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ABSTRACT

Forest cover is declining at an unsustainable rate as development frontiers expand. Though the amount of conservation science being conducted and policy being implemented is ever increasing, forests continue to decline faster than ever before. The conservation science being conducted and policy being implemented is often ineffective and inadequate for conserving forests. To address the issues surrounding forest conservation science and policy, I investigated factors that would improve conservation outcomes. Through conducting a literature review, and participating in conservation fieldwork, I identified four main factors: (1) diversity of stakeholders in the policy development process; (2) increased communication between conservation scientists and policymakers; (3) integration of multiple current conservation science methods and technology; and (4) utilizing place-based analyses to increase data. Through exploring these factors I provide recommendations for improving policy planning and development. In conjunction with increased diversity in stakeholders, conservation efficacy would improve with increased communication between scientists and policymakers. This includes increased access to scientific literature for policymakers. Additionally, scientists developing policy may benefit from integrating current science and technologies such as Unmanned Aerial Vehicles (UAVs or drones) which can strengthen and expedite the process of data collection and forest monitoring. Finally, through increasing the data, policy can be tailored to meet the needs of that location. Through integrating these approaches the policy developed and implemented will be more effective in conserving forests.

INTRODUCTION

Deforestation and land conversion are rapidly occurring on a global scale (Sherman, 2012). Though the output of conservation science and policy is ever increasing, forests continue to decline, demonstrating the inefficacy of current efforts (Laurence, 2012). Forest conservation has many successes but also many failures, and currently global forests are experiencing net loss (FAO, 2010). Deforestation is an ongoing problem in the tropics; in the last decade alone global forest cover declined nearly three times faster than forest regrowth (Hansen, 2013). The current rate of forest loss demonstrates that existing forest conservation methods are inadequate and that both forest conservation policy and the environmental movement require improvements to increase conservation success (Butler, 2008; Laurance, 2008; Lindenmayer, 2014). Thus, until the shortcomings of conservation efforts are addressed, the gap between conservation science and policy will continue to grow (Salafsky, 2002). Humans are dependent upon forest ecosystems, which provide numerous invaluable benefits such as clean water, timber, and the delivery of ecosystem services (i.e. carbon cycling etc.)(MEA, 2005). It is imperative that conservation policy curb deforestation rates; to do so improvements in conservation science need to be made (Salafsky, 2002).

In exploring the efficacy of policy pertaining to human-environment interactions, three core characteristics need to be addressed to create effective conservation policy: (1) Information on the state of the environment; (2) motivation to sustainably manage the environment; and (3) capacity to implement the sustainable management of the environment (Lambin, 2005). When exploring the current weaknesses of conservation policy, one must ask whether it is the information, motivation or capacity (or a combination of any or all) resulting in the inefficacy of forest conservation. There are several theories as to why forest policy is not having the full effect desired. Some hypotheses addressing this inefficacy include: lack of enforcement, funding, research, and incentive to reach beyond the academic community. A few researchers go so far as to say that research conducted by academic conservation scientists makes surprisingly few direct contributions to environmental conservation (Robinson, 2006; Lauarance, 2012). There are a myriad of resources available to support conservation policy. Rather than pinpointing one specific aspect of forest conservation that can be improved, the question that needs asking is, "How the current methods can be synthesized to implement effective forest conservation policy?"

Through conducting a literature review on the gap between conservation science and conservation policy, and exploring the core characteristics required for successful conservation policy, my findings show that the primary factors that would improve conservation policy efficacy are: (1) increasing stakeholder diversity in policy development and planning; (2) increased communication between conservation scientists and policy-makers; (3) integration of conservation science and technology; and lastly (4) increasing place-based analyses to develop conservation policy. Through exploring these topics, recommendations for improving the efficacy of conservation policy will be made.

