.75	26
Okayama-ken	1194	0.61	22	5.83	24
Iwate-ken	832	0.60	23	5.88	22
Kagawa-ken	544	0.54	24	6.1	12
Aomori-ken	765	0.53	25	5.25	40
Hyōgo-ken	2959	0.53	26	5.03	45
Kumamoto-ken	931	0.51	27	6.55	6
Gunma-ken	999	0.49	28	5.8	25
Nagano-ken	1032	0.47	29	6.48	7
Shizuoka-ken	1769	0.47	30	5.93	20
Wakayama-ken	446	0.43	31	5.63	32
Mie-ken	795	0.43	32	6.25	9
Yamaguchi-ken	627	0.42	33	6	16
Aichi-ken	2998	0.41	34	5.9	21
Hiroshima-ken	1187	0.41	35	5.95	18
Miyagi-ken	972	0.41	36	5.43	36
Fukuoka-ken	2041	0.40	37	5.28	39
Kyōto-fu	1045	0.39	38	5.18	42
Chiba-ken	2378	0.39	39	5.53	33
Miyazaki-ken	441	0.38	40	5.73	29
Kagoshima-ken	632	0.36	41	5.45	35
Saitama-ken	1719	0.24	42	5.08	44
Hokkaidō	770	0.14	43	5.15	43
Tōkyō-to	1390	0.11	44	5.38	38
Ōsaka-fu	696	0.08	45	4.75	47
Okinawa-ken	17	0.01	46	5.2	41
Kanagawa-ken	3	0.00	47	5.53	34

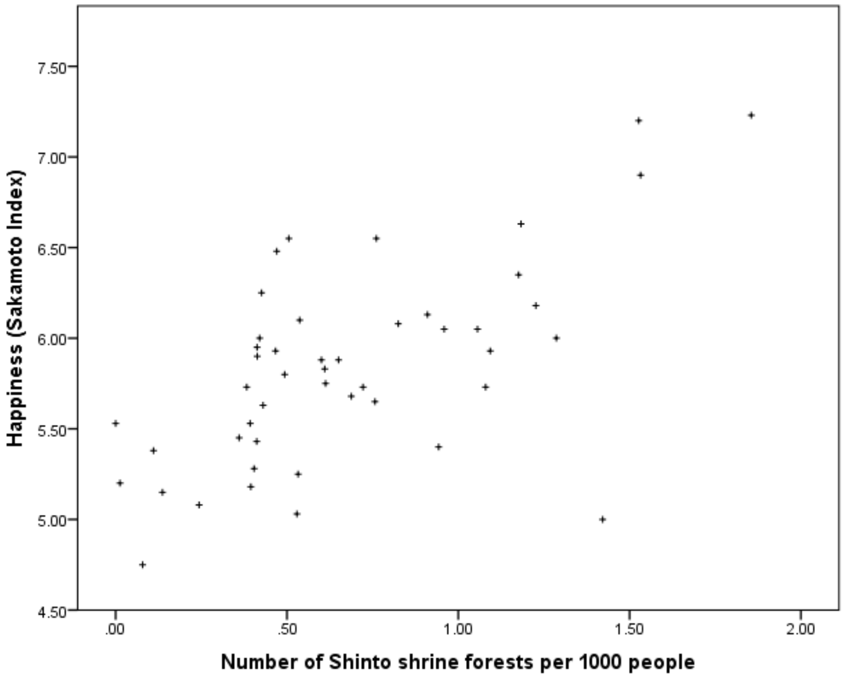


Figure 6-10 Happiness (Sakamoto Index) (Sakamoto, 2011) is positively correlated with the number of Shinto shrine forests per 1000 people, Spearman correlation (n=47, p=0.000, two-tailed, correlation coefficient=0.591)

Sakamoto's 'Happiness Ranking' is negatively correlated with population of the 47 Japanese prefectures (2005) (Spearman correlation (n=47, p=0.001, two-tailed, correlation coefficient=-0.476), but is not correlated with the population density of the prefectures nor the density of Shinto shrines (Figure 6-11).

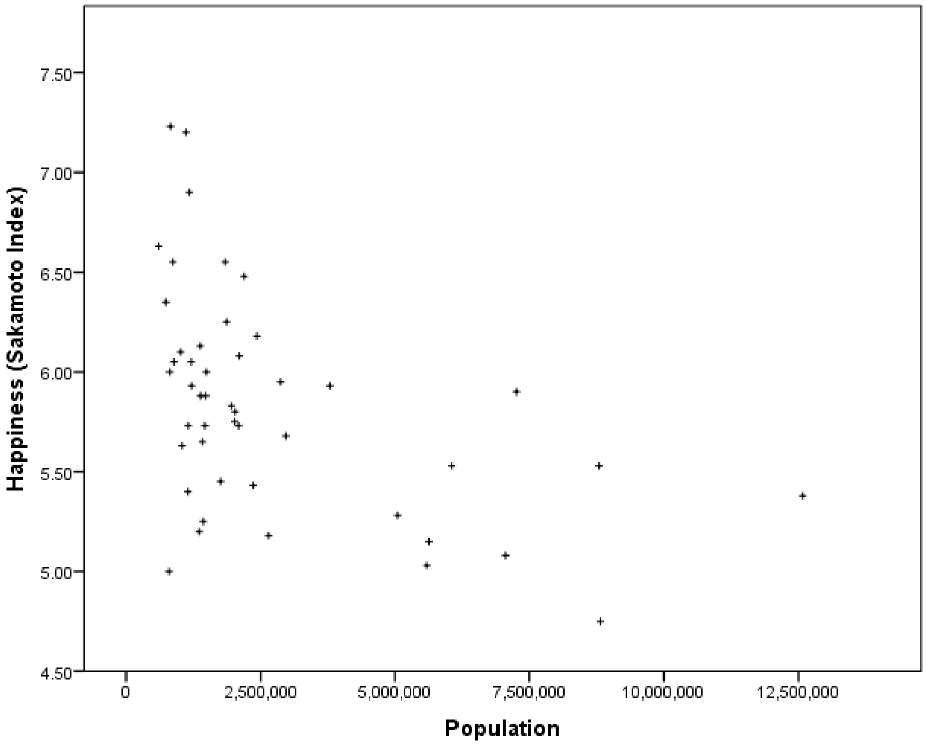


Figure 6-11 Happiness (Sakamoto Index) is negatively correlated with population of the 47 Japanese prefectures (2005), Spearman correlation (n=47, p=0.001, two-tailed, correlation coefficient=-0.476) (Sakamoto, 2011)

6.6 Discussion

Urban green space and forests have been shown to have positive effects on urban populations, including decreasing stress and improving health (Wolf et al., 2012). However, in highly urbanized countries, even those with high percentages of forest cover such as Japan (66%), regular exposure to forests is limited for urban residents; this "Extinction of Experience" of nature is compounded when urban green space is also constrained (Miller, 2005). We hypthosized that sacred natural sistes, such as Japanese Shinto shrine forests, provide cultural ecosystem services to urban residents, including social cohesion and stress relief.

Japan has a high percentage of forest cover overall at 66%, ranking 18th of 233 countries and territories around the world (Food and Agriculture Organization of the

United Nations, 2010). With 91.3% of its population in urban areas, Japan also has a high rate of urbanization, ranking 30th of 231 countries and territories[13] (Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat, 2010/11). We found nearly 15% of Japan's land area is core and surrounding urban areas. Japan's built-up area, 52,067 km^2, comprises 7% of all built-up area in the world (Salvatore et al., 2005). Urban green space is extremely limited; many Japanese cities' green space is below the World Health Organization's recommended threshold (Tokyo Metropolitan Government Bureau of Construction, 2012, Kuchelmeister, 1998, Economist Intelligence Unit, 2012, Yamamoto, 2010). We found prefectures with high percentages of forest area had low percentages of urban areas (e.g. Ehime: 76.22% forest, 0% core urban, 9.87% surrounding urban) and prefectures with low percentages of forest area had high percentages of urban areas (e.g. Kanagawa: 38.42% forest, 16.51% core urban, 42.2% surrounding urban). We assessed the relationship between forest cover and population density across the 47 prefectures, finding negative correlations between population density and forest area and positive correlations between percentage urban areas and population density. These results suggest a strong relationship between urbanization and forest clearance. This relationship has also been observed in the literature on a global scale, with forest area stabilizing before population growth (Mather and Needle, 2000). After World War II, Japan's rapid industrialization spurred a wave of migration to cities, effectively depopulating the countryside. The separation between urban built environments and forests can lead to an 'Extinction of Experience' of nature and loss of the corresponding benefits for urban residents (Miller, 2005). Concerned about the negative social and environmental effects of overpopulated cities, Japanese

[13] The top 10 countries and territories are 100% urban (e.g. Holy See and Hong Kong) ibid.

urban planners began to incorporate greenways in new urban housing complexes (Yokohari et al., 2006). Despite the intense pressure to develop land in urban areas, Shinto shrine forests persisted. Their legal status as state land, in the same classification as Japanese Imperial Court land, served as a bulwark against land use change.