ECO-DRONE MONITORING INTERNSHIP

For my capstone project I interned jointly with Wild Forests and Fauna (WFF) and the University of Washington's Vogt Lab during the summer of 2014. I traveled to the Las Piedras region of Madre de Dios (MdD), Peru where I conducted field research in eco-drone monitoring. The goal of our research was to map and assess the habitat type and quality of a 10,000 ha ecotourism concession. We were also looking for big trees and evidence of illegal logging within the concession as part of WFF's Big Tree Project. On a broader scale, we hope to use this case study to develop a framework to track illegal logging and deforestation using drones to collect high-resolution imagery. Later, we hope to establish localized monitoring programs to increase baseline data of the regions illegal logging. The goal of my internship was to create and implement a drone monitoring program for ARCAmazon, a local NGO, hoping to buy the concession to conserve the vulnerable forest and set-up an eco-lodge to support their research and conservation.

The field research, coupled with a literature review exploring the gaps between conservation science and policy, has provided me with insight into the process of conservation science data collection and policy development and planning. Through working in a developing nation, and specifically in a remote tropical forest region, I learned first-hand about many of the limitations for data collection and policy implementation in frontier environments. Additionally, I gained valuable experience in conservation science methods and application. In coupling my first-hand experience in the field with my findings in my literature review, I explored the reasons for the inefficacy of conservation policy and addressed potential methods in which policy could be strengthened to increase forest conservation success. A list of all deliverable products from my internship are available in Appendix B.

Lastly, MdD makes an excellent case study for testing the feasibility of drone surveying for both deforestation and selective logging monitoring, since MdD is a region undergoing high rates of selective logging. MdD will be used to explore and demonstrate potential solutions for improving conservation science collection and policy development. In MdD there are many drivers of land-conversion such as mining, selective logging, and agriculture. These land-change drivers are similar to those causing forest loss throughout the tropics, particularly because the various drivers are diverse and uneven along the landscape (Geist, 2002). In turn, the research carried out in this region will provide insight into effective policy approaches for a rapidly transforming region.

I. DIVERSIFYING STAKEHOLDERS IN CONSERVATION PLANNING PROCESSES

On a broad scale the diversity of conservation professionals is insufficient with both indigenous people and minorities being under represented in policy planning and development.

Native people are often underrepresented in major data collection efforts, making it difficult for tribes, states, and the federal governments to provide policy solutions and social programs that effectively target and benefit native communities (Lopez, 2011). Some efforts have been made in a number of fields to investigate the knowledge of tribal peoples and minorities to incorporate them into the conservation field (Lopez, 2011; Deloria, 1995; Huntington, 2000).

While it is important that traditional stakeholders such as local, national and international NGO's and government agencies are involved in supporting conservation science and implementing policies, including a more diverse group of stakeholders in the development and implementation is vital to the success of conservation. Forest residents and rural people are potent political actors in tropical forest regions and an essential component of environmental political constituencies (Schwartzman, 2000). These people are needed allies for long-term conservation. Globally, there is more land being protected by rural people than there is by parks (Schwartzman, 2000). Additionally, research suggests that forests managed for the production of goods and services by local or indigenous communities can be equally or even more effective in maintaining forest cover than those managed with solely protection objectives (Porter-Bolland, 2012).

Including local and indigenous people in conservation planning and implementation will increase the knowledge base. Integrating data collected informally through generations of observation from those living in the region will also fortify on-site support (Huntington, 2000). While scientific data has immense value in conservation planning, its timeframe can be short and detailed knowledge sometimes shallow, especially in comparison to selected knowledge of local and indigenous peoples (Herman-Mercer, 2011). The non-western tribal equivalent of science is oral tradition referred to as Traditional Ecological Knowledge (TEK); teachings that have been passed down from one generation to the next over uncounted centuries (Huntington, 2000; Deloria, 1995). Though the data is based on observation and experience, rather than controlled experiments, it provides a base of knowledge on the changes and process of the ecosystem that date back thousands of years (Herman-Mercer, 2011; Deloria, 1995). In addition to information concerning changes and history of local ecosystems, current residents can provide insight into the economic, social and cultural context for the region which largely influences the success of the conservation policy (Herman-Mercer, 2011).

A large part of indigenous culture is the passing down of knowledge through oral history and storytelling. While these stories do contain religious and mythical components, a large portion of their knowledge base concerns the natural history of the region (Herman-Mercer, 2011; Deloria, 1995). Tribal people's oral tradition needs to be represented as precise knowledge of birds, animals, plants, ecological processes and geologic-features, not simply information on ancient events (Deloria, 1995). When integrating indigenous people into policy planning and development and in turn conservation policy enforcement, there is a cultural and spiritual connection to the land which often provides great incentive for developing holistic conservation (Huntington, 2000). Indigenous groups are often powerful defenders of their homelands and when provided with the resources and opportunity to do so, groups have been successful in conserving large portions of forests, particularly in the tropical rainforests (Redford, 1993). Forest dwellers are often the primary advocates and conservationists in the Brazilian and Colombian Amazon. For example, the National Coalition of Brazilian Rubber Tappers were the first alliance of resource extracting people, who now protect more land in Brazil than the national parks do. Local people are more effective in halting direct drivers of deforestation in expanding frontier regions when provided with proper incentives to do so (Schwartzman, 2000).

Construction of alliances of local people has proven to be very effective (Schwartzman, 2000), especially when working in conjunction with outside organizations for support (Porter-Bollard, 2014; Zimmerman, 2001).

While including indigenous groups is very important, local people will also provide novel insight for conservation science and planning. With local people in support of the conservation policy being implemented, conservation stakeholders would benefit from building local capacity which will increase the likelihood of policy success for the region (Ehrlich, 2008; Port-Bollard, 2014). There are several regions in Southern Asia participating in a conservation program known as Join-Forest Management (JFM) which decentralizes and distributes forest management responsibility across the community in exchange for forest resources and governmental support (Bhattacharya, 2010). An example of joint-conservation effort is in Nepal where government agencies are working with local communities to halt endangered species poaching. The country has had huge success, which they attribute to the national collaboration between enforcement agencies and parks agencies, in addition to the effective engagement of local communities (Neme, 2014). If government agencies learn to work with local and indigenous people, and also acknowledge their land rights, incentive to establish conservation programs and live sustainably on indigenous lands would increase (Schwartzman, 2000).

A case study in Madre de Dios, Peru examines local people's interest in conservation programs. In the Manu-Tambopata corridor, 124 farmers and 199 miners were interviewed to understand their interest in and current actions for forest conservation (Scullion, In review). A majority (63%) of miners said they were currently incorporating forest conservation into their mining activities. Farmers were asked about their interest in several hypothetical conservation programs and 97% said they were interested in agricultural technical assistance in exchange for private conservation, 73% said they were interested in alternative jobs and 67% said they were interested in Payments for Ecosystem Services (Figure 1). Additionally, interview results showed that at the current rate of deforestation, it is predicted that by 2021 forest cover will be gone (Figure 2). The results of this survey demonstrate that local people in MdD are aware of the need for forest conservation (Scullion, In review). Yet they are unaware of the magnitude of the impact of their deforestation activities. If support were provided to develop and implement conservation programs, both the local people and the environment would benefit. The inclusion of local people into the policy planning and development processes has been shown to increase forest health and minimized extractive industries in other regions and likely would have similar effects in MdD.

In summation, diversifying the stakeholders involved in government policy development and planning is crucial for formulating holistic and effective conservation policy (Huntington, 2000). Through greater stakeholder diversity and participation there would be greater acceptance of management actions, increased support for conservation initiatives and policies, and in turn greater financial support for conservation (Lopez, 2011). Instead of putting scientists and scientific knowledge on a pedestal, local and indigenous knowledge and history should be acknowledged and included in policy planning to bolster policy efficacy.

II. INCREASED COMMUNICATION AND ACCESSIBILITY TO CONSERVATION SCIENCE

Conservation science accessibility and communication between conservation stakeholders is essential to conserving forests. Though there has been enormous growth in the output of conservation science in the past 20 years, the translation of scientific advancement to on-the-ground action is too slow. This results in an "implementation gap," which is characterized by an increase in deforestation despite an increase in conservation policy (Fuller, 2014). Unfortunately, the implementation gap between conservation science and policy continues to increase, due in part to the inaccessibility of conservation literature and the lack of communication between scientists and policymakers (Levitan, 2014).