First we asked: What is the prevalence and distribution of Shinto shrine forests across the 47 prefectures of Japan? We found Shinto shrine forests to be prevalent (n=57,742) across the 47 prefectures of Japan and the forest area of the prefectures were negatively correlated with Shinto shrine forest density. As Shinto shrine forests are forest patches, this was a surprising result. When we explored the prevalence of Shinto shrine forest in different land cover types (forest: n=12,935, 22%; surrounding urban areas: n=30,423, 53%; core urban areas: n=1,512, 3%), it confirmed that Shinto shrine forests were more prevalent in urban areas than in forest areas and also more densely distributed in urban areas than in forest areas (forest: 0.05 Shinto shrine forests/sq. km; surrounding urban areas: 0.57 Shinto shrine forests/sq. km; core urban areas: 0.75 Shinto shrine forests/sq. km). This second finding helps expain the seeming contradiction of the forest area of the prefectures being negatively correlated with Shinto shrine forest density, as Shinto shrine forests are densely distributed in urban areas where forests and green space are scarce. The distribution of Shinto shrine forests can perhaps be more easily understood as the distribution of religious institutions near the people who use them. Nelson (1996:162) writes, “As recently as twenty years ago, the household to which a child belonged was considered automatically affiliated with a local shrine” and if they have migrated away from their ancestral area, “a local sense of belonging guides the choice of the shrine in which one’s descendents will be dedicated”. In more densely populated urban areas, there are more religious insitutions to meet demand. The Shinto shrine forest is considered part of the Shinto shrine complex, and protected along with it.

The land tenure afforded to Shinto shrines helps them stave off the pressures of urban development, which is especially important in highly urbanized Japan with its densely populated cities, because green space is extremely limited compared to other urban areas in the world (Tokyo Metropolitan Government Bureau of Construction, 2012, Kuchelmeister, 1998, Economist Intelligence Unit, 2012, Yamamoto, 2010).

Shinto spiritual and religious values enable the provision of cultural ecosystem services, including social cohesion and stress relief, for urban residents who comprise 91.3% of Japan's population (CIA, 2014). The prevalence and concentration of Shinto shrine forests we found within urban landscapes may help offset the 'Extinction of Experience' with the natural world pervasive in urban areas (Miller, 2005). The mean distance to Shinto shrine forests varied significantly across the prefectures, however over half of the prefectures had densities of at least one Shinto shrine forest for every 2 km^2 in both core and surrounding urban areas.

Our finding that Sakamoto's 'Happiness Ranking' is negatively correlated with the population of the 47 Japanese prefectures supports the notion in the literature that the negative aspects of urban living (e.g. overcrowding, pollution, crime) can affect happiness. Japanese critiques of the Sakamoto Index note that subjective indicators of happiness and objective indicators usually match, whereas the Sakamoto Index's prefectural ranking is significantly different than subjective indicators of happiness (i.e. happiness surveys such as the Japanese General Social Survey, or JGSS). Kuroki (2011) analyzes subjective indicators of the JGSS vs. the Sakamoto Index and concludes that Sakamoto's indicators are more accurately described as a 'quality-of-life' ranking rather than Sakamoto's 'Happiness Ranking'. This is consistent with our analysis, as social trust and stress relief would be less likely to improve subjective measures of happiness than they would improve objective measures. When we compared the distribution of Shinto shrine forests with the national happiness index, we found greater happiness in prefectures with more Shinto shrine forests per capita. The three prefectures with the fewest Shinto shrine forests relative to population were Kanagwa (3 shrines for 8,791,597 people), Okinawa (17 shrines for 1,361,594 people) and Osaka (696 shrines for 8,817,166 people). These three prefectures also placed on the low end of the Sakamoto Index: Kanagwa (34th of 47), Okinawa (47th of 47) and Osaka (41st of 47). Okinawa is the southernmost prefecture in Japan and was part of the Ryukyu Kingdom until 1879, with a culture and language different from mainland Japanese. The introduction of Shinto shrines was meant to assimilate Okinawans into mainstream Japanese culture, but Shintoism was not embraced by Okinawans (Grayson, 2005). In Okinawa's case, the Shinto shrine forests are a reminder of oppression and threatened indigenous identities, thus they may have a negative effect on residents' happiness. This is an important example of how Japan is not homogenous. In the case of Japan, 85% of the population practice Shintoism, but a minority (15%) do not. This minority may not receive the cultural ecosystem services provided by the Shinto shrine forests. Despite the fact that Shinto shrine forests are open to the public for use, there are segments of the population who do not benefit, such as in Okinawa, where the Shinto shrine forests are a reminder of oppression.

The three prefectures with the highest number of Shinto shrine forests relative to population are all located in the Hokuriku region in the northeastern part of the main island of Japan: Fukui (1.855), Ishikawa (1.532) and Toyama (1.526). The same three prefectures have the highest happiness ranking according to the Sakamoto Index: Fukui (7.23 points), Toyama (7.20 points) and Ishikawa (6.90 points). Fukui is known for its child-friendly environment, good welfare and social programs, and low rates of fire, crime and accidents (Hosei University, 2011). While these factors may be responsible for

Fukui's high happiness ranking, they also may be linked to Shinto shrine forests and the sense of community and social cohesion that they provide.

The prefecture of Kochi is an anomaly: it has a high number of Shinto shrine forests per 1000 people (4th of 47) but a low happiness ranking (46th of 47); it is a visible outlier in the lower right hand quadrant of the correlation graph. In Kochi, typhoons cause frequent landslides and floods leading to huge losses of life and property, which lead to low rankings in the safety and security indicators in the Sakamoto Index.

The literature suggests that the cultural ecosystem services that Shinto shrine forests contribute to happiness are social cohesion and stress relief. A potential misinterpretation of the correlation we found is that Shinto shrines contribute social cohesion while Shinto shrine forests provide stress relief. As described in the introduction, the separation of Shinto shrines from Shinto shrine forests is pedantic and does not represent the Shinto experience.

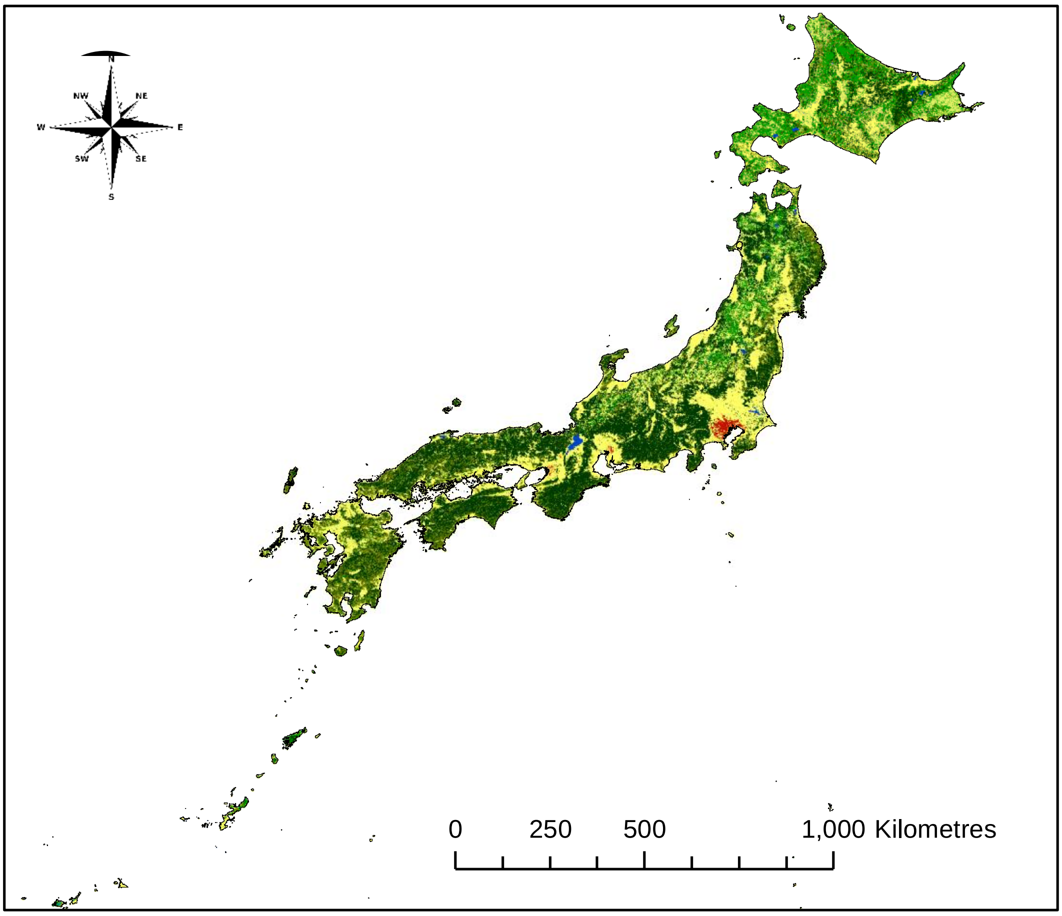
As national happiness assessments begin to yield data at finer scales than the prefectural level, the relationship between happiness and sacred natural sites at the national scale may be further elucidated. Our study demonstrates the potential for spatial analysis to contribute to this emerging research area. Future work may also determine the qualities of sacred natural sites that increase wellbeing. For example, Shinto shrine forests are in many cases old stands of forest with more biodiversity than other types of secondary forest and may provide different cultural ecosystem services than newer green spaces (Dean et al., 2011). Furthermore, the religious and spiritual values underpinning sacred natural sites may provide different benefits than 'secular' green space, such as improving social trust and relatedness, as seen in the Japanese case (Kuroki, 2011, Zelenski and Nisbet, 2014).