There are several factors that contribute to the widening implementation gap. First, conservation literature is written for academics which is very difficult for people outside the world of academia to comprehend. Conservation managers infrequently read scientific literature due to the indigestible nature of it (Laurance, 2012). Translating this valuable information into a digestible format for conservationists would make it more useful (Fuller, 2014). There is even less regard for public access of this literature. Conservation science is currently about communicating results to other scientists (Fuller, 2014). Academics must see conservation implementation as part of their job because they are most familiar with it (Ehrlich, 2008). As conservation is a time-critical field, forests cannot afford the divide between researchers and practitioners (Karanth, 2003). The challenge is to provide practitioners with the skills and knowledge to make effective conservation policy (Salafsky, 2002).

Secondly, the cost of accessing conservation literature is absurd. Fuller et al. (2014) calculated that to access all conservation literature published from 2000 to 2013 would cost $51 million (Fuller, 2014). In this study, less than 9% of the literature was freely downloadable and ~5% was open access (Fuller, 2014). These results were compared to a related field, evolutionary biology, which had about 32% freely downloadable and about 7.5% open access (Levitan, 2014). Essentially, without access to the literature, conservationists cannot conserve forests well; and in general they do not have access to it (Levitan, 2014). This is highly problematic because conservation is one of the few scientific disciplines that depend on practitioners for success (Levitan, 2014). It is logical to supply those making policy with all available information as conservation is a science with an urgent deadline (Martinich, 2006). Additionally, the access to this literature is most difficult in developing nations, many of which contain most of the world's biodiversity (Fuller, 2014). Due to both the financial and the intellectual inaccessibility of conservation science, the literature is rarely read outside of the academic community (Fuller, 2014).

An example of the disconnect between conservation science and policy is explored by Karanth et al. (2003) in the research of tiger populations over a 30-year period. The study showed that despite tens of millions of dollars invested by the government and private donors, the policy implemented was ineffective for several reasons. Specifically policy was not meeting the needs of the region due to sparse data, incomplete knowledge, and the disjunction between conservation scientists and policymakers. This disconnect was attributed to several factors but most importantly the pace at which new scientific knowledge was transferred to practitioners was too slow to assist the species recovery, and too slow in influencing policy. Therefore, though it is conservation scientist's responsibility to make the literature available, it is also the responsibility of the practitioners to make practical but also scientifically defensible policy (Karanth, 2003).

Additionally, some conservationists claim that research conducted by academic conservation scientists makes surprisingly few direct contributions to environmental conservation (Robinson, 2006; Lauarance, 2012). Laurance et al. (2012) explore the link between the conservation science being published and it's applicability to conserving forests. The authors conclude that due to a large portion of funding coming from national science agencies which value conceptual novelty over conservation relevance, the policy follows suit. Thus, scientists are not eager to spend their time, nor their energy, on projects where they will not receive funding nor recognition (Redford, 2013; Ehrlich, 2008). Therefore, the disconnect spreads misconceptions among many conservation scientists about how conservation works and what policymakers actually need. To further the issue, too few scientists are taking steps to bridge this gap (Laurence, 2012). To mitigate this disconnect the conservation science community needs to shift their focus to developing and implementing practical and applicable research that can be quickly implemented to meet political demand (Laurance, 2012; Karanth, 2003).

Additionally, a major part of communication is interagency communication. Governmental structures are complex, and the lines are often unclear as to whose jurisdiction certain aspects fall under. Land-use titles are unclear and frequently designated for many uses. Lawlor et al. (2009) explored the main drivers of tropical deforestation, which they believe to be ambiguous property rights, in conjunction with weak governance. To address these issues governance needs to be improved to decrease ambiguity of property rights (Lawlor, 2009). Through increased inter-agency and stakeholder communication, clear permitting processes can be established and laws can be enforced. Overlapping land-titles will decrease in frequency, increasing conservation efficacy.

Finally, consumers play a key role in conservation. Communication to consumers and the general public can increase conservation success. Developed nations are primary drivers of resource extraction in developing nations (Geist, 2002). Through creating campaigns advertising conservation efforts, such as the benefits of certified and sustainable products, awareness of and support for conservation efforts can be fortified. The Rainforest Alliance Certification, is a successful eco-certification program which addresses both the awareness aspect for consumers and works to support companies that use sustainably harvested resources, targeting environmental degradation issues (Bennett, 2008). To create more programs like this, independent scientists should evaluate these programs and also provide guidelines for measuring effectiveness, costs, use of time, and cost-benefit analysis (Laurance, 2012).

In summary, communication is needed among a variety of conservation stakeholders. First and foremost, conservation scientists and policymakers are responsible for increasing communication among themselves. The inaccessibility of conservation science for policymakers is a very pressing issue. Conservation science is one of the few scientific disciplines that depends on its practitioners for its success and, yet, the literature published is not targeted towards practitioners, nor is it monetarily accessible. Additionally, increased interagency communication would decrease land-title ambiguity, which significantly contributes to tropical deforestation. Lastly, increasing consumer awareness about environmental issues, through eco-certifications, will help support companies that support sustainable industries. In conservation there is much room for improvement in communication. It is the responsibility of scientists and policymakers to increase the flow of information between stakeholders which will increase the applicability of conservation science, and ultimately its efficacy.

III. INTEGRATING CURRENT CONSERVATION SCIENCE AND TECHNOLOGY

Integrating current conservation science and technology into conservation policy development will create multi-faceted policies that can produce scientific data quickly. Several aspects contribute to the slow implementation of conservation science, primarily: (1) the inaccessibility of current conservation science for policymakers; (2) the inefficiency in technology used for data collection; and (3) slow governmental processing (Fuller, 2014).

Current policy needs to integrate several approaches to improve conservation science and policy efficacy (Lawlor, 2009).

Environmental issues are often time-critical and methods to collect data quickly are increasingly important (Laurance, 2012; Salafsky, 2002). Due to the rapid rate of decline in global forests, the science behind forest conservation is vital, but useless if not utilized and implemented on the ground in a timely fashion. While timing of scientific research can be difficult when trying to inform present day policy decisions, it is imperative in developing relevant conservation policy (Laurance, 2012). One way to solve the time-critical nature of conservation data collection is by incorporating efficient cutting-edge technology. The use of drones to improve conservation data collection, and policy enforcement, is one example of up-and-coming technology. Drones have an interesting history and were originally developed for military operations involving the "three D's: dull, dirty and dangerous missions" where human pilots were disadvantaged or at high risk (Watts, 2012). In 1970 NASA developed and began using drones for high altitude atmospheric sampling through their Environmental Research Aircraft and Sensor Technology (ERAST) program. A major contribution of the ERAST program was sensor miniaturization, allowing for smaller-class and more affordable UAV platforms. In the 1990's many smaller organizations began to tailor and modify drones to suit their own research needs (Watts 2012).

While drones currently receive primarily negative media attention due to military use, when implemented in conservation science, drones have immense potential to be used in a variety of conservation programs. For forest conservation in particular drones provide an inexpensive, high-resolution and easily accessible alternative to satellites for imaging, thereby enhancing data collection abilities dramatically. Unlike satellites, drones provide real-time mapping at a very low cost, and have very high-resolution (Koh, 2012). Satellite images require hours of sifting through to find good quality images. Weather impediments, such as cloud coverage inhibits visibility and leads to poor image quality (Koh, 2012). Satellite imaging is often of similar quality of Google Earth which is insufficient for aerial identification of tree species. In contrast, images collected from drones are similar to Google Earth imaging but with roughly 30 times more detail, depending on the onboard sensors. Each pixel on the screen can account for two centimeters of Earth" (Stone, 2013).

Drones are easy to use and transport, making them excellent for taking high-resolution imaging of a region which can be used in a breadth of ways; from habitat typing and assessment, to monitoring of a region to ensure adherence to governmental policies. The application of drones for monitoring will cut cost and reduce man hours, risk and obstacles for scientist who desire to monitor remote regions (Koh, 2012). Drones allow researchers to survey areas that were previously inaccessible due to difficult terrain or great risk (Koh, 2012). For example, the Brazilian Government is using drones to monitor the building of roads in the Amazon region (Butler, 2014). Building roads and infrastructure is directly linked to deforestation activities (Geist, 2002; Appendix A.1). Access to forested areas is a main driver in deforestation and as roads increase population and destruction increases. This results in planned and unplanned resource extraction opportunities and infrastructure. Therefore, monitoring forests would increase enforcement capabilities to regulate development of intact forested areas and thus reduce logging (Lawlor, 2009).