6.7 Conclusion

As sacred natural sites are often small, autonomously managed religious institutions seemingly scattered across the landscape, the extent of the cultural ecosystem services they provide can be overlooked. However, assessing the distribution of sacred natural sites in the landscape can hold implications for cultural ecosystem service delivery. Our study considered the distribution of Shinto shrine forests in one of the most highly urbanized nations, Japan. We found that Shinto shrine forests were prevalent in urban areas where green space is scarce; over half of the prefectures had densities of at least one Shinto shrine forest for every 2 km^2 in both core and surrounding urban areas. Increasing global recognition of the benefits of green space in urban areas has led to the accounting of green spaces in cities around the world with metrics such as 'The Green City Index' (Economist Intelligence Unit, 2012). We also found that more shrines are in prefectures with higher happiness indexes. While national happiness indexes have only recently emerged, this paper is a first step towards assessing spatial datasets using non-monetary valuation tools for cultural ecosystem services on a national scale. Our study also raises an important research question for future work, do the spiritual and religious values underpinning sacred natural sites, their cultural ecosystem processes, enable cultural ecosystem services that differ from 'secular' green space?

6.8 Supplementary Information

SI 6-1 Land cover map of Japan (European Space Agency, 2009)



Legend

- Post-flooding or irrigated croplands (or aquatic)
- Rainfed croplands
- Mosaic cropland (50-70%) / vegetation (grassland/shrubland/forest) (20-50%)
- Mosaic vegetation (grassland/shrubland/forest) (50-70%) / cropland (20-50%)
- Closed to open (>15%) broadleaved evergreen or semi-deciduous forest (>5m)
- Closed (>40%) broadleaved deciduous forest (>5m)
- Open (15-40%) broadleaved deciduous forest/woodland (>5m)
- Closed (>40%) needleleaved evergreen forest (>5m)
- Open (15-40%) needleleaved deciduous or evergreen forest (>5m)
- Closed to open (>15%) mixed broadleaved and needleleaved forest (>5m)
- Mosaic forest or shrubland (50-70%) / grassland (20-50%)
- Mosaic grassland (50-70%) / forest or shrubland (20-50%)
- Closed to open (>15%) (broadleaved or needleleaved, evergreen or deciduous) shrubland (<5m)
- Closed to open (>15%) herbaceous vegetation (grassland, savannas or lichens/mosses)
- Sparse (<15%) vegetation
- Closed to open (>15%) broadleaved forest regularly flooded (semi-permanently or temporarily) - Fresh or brackish water
- Closed (>40%) broadleaved forest or shrubland permanently flooded - Saline or brackish water
- Closed to open (>15%) grassland or woody vegetation on regularly flooded or waterlogged soil - Fresh, brackish or saline water
- Artificial surfaces and associated areas (Urban areas >50%)
- Bare areas
- Water bodies
- Permanent snow and ice
- No data (burnt areas, clouds,…)

SI 6-2 Percentage forest, core urban areas, and surrounding urban areas for the 47 prefectures of Japan

Prefecture	% Forest	% Core Urban	% Surrounding Urban
Aichi	44.00	1.93	51.71
Akita	65.16	0.01	2.72
Aomori	60.18	0.05	6.68
Chiba	34.88	4.04	55.64
Ehime	76.22	0.00	9.87
Fukui	66.84	0.00	14.54
Fukuoka	42.00	0.11	48.36
Fukushima	61.91	0.01	11.29
Gifu	74.33	0.00	12.61
Gunma	52.79	0.15	25.93
Hiroshima	75.52	0.16	9.92
Hokkaido	62.83	0.02	1.72
Hyogo	61.76	0.18	22.91
Ibaraki	29.97	0.14	63.13
Ishikawa	64.47	0.02	17.13
Iwate	67.68	0.00	3.01
Kagawa	44.48	0.20	40.94
Kagoshima	72.28	0.02	5.81
Kanagawa	38.42	16.51	42.20
Kochi	90.01	0.03	4.86
Kumamoto	69.87	0.09	16.75
Kyoto	75.81	0.11	12.87
Mie	66.24	0.04	24.98
Miyagi	49.36	0.04	16.51
Miyazaki	82.40	0.01	9.64
Nagano	65.64	0.01	14.88
Nagasaki	57.23	0.03	13.91
Nara	78.12	0.00	16.18
Niigata	55.75	0.03	14.87
Oita	73.92	0.04	9.23
Okayama	71.46	0.10	15.79
Okinawa	38.28	0.01	16.67
Osaka	28.23	3.88	63.84
Saga	46.57	0.03	35.54
Saitama	32.72	7.47	58.00
Shiga	47.27	0.01	27.49
Shimane	84.02	0.01	4.60
Shizuoka	68.02	0.23	23.45

Prefecture	**% Forest**	**% Core Urban**	**% Surrounding Urban**
Tochigi	46.27	0.06	35.21
Tokushima	80.94	0.04	12.07
Tokyo	31.01	43.72	22.99
Tottori	76.38	0.00	6.86
Toyama	42.22	0.01	25.10
Wakayama	83.68	0.07	10.77
Yamagata	56.78	0.00	5.22
Yamaguchi	71.93	0.03	11.20
Yamanashi	76.36	0.00	14.71

SI 6-3 Shapiro-Wilk tests of normality

Variable	Statistic	df	Sig.
Percentage forest cover	.954	47	.061
Percentage core urban areas	.268	47	.000
Percentage surrounding urban areas	.847	47	.000
Population density	.457	47	.000
Shinto shrine forest per 1000 people	.942	47	.022
Shinto shrine forest density overall	.919	47	.003
Shinto shrine forest density in forest	.257	47	.000
Shinto shrine forest density in core urban areas	.673	47	.000
Shinto shrine forest density in surrounding urban areas	.980	47	.590
Sakamoto Index	.974	47	.360

SI 6-4 Number of Shinto shrine forests in forest, core urban areas and surrounding urban areas in the 47 prefectures of Japan

Prefecture	Area (sq. km.)	# Shinto shrine forests	# Shinto shrine forests in forest	# Shinto shrine forests in core urban areas	# Shinto shrine forests in surrounding urban areas
Aichi	5,153.26	2998	456	97	2399
Akita	11,644.26	1080	280	1	141
Aomori	9,669.58	765	147	3	191
Chiba	5,043.66	2378	445	142	1578
Ehime	5,749.15	1060	306	0	385
Fukui	4,234.79	1524	416	0	740
Fukuoka	5,009.45	2041	152	4	1680
Fukushima	13,737.61	2258	591	0	902
Gifu	10,604.49	1738	389	0	1180
Gunma	6,369.25	999	130	12	779
Hiroshima	8,429.54	1187	357	10	457
Hokkaido	78,057.87	770	98	3	199
Hyogo	8,381.54	2959	646	16	1504
Ibaraki	6,104.77	2047	196	3	1717
Ishikawa	4,235.93	1799	560	2	818
Iwate	15,235.49	832	279	0	163
Kagawa	1,726.82	544	69	1	369
Kagoshima	9,132.53	632	165	0	210
Kanagawa	2,383.59	3	691	2	1
Kochi	7,043.21	1132	202	1	230
Kumamoto	7,563.74	931	397	5	513
Kyoto	4,622.48	1045	120	2	408
Mie	5,776.62	795	203	0	537
Miyagi	7,222.97	972	126	3	363
Miyazaki	7,678.79	441	215	0	213

Prefecture	Area (sq. km.)	# Shinto shrine forests	# Shinto shrine forests in forest	# Shinto shrine forests in core urban areas	# Shinto shrine forests in surrounding urban areas
Nagano	13,579.62	1032	1	0	699
Nagasaki	4,204.26	962	210	3	301
Nara	3,682.81	1076	302	0	640
Niigata	12,687.89	2982	792	9	1127
Oita	6,344.22	1160	344	0	415
Okayama	7,260.19	1194	408	3	471
Okinawa	2,339.85	17	37	0	16
Osaka	1,912.69	696	92	48	595
Saga	2,455.47	659	106	0	371
Saitama	3,794.94	1719	182	200	1403
Shiga	4,017.17	1256	390	0	905
Shimane	6,692.52	873	355	2	196
Shizuoka	8,005.96	1769	198	37	1207
Tochigi	6,403.44	1236	426	8	877
Tokushima	4,128.36	1042	105	1	447
Tokyo	1,801.15	1390	257	889	383
Tottori	3,478.89	718	240	0	183
Toyama	4,269.82	1697	165	2	1194
Wakayama	4,650.67	446	255	2	200
Yamagata	9,358.19	1330	147	0	342
Yamaguchi	6,118.17	627	287	1	226
Yamanashi	4,470.45	934	12935	0	548

SI 6-5 Shinto shrine forest density (number of Shinto shrine forests/ km^2) in forest, core urban areas and urban areas of the 47 prefectures of Japan