Overall conservation drones are very inexpensive, costing around $2,000 which includes both video camera capacity and still shots (Koh, 2012). Through establishing monitoring programs, drones can be deployed regularly to monitor forestry activities. One application of drones is tracking animals. A research team is working with Microsoft to develop tracking tags for animals that can be read by drones (Hance, 2014). This would allow researchers to track animal locations more efficiently and in a less invasive manner. Lastly, due to ease of use local community groups can be taught to use drones which can increase monitoring and enforcement of land-use. Drones can greatly reduce costs of enforcement because less man power is needed and it can be much more effective if regular monitoring missions are conducted.

While drones are not an end-all to conservation data collection and policy enforcement issues, they have vast potential in this field. Drones can be used to replace or supplement satellite images. Satellite images are more difficult to access as there are limited sources. Drones in comparison, can be purchased by individuals because are relatively inexpensive and readily available. The results of my research in Peru show that using drone imagery for assessing habitat type and quality is feasible. Additionally, this technology is easy to transport and use which makes it more accessible to local and, particularly, indigenous environmental defense groups interested in protecting their land and enforcing environmental regulations (Appendix A.2-6).

IV. PLACE-BASED CONSERVATION POLICY

Implementing place-based conservation policies would target the specific conservation needs of a region while working to address the lack of localized data needed for creating robust conservation policies. Policy efficacy can be improved by eliminating the attempts to implement a one-size-fits-all conservation policy (Geist, 2002; Salafsky, 2002). Conservation policy will be significantly more effective when the policy is matched to the needs of the region, rather than matching a region to a cookie-cutter policy (Geist, 2002). While regional case-studies are traditionally more time and energy intensive, drones can be used to mitigate costs and assist in assessing a variety of factors which will greatly inform and contribute to policy formulation (Scullion, 2014). For example, in some regions ecotourism has been successful in increasing conservation efforts and boosting local economies, however in others it has had negative impacts (Brandt, 2014). Brandt et al. (2014) conducted a study in China which showed that protected area status conserved old-growth forests from clear-cutting, while the logging ban increased total forest cover but accelerated old-growth logging. Additionally, old-growth forest loss occurred most rapidly where ecotourism was most prominent. These results show that for this region ecotourism-based economic development had negative impacts on the environment and outweighed conservation efforts. The research of Brandt et al. (2014) highlights a need for increased understanding of interactions among government policies and local land management approaches. Through place-based analyses implications of an environmental policy's effects can be explored to limit the unknown confounding variables.

Doing place-based analyses will also provide scientists with insight into a region's extractive industries i.e. logging, mining etc. Through identifying the extractive industries, the policy could incorporate methods, by which primary industries are shifted to non-extractive industries such as fish-farming, reforestation, Reducing Emissions from Deforestation and Forest Degradation (REDD) conservation, ecotourism or mitigated through certifications such as low-impact or sustainable logging (Scullion, In review; Putz, 2000). These industries have lower environmental impact but also have the potential to bolster local economies. However, not all methods are suited to a region and with further research the best methods could be synthesized to create an effective tailored policy.

For example, one study explored the long term benefits of reduced-impact logging (RIL) and argues that the benefits will be experienced by everyone including the forestry industry if implemented (Putz, 2000). The authors argue that RIL is not common practice because it is not publicly advertised. RIL required more training for workers, pre-planning of skid trails, using direction felling and sustainable forestry practices (Putz, 2000). However, this model protects the regeneration of forest, minimizes soil damage, limits unnecessary damage to non-target species and protects ecosystem processes. Where RIL was practiced the soil quality was only 50% reduced as compared to that of conventional logging. RIL is not sustainable forest management but it is a step forward and in conjunction with other practices would protect forests (Putz, 2000). To facilitate the switch to a previously unused model there needs to be increased communication between all parties involved i.e. loggers, concession holders, land-owners, and forest scientists (Putz, 2000). With financial incentive conventional logging would cease and everyone would benefit from healthier forests (Putz, 2000).

Though logging and timber extraction is a common reason for deforestation, most frequently deforestation occurs due to agricultural expansion, which includes cattle ranching, colonization agriculture and permanent cropping (Geist, 2002). As previously mentioned, agricultural expansion can be mitigated if low-impact industries are introduced. Reforestation using fruit, nut and other trees that produce cash crops (resin, medicinals etc.), can provide income and prevent further deforestation. Place-based analysis can inform the development of conservation policy through identifying factors greatly contributing to deforestation.

Scullion et al. (In review) conducted a case study in Madre de Dios, Peru that explored ongoing conservation activities and interest levels of local miners and farmers in four hypothetical conservation models. The interviews results of farmers and miners showed great interest in technical assistance, education, alternative non-extractive jobs (e.g. pisciculture, ecotourism etc.) and Payments for Ecosystem Services in exchange for forest conservation. The surveys also conveyed that the locals were taking initiative and participating in conservation activities on their own accord (Scullion, In review). This case study demonstrates not only the vast interest in alternative non-extractive jobs, but also the level of engagement in existing conservation efforts. Through increasing data available to policymakers more robust policies can be made. Place-based analyses are very valuable, as this example brought to light the needs of local communities in Madre de Dios and their interest in conservation. A policy that addresses the needs of the local community, and also the environment, has much more potential for success. Though regional case studies are more time and energy intensive, they assess a variety of factors which will greatly inform and contribute to effective policy.

Porter-Bolland et al. (2014) conducted a meta-analysis reviewing 73 case studies that explored the efficacy of protected areas such as national parks and reserves (90% owned by the government) and community-managed forests in the tropics. The authors found that, overall, the community managed forests had a lower average rate of deforestation and that the rates were also less variable than the protected areas. This meta-analysis demonstrates that community managed forests which are place-based policies, are equally, if not more, effective in conserving forests than protected areas (Porter-Bolland, 2012). This further supports the recommendation that policy should incorporate both local people and local levels of government.

Through place-based analyses and involvement of local communities conservation measures will have more information to draw from thereby limiting policies initiated on the basis of sparse data and incomplete knowledge (Karanth, 2002). That being said, intense analyses will not need to be conducted every time. Once a large pool of data is collected from varying regions policymakers and governments will be able to draw from regions with similar variables to facilitate assessing the region’s needs (Porter-Bolland, 2014). Additionally, local and indigenous communities will be a valuable asset for incorporating TEK into policy development, and in policy implementation. Increasing data availability on a local and regional level will provide scientists and policy-makers with more information to develop more robust policy.

CONCLUSION

Through improving: (1) stakeholder diversity; (2) communication between stakeholders; (3) integration of science and technology; and (4) data collection processes, conservation science, policy development and implementation can be improved. To resolve these problems one must use part science, part politics. The gap between conservation science and policy is wide and conservation problems are multifaceted and very complicated (Levitan, 2014). The inefficacy of conservation efforts results from failures in all aspects of conservation development and implementation. There is much room for improvement among all conservation stakeholders who are connected by the overarching goal of forest conservation which should be used to bridge gaps between parties. Through integrating the aforementioned recommendations, conservation policy and implementation can be translated into effective forest conservation. Ultimately, the issues of conservation efficacy boil down to the need for information, motivation to conserve the environment, and the capacity to implement policy (Lambin, 2005). Through empowering a diversity of conservation stakeholders globally, conservation policy can be made more effective in conserving the worlds remaining forests.