Prefecture name	Shinto shrine forest density in forest	Shinto shrine forest density in core urban areas	Shinto shrine forest density in surrounding urban areas
Aichi	0.20	0.98	0.90
Akita	0.04	0.64	0.45
Aomori	0.03	0.68	0.30
Chiba	0.25	0.70	0.56
Ehime	0.07	0.00	0.68
Fukui	0.15	0.00	1.20
Fukuoka	0.07	0.75	0.69
Fukushima	0.07	0.00	0.58
Gifu	0.05	0.00	0.88
Gunma	0.04	1.26	0.47
Hiroshima	0.06	0.74	0.55
Hokkaido	0.00	0.23	0.15
Hyogo	0.12	1.03	0.78
Ibaraki	0.11	0.34	0.45
Ishikawa	0.21	2.19	1.13
Iwate	0.03	0.00	0.36
Kagawa	0.09	0.29	0.52
Kagoshima	0.02	0.00	0.40
Kanagawa	0.75	0.01	0.00
Kochi	0.03	0.55	0.67
Kumamoto	0.08	0.75	0.40
Kyoto	0.03	0.41	0.69
Mie	0.05	0.00	0.37
Miyagi	0.04	1.02	0.30
Miyazaki	0.03	0.00	0.29
Nagano	0.00	0.00	0.35
Nagasaki	0.09	2.18	0.51
Nara	0.10	0.00	1.07
Niigata	0.11	2.75	0.60
Oita	0.07	0.00	0.71
Okayama	0.08	0.41	0.41
Okinawa	0.04	0.00	0.04
Osaka	0.17	0.65	0.49
Saga	0.09	0.00	0.43
Saitama	0.15	0.71	0.64
Shiga	0.21	0.00	0.82
Shimane	0.06	5.45	0.64

Prefecture name	Shinto shrine forest density in forest	Shinto shrine forest density in core urban areas	Shinto shrine forest density in surrounding urban areas
Shizuoka	0.04	2.02	0.64
Tochigi	0.14	2.04	0.39
Tokushima	0.03	0.60	0.90
Tokyo	0.46	1.13	0.92
Tottori	0.09	0.00	0.77
Toyama	0.09	4.82	1.11
Wakayama	0.07	0.65	0.40
Yamagata	0.03	0.00	0.70
Yamaguchi	0.07	0.49	0.33
Yamanashi	3.79	0.00	0.83

SI 6-6 Distance (m) from 100 random points in core urban areas in each prefecture (N = 4,400) to nearest Shinto shrine forest for the 44 prefectures of Japan with core urban areas

Prefecture	Minimum	Maximum	Mean	Median	Standard Error
Aichi	59.26	2,453.84	659.96	555.05	44.33
Akita	97.66	2,432.55	947.09	815.32	61.96
Aomori	46.5	10,179,91	1,655.95	507.64	267.18
Chiba	79.85	4,198.81	760.54	588.56	73.55
Ehime	527.69	1,709.99	1,059.40	886.52	39.64
Fukui	181.15	1,290.37	761.67	1,060.12	44.32
Fukuoka	135.02	3,883.80	730.43	609.38	67.91
Fukushima	171.48	1,412.56	718.32	639.73	36.3
Gunma	13.48	8,812.05	1,077.93	453.56	212.31
Hiroshima	95.27	3,252.56	880.84	613.18	74.58
Hokkaido	92.2	25,232.27	5,537.02	1,679.64	726.8
Hyogo	75.17	2,805.63	739.12	602.74	54.16
Ibaraki	88.93	2,989.21	1,166.56	1,074.76	72.49
Ishikawa	27.03	1,097.22	443.77	372.18	29.37
Iwate	128.2	11,204.60	2,639.10	960.76	386.17
Kagawa	74.23	1,763.87	679.17	655.29	34.16
Kagoshima	51.9	137,524.20	36,132.22	2,447.34	5,839.69
Kanagawa	655.38	23,020.27	7,589.68	6,215.43	599.02
Kochi	100.97	1,832.64	581.15	546.25	35.56
Kumamoto	83.16	5,402.91	1,239.52	538	163.71
Kyoto	17.36	1,275.16	575.27	563.34	25.49
Mie	99.53	2,501.97	674.1	517.37	48.44
Miyagi	64.71	3,025.11	744.23	659.33	50.09
Miyazaki	181.64	2,913.97	1,476.75	1,311.14	85.89
Nagano	638.28	8,320.07	3,884.32	1,632.35	341.83
Nagasaki	29.9	1,728.23	830.93	853.06	43.85
Niigata	38.86	2,971.58	485.62	348.71	47.03
Oita	121	2,455.91	1,152.07	1,132.66	61.69
Okayama	35.64	5,790.63	1,278.61	707.87	141.69
Okinawa	3,745.21	301,081.98	99,302.71	21,483.14	13,278.59
Osaka	34.37	1,889.19	660.72	624.9	35.1
Saga	423.84	5,841.68	3,486.17	3,608.17	156.79
Saitama	79.51	1,805.83	630.53	539.68	38.4
Shiga	13.92	864.11	385.58	332.48	21.42
Shimane	24.08	1,034.66	397.36	355.89	29.55
Shizuoka	37.08	2,654.09	560.21	383.79	48.67
Tochigi	23.32	5,191.37	533.92	386.87	70.03
Tokushima	59.78	1,922.70	540.77	424.61	40.85

Prefecture	Minimum	Maximum	Mean	Median	Standard Error
Tokyo	77.04	1,856.64	541.86	510.08	33.07
Tottori	364.57	2,111.07	1,465.40	1,917.30	69.24
Toyama	17.44	10,553.55	1,961.12	400.22	371.71
Wakayama	49.05	2,119.71	587.81	540.05	34.67
Yamagata	138.35	5,532.92	229.95	364.47	229.95
Yamaguchi	94.5	2,676.85	1,272.84	1266.6	76.71

SI 6-7 Distance (m) from 100 random points in surrounding urban areas in each prefecture (N = 4,700) to nearest Shinto shrine forest for the 47 prefectures of Japan

Prefecture	Minimum	Maximum	Mean	Median	Standard Error
Aichi	37.35	4,161.32	798.05	645.95	62.06
Akita	58.28	3,135.50	955.39	718.46	69.66
Aomori	72.69	7,977.24	1,671.01	1,349.13	147.33
Chiba	94.78	3,206.60	789.75	691.83	52.45
Ehime	114.74	2,203.05	675.25	624.97	34.86
Fukui	65.65	1,226.03	412.68	392.6	21.43
Fukuoka	91.59	3,068.91	797.37	659.88	56.9
Fukushima	44.55	2,354.76	813.73	750.93	52.93
Gifu	56.63	2,870.53	586.89	527.14	42.45
Gunma	16.34	2,941.89	840.83	746.98	56.46
Hiroshima	63.76	5,724.57	863.89	638.97	78.56
Hokkaido	77.56	6,611.99	1,947.50	1,653.11	141.64
Hyogo	38.86	2,309.53	674.23	518.73	50.41
Ibaraki	98.3	2,034.10	791.26	759.17	39.76
Ishikawa	74.23	2,204.21	554.29	484.05	36.41
Iwate	136.72	3,063.33	1,127.25	910.6	68.15
Kagawa	33.02	4,096.49	889.2	763.32	65.36
Kagoshima	64.06	3,534.67	931.38	767.85	65.03
Kanagawa	1,435.25	27,291.08	13,820.02	14,622.62	632.18
Kochi	31.85	3,911.68	760.7	618.03	64.79
Kumamoto	32.5	2,661.57	882.73	755.31	59.34
Kyoto	35.6	2,306.83	627.37	478.57	48.44
Mie	93.87	2,136.60	840.06	788.56	49.7
Miyagi	123.01	2,500.41	1,014.98	929.42	52.9
Miyazaki	94.19	2,981.52	1,171.95	1,088.07	65.02
Nagano	122.37	5,214.65	1,174.18	964.18	95.23
Nagasaki	14.03	3,215.69	931.03	838.11	59.49
Nara	54.7	1,754.42	536.15	444.92	36.74
Niigata	105.72	6,888.36	1190.63	711.58	124.21
Oita	55	2,120.83	714.14	600.16	44.05
Okayama	71.22	2,688.64	868.38	795.67	53.66
Okinawa	347.9	121,395.73	10,549.43	4,499.73	2,502.61
Osaka	78.97	4,346.78	947.59	822.73	66.36
Saga	154.03	4,692.07	1,103.64	885.71	89.4
Saitama	80.18	2,055.98	604.91	535.16	34.63
Shiga	36.45	3,070.64	623.11	485.16	44.19
Shimane	32.49	2,231.22	710.17	652.16	41.31
Shizuoka	125.88	5,693.34	1,028.66	711.88	98.03

Prefecture	Minimum	Maximum	Mean	Median	Standard Error
Tochigi	13.18	3,399.57	876.72	734.49	56.91
Tokushima	64.48	2,643.60	623.11	545.28	42.94
Tokyo	20.2	4,009.61	815.48	577.14	81.08
Tottori	61.7	2,493.17	738.7	612.33	54.05
Toyama	39.22	1,581.85	483.65	434.23	28.7
Wakayama	123.47	1,999.01	899.63	847.9	44.45
Yamagata	21.56	2,069.51	710.28	657.3	43.56
Yamaguchi	74.52	2,990.26	1,047.02	1,062.39	59.5
Yamanashi	67.63	4,236.18	683.71	552.11	62.05

SI 6-8 Kolmogorov-Smirnov tests of normality

Variable	Statistic	df	Sig.
Distance from core urban area random points (n=4,400) to nearest Shinto shrine forests	.433	4400	.000
Distance from surrounding urban area random points (n=4,700) to nearest Shinto shrine forests	.384	4700	.000

SI 6-9 Significant statistical tests

Variable A	Variable B	Relationship	Test	N	p	Tails	Correlation coefficient
SSF density in forest areas	SSF density in core urban areas	Significant difference	Related Sample Wilcoxon Signed Rank Test	44	0.000	-	-
SSF density in forest areas	SSF density in surrounding urban areas	Significant difference	Related Sample Wilcoxon Signed Rank Test	47	0.000	-	-
% forest area	SSF density in urban areas	Negative correlation	Spearman	47	0.006	Two-tailed	-0.392
% forest area	Population density	Negative correlation	Spearman	47	0.000	Two-tailed	-0.603
% core urban areas	Population density	Positive correlation	Spearman	47	0.000	Two-tailed	0.687
% surrounding urban areas	Population density	Positive correlation	Spearman	47	0.000	Two-tailed	0.851
Distance from random points in core urban areas to SSFs	(Variable A compared between the 44 prefectures with core urban areas)	Significant difference	Independent Samples Kruskal - Wallis Test	4,400	0.000	-	-
Distance from random points in surrounding urban areas to SSFs	(Variable A compared between the 47 prefectures)	Significant difference	Independent Samples Kruskal - Wallis Test	4,700	0.083	-	-
# SSF per 1,000 people	Sakamoto Index (Happiness)	Positive correlation	Spearman	47	0.000	Two-tailed	0.083
Population	Sakamoto Index (Happiness)	Negative correlation	Spearman	47	0.001	Two-tailed	-0.476

SI 6-10 Shinto shrine forests as percentage of total number of green spaces in Tokyo prefecture's 53 districts

Tokyo district	No. Shinto Shrine Forests	% No. Shinto Shrine Forests of Total No. Green Spaces	Total No. Parks	Tokyo metropolitan parks	Municipal parks	National parks	Nature parks	Municipal parks	National gardens	Public housing parks
Adachi	77	13.16	508	3	331	-	-	157	-	17
Akiruno	36	34.62	68	1	32	-	1	34	-	-
Akishima	16	16.16	83	-	34	-	-	49	-	-
Arakawa	15	12.00	110	2	32	-	-	74	-	2
Bunkyo	28	19.58	115	2	42	-	-	70	1	-
Chiyoda	24	31.17	53	1	22	-	-	25	5	-
Chofu	16	6.69	223	3	182	-	-	35	-	3
Chuo	33	26.83	89	1	53	-	-	33	-	2
Edogawa	76	14.26	456	4	295	-	-	139	-	18
Fuchu	30	7.89	350	3	271	-	-	76	-	-
Fussa	5	6.58	71	-	54	-	-	14	-	3
Hachioji	87	9.20	859	5	772	-	-	68	-	14

Tokyo district	**No. Shinto Shrine Forests**	**% No. Shinto Shrine Forests of Total No. Green Spaces**	**Total No. Parks**	**Tokyo metropolitan parks**	**Municipal parks**	**National parks**	**Nature parks**	**Municipal parks**		
Hamura	5	5.05	94	-	73	-	-	20	-	1
Higashikurume	6	4.23	136	1	126	-	-	4	-	5
Higashimurayama	10	18.87	43	3	17	-	-	19	-	4
Higashiyamato	13	10.08	116	2	92	-	-	19	-	3
Hino	24	9.56	227	1	196	-	-	25	-	5
Hinode	15	37.50	25	-	23	-	-	2	-	-
Hinohara	9	No data	-	-	-	-	-	-	-	-
Inagi	8	6.35	118	-	113	-	-	-	-	5
Itabashi	39	9.87	356	2	341	-	-	-	-	13
Katsushika	59	15.49	322	1	142	-	-	169	-	10
Kita	30	13.76	188	1	84	-	-	95	-	8
Kiyose	18	15.00	102	-	4	-	-	95	-	3
Kodaira	8	2.65	294	2	291	-	-	-	-	1

Tokyo district	No. Shinto Shrine Forests	% No. Shinto Shrine Forests of Total No. Green Spaces	Total No. Parks	Tokyo metropolitan parks	Municipal parks	National parks	Nature parks	Municipal parks	Tokyo district	No. Shinto Shrine Forests
Koganei	16	10.00	144	1	11	-	-	128	-	4
Kokubunji	11	6.67	154	2	12	-	-	138	-	2
Komae	7	8.54	75	-	26	-	-	49	-	-
Koto	22	6.75	287	6	165	1	-	91	-	24
Kunitachi	5	5.43	87	-	25	-	-	60	-	2
Machida	33	4.28	738	3	689	-	-	35	-	11
Meguro	21	13.91	130	-	80	-	-	49	-	1
Minato	33	22.15	113	4	47	-	-	59	1	2
Mitaka	12	6.25	180	1	37	-	-	140	-	2
Mizuho	15	22.39	52	-	52	-	-	-	-	-
Musashimurayama	5	7.04	66	1	18	-	-	47	-	-
Musashino	8	4.42	173	1	110	-	-	60	-	2
Nakano	21	9.91	191	-	159	-	-	27	-	5

Tokyo district	No. Shinto Shrine Forests	% No. Shinto Shrine Forests of Total No. Green Spaces	Total No. Parks	Tokyo metropolitan parks	Municipal parks	National parks	Nature parks	Municipal parks	Tokyo district	No. Shinto Shrine Forests
Nerima	43	6.15	656	4	425	-	-	218	-	9
Nishitokyo	8	3.35	231	1	47	-	-	178	-	5
Okutama	19	86.36	3	-	-	-	1	2	-	-
Ome	72	31.30	158	-	96	-	-	59	1	2
Ota	85	13.30	544	-	499	-	-	38	-	7
Setagaya	56	9.52	532	4	385	-	-	128	1	14
Shibuya	21	14.38	125	1	122	-	-	-	1	1
Shinagawa	34	11.33	269	2	144	-	-	108	-	6
Shinjuku	34	15.74	182	2	176	-	-	1	2	1
Suginami	31	8.73	324	3	267	-	-	51	-	3
Sumida	27	15.79	144	3	139	-	-	-	-	2
Tachikawa	9	3.52	247	-	91	1	-	146	-	9
Taito	32	29.91	75	2	49	-	-	24	-	-

Tokyo district	**No. Shinto Shrine Forests**	**% No. Shinto Shrine Forests of Total No. Green Spaces**	**Total No. Parks**	**Tokyo metropolitan parks**	**Municipal parks**	**National parks**	**Nature parks**	**Municipal parks**	**Tokyo district**	**No. Shinto Shrine Forests**
Tama	6	2.76	211	1	205	-	-	-	-	5
Toshima	16	9.58	151	-	85	-	-	66	-	-
Total	1,389		11,248	80	7,783	2	2	3,124	12	236

SI 6-11 Sakamoto's Happiness Ranking; English translation by Yukari Fukui (Sakamoto, 2011)

— 47 都道府県幸福度ランキング —
47 prefectures wellbeing ranking

【研究期間】 2011年4月〜9 月 [research period] 2011 April - September
【研 究 者】 [researchers]
法政大学大学院 政策創造研究科 教授 坂本光司 Hosei Graduate School of Regional Policy Design, Prof. Kouji Sakamoto
幸福度指数研究会（社会人学生10 名） Wellbeing index research group (10 working professional students)
【研究方法】 [research method]
様々な社会経済統計の中から、地域住民の幸福度を端的に示して
いると思われる 40 の指標を抽出・加工。これら 40 の指標を上位から
順にランキングを付すとともに 10 段階評価（1〜10 点）をした。
→1〜5 位＝10 点、6〜10位＝9点、11〜15位＝8 点、
16〜20 位＝7点、21〜25位＝6点、26〜30 位＝5点、
31〜35 位＝4点、36〜40位＝3点、41〜45 位＝2点、
46〜47 位＝1点
そして、40 の指標ごとの評点の平均値（総合平均評点）を計算し、
ランキングした。

Based on various socio-economic statistics, 40 indices, which are believed to show the level of well being of local residents, were extracted and processed. According to the ranking of the each 40 indices, points (1-10 points) were given to the prefectures.
Rank#1〜5 ＝10 points、Rank#6〜10＝9 points、Rank#11〜15＝8 points、
Rank#16〜20＝7 points、Rank#21〜25＝6 points、Rank#26〜30＝5points、
Rank#31〜35 ＝4 points、Rank#36〜40＝3 points、Rank#41〜45＝2 points、
Rank#46〜47 ＝1 point

The final ranking is according to the average points of the 40 indices.

＜40 の指標＞ <40 indices>

■生活・家族部門／9 指標 Life and family category / 9 indices
1. 出生率 birth rate
2. 未婚率 unmarried rate
3. 転入率 move-in rate
4. 交際費比率 social expenses
5. 持ち家率 home ownership rate
6. 畳数 property size
7. 下水道普及率 coverage of the sewage system
8. 生活保護比率 social aid rate
9. 保育所定員比率 nursery capacity

■労働・企業部門／10 指標 labour and company category / 10 indices
10. 離職率 employee turnover rate
11. 労働時間 labour hours
12. 有業率 employment rate
13. 正社員比率 permanent staff rate
14. 就業希望者比率 job seeker rate
15. 就業期間 employment period
16. 完全失業率 unemployment rate
17. 障がい者雇用比率 employment rate of disabled people
18. 欠損法人（赤字企業）比率 money-losing enterprises rate
19. 平均工賃月額 average monthly wage

■安全・安心部門／12 指標 safety and security category / 12 indices
20. 刑法犯認知数 # of criminals
21. 公害苦情件数 # of pollution complaints
22. 交通事故件数 # of traffic accidents
23. 出火件数 # of fires
24. 労働災害率 industrial accident rate
25. 地方債現在高 current values of local bonds
26. 負債現在高 current values of debts
27. 貯蓄現在高 current value of savings
28. 老人福祉費 expenses for welfare of the elderly
29. 手助け必要者比率 rate of people who need special help
30. 悩みストレス比率 stress rate
31. 相談できない人比率 rate of people who are not able to receive counseling

■医療・健康部門／9 指標 health and medical services category/ 9 indices
32. 休養時間 time for rest
33. 趣味娯楽時間 time for leisure
34. 医療費 medical cost
35. 病床数 number of clinical beds
36. 医師数 number of doctors
37. 老衰死亡者数 number of deaths because of the age
38. 自殺死亡者数 number of suicides
39. 平均寿命（男） life expectancy (male)
40. 平均寿命（女） life expectancy (female)

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Chapter 7 CONCLUSIONS

7.1 Introduction

As conservation expands beyond protected areas into the land use matrix, sacred forests are recognized as potential protected areas governed by indigenous peoples and local communities with new protected area designations, such as Indigenous and Community Conserved Areas. Despite diversities in perspectives and worldviews, unities emerge that enable the engagement of conservationists with custodians of sacred forests. The previous chapters examined sacred forests in diverse landscapes using quantitative and spatial analyses on a landscape scale. It asked the research questions:

1) How well do sacred forests conserve forests over time in comparison with ‘formally’ protected areas?
2) How do the location and distribution of sacred forests affect the provision of ecosystem services in diverse landscapes?
3) How can conservationists engage with custodians of sacred forests in bioculturally diverse landscapes?

To answer these questions, study areas were identified across varying scales and in diverse landscapes in 1) Kiang West, Lower River Region, the Gambia, 2) South Gondar, Amhara, Ethiopia, 3) Sabah, Malaysian Borneo and 4) Japan. Each paper geolocated sacred forests within the landscape and then assessed the distribution of sacred forests within their respective contexts.

7.2 Summary and discussion of key findings by research question

7.2.1 How well do sacred forests conserve forests over time in comparison with 'formally' protected areas?

In chapter three, change in forest cover over time was assessed for a study area in Kiang West, the Gambia, using nine satellite images between the years of 1984 and 2009. Clusters of forest were compared across three dominant land covers: mangroves, savanna woodlands/woodland transition and riparian and fringing savanna woodlands/woodlands. The greenness of the forest clusters, measured by NDVI, was compared over time for a national park, forest reserves, and forest patches conserved by a prevalent local belief in the *ninkananka*, a 'dragon' that inhabits the forest; it is believed that people die upon seeing it or shortly after. Chapter three found that across all land covers, dragon areas were the greenest over time, greener than the national park and forest reserve clusters. All three conservation types (dragon forests, forest reserves and national park) were greener over time than unprotected surrounding areas.

While chapter three's findings do show that forest cover overall is more resilient over time in the dragon areas, it is important to note that this does not mean that forest parks and the national park do not serve additional critical conservation roles in the landscape. Like most sacred forests, dragon patches are quite small in comparison to larger forest parks and national parks. Small, regularly distributed forest patches in the matrix of land uses beyond protected areas have a variety of conservation benefits, *inter alia* increasing connectivity in the landscape and serving as seed banks and refuges for flora and fauna (Bengtsson et al., 2003, Mgumia and Oba, 2003b, Ntiamoa-Baidu, 2008, Bhagwat et al., 2005b). Larger, contiguous patches of forests in forest parks and national park provide intact habitat and territory for larger mammal species that require larger ranges (Whittaker and Fernández-Palacios, 2007). Sacred forests and protected areas both play critical and complementary roles in conservation. Emerging research on the role of forest patches beyond protected area boundaries to bolster the conservation success of protected areas supports this complementary perspective (Bhagwat et al., 2005b, Bodin et al., 2006, Arroyo-Rodríguez et al., 2009). Chapter three's findings demonstrate that 'informal' local protections of sacred forests can protect forest cover over time like formally protected areas. The dragon forests, forest reserves, and national park all retained forest over time better than surrounding unprotected areas.

While chapter three explicitly addresses the first research question, the finding that sacred forests protect forest amid land use conversion is also suggested by the study area landscapes of chapters four and six. In the agricultural landscape of South Gondar, Ethiopia, land use conversion from forest to agriculture is near total, save for the church forest fragments investigated by the paper. Similarly, in urban landscapes in Japan, green space is scarce, even more so than in comparable cities worldwide (Yamamoto, 2010, Fuller and Gaston, 2009), however Shinto shrine forests persist.

The literature is replete with calls for land tenure for forest conservation by local custodians. This thesis chose four study areas with state controlled land tenure, which means that the sacred forests are only 'protected' in deed by custodians on the ground, but the state has the ultimate legal authority. This means that the sacred forest could be leased out to a foreign company, or cleared for the planting of fast-growing exotic species (as was attempted by the state in the case study of Gumantong in chapter five). The state land designation for Shinto shrines in chapter six is the form of state control with the least risk of forest clearance of all of the study areas, but the actions of the state against small Shinto shrines in the Meiji Era demonstrated that they are not immune to the shifting priorities and values of the state.

7.2.2 How do the location and distribution of sacred forests affect ecosystem delivery in diverse landscapes?

In chapter four, we mapped 1,173 Ethiopian Orthodox Tewahido Church forests– islands of forest patches in a sea of agriculture. With near-total agricultural land use conversion in the landscape, the paper considered the ecosystem service of pollination provided by these church forests, which offer nesting and forage for bees, especially during times of floral resource scarcity. Ethiopia is Africa's top exporter of honey and wax (Pauly and Hora, 2013) and Amhara's honey production comprises 22% of national production (Central Statistical Agency of Ethiopia, 2013). In South Gondar, 54% of honey is sold, 44% is used for household consumption and 2% is used in other ways (Central Statistical Agency of Ethiopia, 2012a). Honey is an important complement to local diets as it keeps for periods of food scarcity, is served as a medicine or tonic, has cultural value as a festival drink of honey mead, or 'tej', and wax is used to make votive candles for religious ceremonies (Ejigu et al., 2009).

The availability of honeybee forage is a critical component of local honey production; Amhara beekeepers report a lack of suitable honeybee forage as their main constraint (Ejigu et al., 2009). Of the vegetation species surveyed in the church forests, 64% are considered honeybee flora. The foraging distance of honeybees was used to create pollination zones around the church forests. While the church forests themselves cover a mere 0.5% of South Gondar's area, the estimated pollination zones surrounding them accounted for up to 83% of South Gondar's croplands and 19% of South Gondar overall. This distinction, 83% vs. 19%, is a striking indication of the key role location and distribution of the church forests may play in their utility for ecosystem service provision. While they may be small and seemingly scattered throughout the agricultural landscape, these autonomously managed local church forests provide key landscape scale ecosystem functions in concert. This is mainly due to the fact that the distance between church forests (mean=1,503 m) is similar to the foraging distance of honeybees (50% decay of pollinator visitation= 2,170 m).

In addition to honey production, pollination by honeybees has been shown to improve yields of certain global food crops (Klein et al., 2007). In South Gondar, crops grown by private peasant holdings in the 2010-2012 meher season (harvested September – February) include self-pollinating cereals, which comprise 67-74% of crop area and 71-77% of production, and pulses and oilseeds, crops predominantly pollinated by bees and other insects, which comprise 12-20% and 4-6%, respectively, of crop area and 8-18% and 2-3% of total production (Central Statistical Agency of Ethiopia, 2012b). Despite accounting for <20% of crop production in South Gondar, pulses and oilseeds are higher value crops than cereals and serve as critical local sources of 1) dietary protein, 2) animal fodder and 3) nitrogen fixation (Rashid et al., 2010). After coffee, oilseeds and pulses are the second and third largest export crops in Ethiopia, and the production of pulses has surged over the last decade. Ethiopia is the second largest producer of faba beans after China and one of the top ten honey and pulse-producing nations in the world (Rashid et al., 2010, FAO, 2015). Bees and other insects increase yields of pulses and oilseeds; especially notable in South Gondar are neug or niger seed (*Guizotia abyssinica*) (~43% increased yields), faba bean (*Vicia faba*) and rapeseed (*Brassica napus*) (10-40% increased yields) and field pea (*Pisum sativum*), haricot bean (*Phaseolus vulgaris*) and linseed (*Linum usitatissimum*) (0-10% increased yields) (Admassu and Nuru, 1999, Klein et al., 2007, Central Statistical Agency of Ethiopia, 2012b, Matiur et al., 1995). As the only stands of forest for nesting and year-round forage resources for pollinators, church forests may allow for crop diversification away from self-pollinating crop species, which may be necessitated by bioclimatic (e.g. climate change, pests and disease) or social (e.g.

market trends, seed access) factors, thus enabling adaptation to future conditions. While the ecological importance of forest patch size has been widely discussed in the literature (MacArthur and Wilson, 1967, Prugh et al., 2008), the findings of chapter four support growing interest in smaller forest patches, as their location and distribution support additional ecological functions and processes (Bodin et al., 2006).

Chapter six considered the distribution of 57,742 Shinto shrine forests, or *chinju no mori*, across the 47 prefectures of Japan, and employed the Sakamoto 'Happiness Index' to assess the implications of their distribution for the happiness of Japan's populace. In the highly urbanised nation of Japan[14], urban green space is extremely limited; many Japanese cities' green space is below the World Health Organization's recommended threshold of 9 m^2 green space per capita (Economist Intelligence Unit, 2012, Yamamoto, 2010, Tokyo Metropolitan Government Bureau of Construction, 2012). Over 50% of Japanese workers report stress at work in government surveys and some succumb to *karoshi*, or death from over-work (Kawakami and Haratani, 1999). Research has found that *shinrin-yoku*, or 'taking in the forest atmosphere or forest bathing', improves relaxation and decreases stress (Park et al., 2010, Li, 2010, Tsunetsugu et al., 2010) and may help to reduce the risk of psychosocial stress-related diseases (Morita et al., 2007).

With 85.9% of the global population slated to live in cities and 67.2% to live in urban areas by 2050, investigation into the role of sacred forests within urban landscapes is of increasing interest (Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat, 2010/11). Urban green space and forests have positive effects, including decreasing stress and improving health (Wolf et al., 2012). Chapter six found that Shinto shrine forests were more prevalent in urban areas than in

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[14] 91.3% of population lives in urban areas.

forest areas and were also more densely distributed in urban areas than in forest areas (forest: 0.05 Shinto shrine forests/sq. km; surrounding urban areas: 0.57 Shinto shrine forests/sq. km; core urban areas: 0.75 Shinto shrine forests/sq. km). Distance to access Shinto shrine forests varied significantly across the prefectures – however over half of the prefectures had densities of at least one Shinto shrine forest for every 2 km^2 in both core and surrounding urban areas. There was an observed mean distance of 913.82 m between Shinto shrine forests; the median distance from a random point to a Shinto shrine forest was 666.81 m in core urban areas and 700.3 m in surrounding urban areas, respectively.

The number of Shinto shrine forests per capita was positively correlated with Sakamoto's 'Happiness Ranking'. Urban green space and happiness have been linked at smaller scales and support this finding (Wolf et al., 2012), however at a prefectural scale, the extent of cultural ecosystem provision by Shinto shrine forests remains unclear. The number of Shinto shrine forests per capita may be the result of factors that affect happiness, for example, good local governance or historical political processes. However, even if Shinto shrine forests are not the primary driver of happiness, but rather, the result of a driver of happiness (e.g. strong local governance), the depth of research linking urban green spaces and Shinto shrine forests with increased happiness warrants further investigation across multiple scales.

7.2.3 How can conservationists engage with custodians of sacred forests in bioculturally diverse landscapes?

The religious and spiritual values underscoring sacred forests are highly variable and diverse, especially in bioculturally diverse landscapes. The third paper of the thesis (Chapter 5) considered sacred forests in one such highly bioculturally diverse region: Sabah, Malaysian Borneo. In chapter five's case study, a forest on the hilltop of Gumantong was conserved by a Rungus belief in 'dancing animals' that would provoke interlopers to laugh and die. This local cosmology echoes the description of the Gambia's *ninkananko* in chapter three. Chapter five introduces the IUCN's (2003:202) definition of Community Conserved Areas as "natural and modified ecosystems including significant biodiversity, ecological services and cultural values voluntarily conserved by custodians through customary laws or other effective means". In the case of Gumantong (Chapter 5), an event of Iban outsiders disregarding the local belief led to the loss of local belief in the 'dancing animals'. As the Rungus converted to Christianity and began clearing their smaller sacred forests, *puru*, for agriculture, water scarcity increased.[15] When the government sought to clear the hilltop of Gumantong and replace with a fast-growing non-native species, *Acacia mangium*, the local community rallied against the scheme. Despite their loss of beliefs in the 'dancing animals', they recognized the functional value of the hilltop's forest in securing their water supply and partnered with the United Nations Development Programme (UNDP) on Climate Change.

When the Forest Department sought to gazette the hilltop of Gumantong as a forest reserve, local communities proposed Gumantong be recognized as an Indigenous

[15] A similar phenomenon of increased local awareness of conservation value of sacred forests after their loss may also be occurring in chapter four's study area; one farmer noted decreased crop yields after the clearing of a local church forest.

Peoples’ and Community Conserved Area (ICCA) (Sabah Publishing House, 2011). It must be noted that conservation frameworks may also be used as a means to an end– an end other than the conservation of nature, and in some cases, antithetical to the conservation of nature (e.g. gaining land tenure to secure mineral rights for mining) (Anaya, 2013). Chapter five noted that some communities in Sabah have expressed interest in the ICCA concept as a means to circumvent their inability to acquire tenure of land of greater than 25 degree slope for farming— an environmental regulation in Sabah that is perceived to be unequally applied between land applications of rural villages versus commercial interests (Wyn, 2013).

In the other study areas of the thesis, even though each sacred forest was autonomously managed, there was only one type of sacred forest in the landscape: dragon forests in the Gambia (Chapter 3), Ethiopian Orthodox Tewahido church forests in Ethiopia (Chapter 4), and Shinto shrine forests in Japan (Chapter 6). Conversely, the sacred forests in Sabah, Malaysian Borneo (Chapter 5) comprise a myriad of forms, and this diversity presents challenges for recognition and integration with contemporary conservation frameworks. As Chazdon et al. (2009:147) note, “Designing successful conservation strategies requires an understanding of how and why local residents manage their landscapes and adapt to environmental changes”. In chapter five, 24 custodians across Sabah were surveyed to describe their local forms of natural resource use, regulations and form of community-based conservation. In addition, three case studies explored the integration of potential ICCAs with protected area networks. The survey showed that rural villages in Sabah employ village forest reserves (66.7%), ‘spirit forests’ (37.5%), customary spatial and temporal resource use regulations (*tagal/bombon*, 33.3%) and water catchment systems (20.8%) to conserve their natural resources. Conservation is practiced to safeguard ecosystem services (e.g. water catchment conservation), for aesthetic/moral reasons (e.g. to protect heritage sites in ancestral lands) and in some cases conservation is not an expressed intention but rather epiphenomenal in nature (e.g. spirits are believed to live in forest patches).

Our research indicates that community-based forms of conservation are not static, but rather can be shifted by events such as religious conversion, modernisation, and the influence of outsiders on natural resource use. In chapter three, the survey in Dumbuto, the Gambia, of cultural beliefs regarding the *ninkananka* (dragon) indicates a negative correlation between professed belief in the *ninkananka* and religious and secular education. Correlation does not imply causation, but this finding indicates that religious and secular education may affect belief in the dragons and threaten dragon forests' persistence in the future as local education attainment increases. In chapter five we applied social-ecological systems theory to describe transformations in the human-environment relationships observed in the three Sabah case studies, highlighting the contributions of social memory and ecological memory incorporated into the system through 'large and slow' processes, as well as new innovations developed through 'small and fast' processes. The findings of chapter five highlight the dynamic nature of beliefs and practices over time. As conservation science adapts to incorporate a dynamic view of ecological systems, including tools incorporating adaptive management strategies, so too must it adapt to incorporate the dynamic nature of local stewardship, including shifting beliefs and practices underpinning sacred forests (Dove, 2011, Sasaoka and Laumonier, 2012). Social-ecological systems theory provides a valuable framework for identifying points of engagement with biocultural conservation and a path forward to engaging with conservation in the matrix beyond protected areas. For example, chapter five's case study of *tagal* in Luanti Baru demonstrates that successfully integrating ICCAs into the protected area network a few at a time could provide landscape-scale rewards if the 'proof of concept’ engages neighbouring communities, potentially facilitating a landscape-scale roll-out.

7.3 Opportunities and challenges for engagement

This thesis sought to identify opportunities and challenges for conservationists to engage with custodians of sacred forests in diverse landscapes (Objective 2). The thesis considers each paper here in turn, first the two study areas with sacred groves and then the two study areas with sacred natural sites. For the dragon forests, belief in the *ninkananka*, is rarely discussed openly. As Byrne (2010:53) notes, “In many cases a fear of this agency, in the form of divine retribution, has been enough to prevent people physically damaging sacred places”. This is particularly challenging for conservation engagement, and as mentioned previously, there are ethical concerns surrounding the promotion of belief in the dragon by conservationists. Furthermore, the sustainability of such a conservation approach is questionable, especially considering the survey results that indicated changing beliefs with increasing levels of secular and/or religious education. Endogenous development empowers local communities to select the resources they deem useful or applicable to their development (Delgado et al., 2010). Designation as Indigenous and Community Conserved Areas (ICCAs), or similar, lend flexibility for management when beliefs shift, as was the case in chapter five’s case studies of the Gumantong mountaintop and *tagal* river protections.

Endogenous development is described by the findings of the papers on sacred forests in Sabah, Malaysian Borneo. The Sabah Department of Fisheries’ ‘Love your river’ campaign was an existing resource in the region, which the village committee of Luanti Baru investigated when they realized their river resource was becoming polluted and unusable. With the traditional form of management no longer being practiced, the custodians engaged with a conservation department for assistance. The Sabah Department of Fisheries in turn successfully engaged the custodians with an apposite form of conservation– the reintroduction and reinvigoration of traditional forms of river management, *tagal*. The case study of Gumantong also demonstrated the endogenous development with the custodians' alignment with the UNEP programme on climate change to conserve their hilltop in the face of threats of clearance by the Forest Department. The regional ICCA framework proposed by the Sabah ICCA Review similarly recommends custodian-led engagement with emerging ICCA structures (Majid Cooke and Vaz, 2011). In the case of the church forests of Ethiopia, they are linked by a religion even though they are autonomously managed. Local beliefs and spiritualties can be syncretic with major world religions, as in the case of Gambian imams who wear traditional juju protections on their upper arms (Saul, 2006). Church forest priests can communicate and interpret ecosystem services provided by the church forests to their congregations in spiritually meaningful ways. For example, as mentioned in chapter four, angels are believed to live in the old church forest trees and guard the church. The priests might share reports of nearby churches where church forest clearance or encroachment has affected crop harvests, and pray that their church's respect and care for their church forest and its angels will protect their crops in kind.

The other study area that considered sacred natural sites, the Shinto shrine forests of Japan, presents an analog to the Ethiopian case. In Japan, the national government seeks to measure happiness and combat problems of overwork and stress in Japanese urban culture. By aligning Shinto shrine forests with the empirical research on the benefits of *shinrin-yoku*, or 'forest bathing', engagement with civil society at multiple levels is possible. However, conservationists and custodians would likely have a greater chance of synergy at a sub-national scale, where datasets are finer and where there is increased opportunity for engagement with individual Shinto shrine forests as case studies to identify unities, as was the case in Sabah's *tagal* case study, where conservationists and custodians had the synergistic aim to improve the condition of the river.

Considering the limitations of the four papers in terms of scale, engagement between conservationists and custodians is recommended at the regional scale, as was the case of Sabah in chapter five. Despite being an incredibly bioculturally diverse landscape, which could be initially overwhelming to conservationists, paper three demonstrated how a mixed approach of surveys, key informant interviews, participant observation, and the identification of case studies lends itself to identifying recommendations for how custodians and conservationists can successfully engage where their interests converge. The smaller scale case, the dragon forests of chapter three, shows that sacred forests can persist over time even if they are underscored by secretive beliefs, even if they are found on state land that is effectively an open access common property resource, and even if they occur in the same landscape as formally protected areas. The two largest scale study areas, Ethiopia and Japan, may appear the most straightforward and appealing to conservationists at first approach, as the autonomous sacred natural sites are the subject of extensive literature detailing their biodiversity and the fact that the sites are linked by a common religion. Papers two and four faced significant limitations due to the lack of data availability at that scale which can be applied in an actionable way. Analysis can raise research questions and demonstrate the need for new agendas and more extensive datasets, but synergistic engagement with custodians is more likely to occur on smaller scales.

All study areas have sacred forests on state land, but it is important to note that the sacred natural sites, due to their recognized status as religious institutions, were the least likely to lose their land tenure. Shinto shrine forests have a special designation of state land dating back to the Imperial Court of Japan, while Ethiopian church forests have a hybrid land tenure where they are technically on state land but the government has ceded it in practice to the church. The sacred groves of the thesis had no such protections, legal or otherwise. Dragon forests are effectively invisible on land use planning maps as they are not discussed. In the Sabah case study of Gumantong, the government came in multiple times trying to clear the mountaintop, including to plant a fast-growing exotic tree species that now dominates the vegetation of Kudat. The villages surrounding Gumantong had to band together to stop the gazetting of 'their' state land.

7.4 Key messages for conservationists

It is estimated that the global land area 'informally' protected by custodians is equal to or greater than that of formally protected areas (13-20% of Earth's terrestrial surface) (ICCA Consortium, 2013, Chape et al., 2008). Sacred forests are dynamic and adaptive components of social-ecological systems and must be managed accordingly. Conservationists and custodians have diverse perceptions of landscape, however unities provide opportunities for engagement. Sacred forests can be overlooked by conservationists as they are usually small in size (less than a hectare), managed autonomously, i.e. they are associated with a community or settlement instead of being managed within a wider network of sites, and protected by local beliefs and practices that may seem incompatible or even antithetical to conservation paradigms, such as fear of dragons living in the forest.

Benefits of engaging sacred forests with conservation include that they are a locally developed and context-appropriate form of conservation, governance and/or stewardship is suggested by their persistence in the landscape, they are locally funded/supported in a context of constrained conservation funding, they are prevalent in landscapes beyond protected areas which are a priority area for conservation engagement and comprise 87% of Earth's terrestrial surface, and they contribute to Convention on

Biological Diversity's Aichi Targets, which aim to increase global land area conserved to 17% by 2020, including areas important for ecosystem services (Target 11) that contribute to the livelihoods and wellbeing of local communities, the poor and vulnerable (Target 14) (Secretariat of the Convention on Biological Diversity, 2011). Additionally, resulting from their location and spatial distribution in the landscape, sacred forests provide conservation benefits complementary to large protected areas. Conservation engagement can bolster defence against external threats which local governance structures are unable to mitigate.

7.5 Future work

Each of the papers in the thesis considered the distribution of sacred forests on a landscape scale in terms of engagement between conservationists and custodians of sacred forests. National and global scaled mapping projects are collating data on sacred forests, including the ICCA Registry maintained alongside the World Database on Protected Areas (ICCA Consortium, 2013) and Mapping the Sacred, a database developed from the World Database on Sacred Natural Sites (SANASI) (2013). National registries are also underway in Iran, Madagascar, and the Philippines and there are regional registries in Madhya Pradesh and Orissa, India (ICCA Consortium, 2013) and Sabah, Malaysian Borneo (Majid Cooke and Vaz, 2011). The availability of these datasets will enable increased range and scope of future analyses, including comparative analyses of sacred forests in different landscapes around the world. Future work employing improved biodiversity data, fine scale spatial 'happiness' data, and pollinator visitation data can build on the findings of the papers comprising this thesis.

The findings of this thesis suggest that engagement with sacred forests is most synergistic for conservationists and custodians when sacred forests are viewed neither as only trees providing habitat nor as only the physical manifestation of spiritual or religious values. To separate sacred forests from the natural world, spiritual world, or human world that comprises them is to strip them of their meaning. The conceptual framework of the thesis notes that successful engagement between conservationists and custodians of sacred forests is rooted in their unities, but the diversities are also important and warrant further investigation.

7.6 Concluding remarks

As conservation expands beyond protected areas into the land use matrix, alternative conceptions of the human-environment relationship emerge. Small and autonomous forest patches associated with the religious and spiritual values of custodians may not appear a priority for conservation engagement. However, this thesis demonstrates that geolocating sacred forests on a landscape scale can present points of engagement for conservationists. Ethiopian Orthodox Tewahido Church priests have gathered to discuss the ecosystem services that their individual church forests provide to agriculture and how to communicate with their congregations to prevent agricultural encroachment. In Japan, Shinto priests gathered at the Grand Shrine of Ise for its ceremonial re-building and to discuss shrine forest management with the Alliance for Religions and Conservation. In Sabah, Malaysian Borneo, a review of potential ICCAs shows that the process of engaging with a myriad of forms of natural resource management across bioculturally diverse regions is possible. In addition, custodians are collaborating with the Sabah Department of Fisheries to reinvigorate or introduce *tagal*, spatio-temporal natural resource regulations, to conserve their rivers and forests. This thesis demonstrated that sacred forests are prevalent in diverse landscapes, persist over time, and provide ecosystem services across the landscape due to their spatial distribution. As conservation expands beyond protected areas, successful engagement with dynamic social-ecological systems emerges from unities in the perspectives of conservationists and custodians.

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4 October 2015

Dear Professor Wojcik,

I am a co-author of a paper that contributes to D.Phil. candidate Ashley Massey's thesis at the University of Oxford's School of Geography and the Environment and the Biodiversity Institute. I hereby certify that the majority of the work represents that of the candidate, Ashley Massey, who retains first authorship of the paper.

Sincerely,

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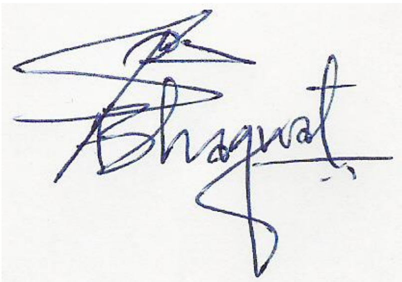
Sincerely,



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ENVIRONMENTAL STUDIES PROGRAM

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October 5, 2015

Dear Professor Wojcik,

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Dear Professor Wojcik,

I am a co-author of a paper that contributes to D.Phil. candidate Ashley Massey's thesis at the University of Oxford's School of Geography and the Environment and the Biodiversity Institute. I hereby certify that the majority of the work represents that of the candidate, Ashley Massey, who retains first authorship of the paper.

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Sincerely,

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I am a co-author of a paper that contributes to D.Phil. candidate Ashley Massey's thesis at the University of Oxford's School of Geography and the Environment and the Biodiversity Institute. I hereby certify that the majority of the work represents that of the candidate, Ashley Massey, who retains first authorship of the paper.

Sincerely,

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Dear Professor Wojcik,

I am a co-author of a paper that contributes to D.Phil. candidate Ashley Massey's thesis at the University of Oxford's School of Geography and the Environment and the Biodiversity Institute. I hereby certify that the majority of the work represents that of the candidate, Ashley Massey, who retains first authorship of the paper.

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Yours faithfully,

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