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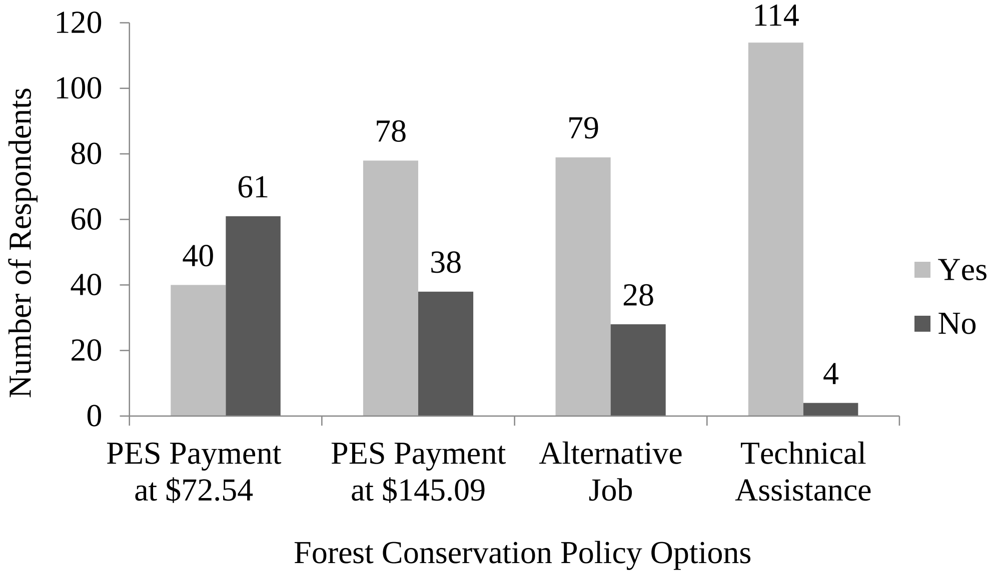

Figure 1: **Farmer Preferences for Proposed Conservation Programs**
Farmers' stated interest in four hypothetical conservation programs. The average Payment for Ecosystem Service (PES) price per hectare paid is based on Butler et al. (2009), which provided an estimated per hectare voluntary carbon markets price of $72.54 (USD). For the purposes of the survey, the estimated carbon price was converted to the value of Peruvian Soles based on the exchange for Soles on November 15th 2011 ($2.708 Soles = $1 USD) (Scullion, In review).

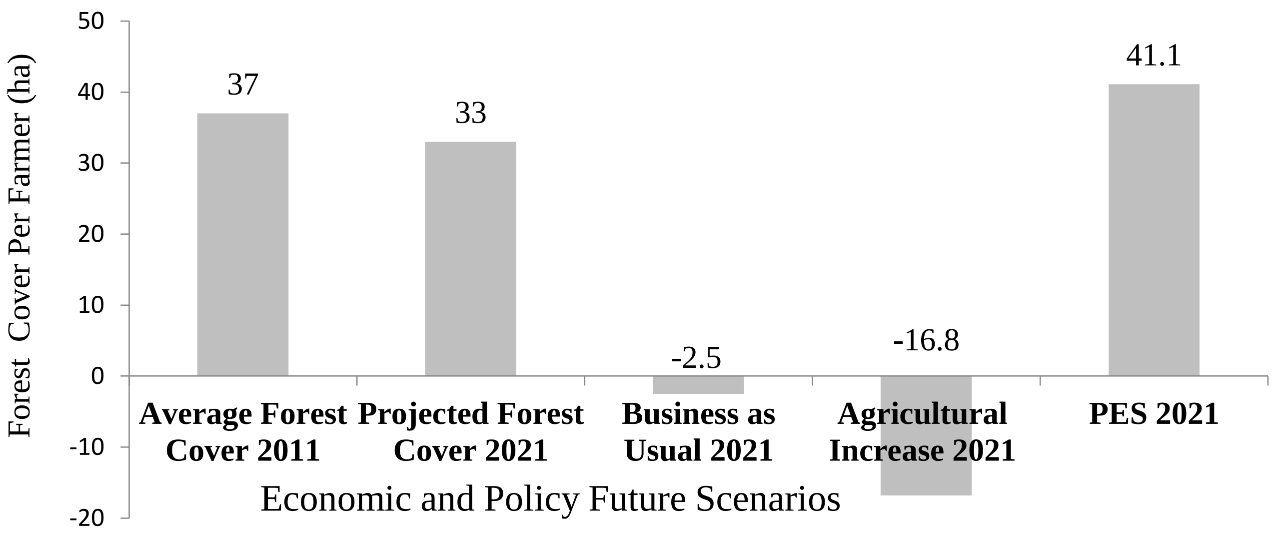

Figure 2. Forest Cover Projections for Private Agricultural Lands for Year 2021

Estimated amount of forest cover in 2011 on farmers' private parcels compared to projections of forest cover for the year 2021 under alternative economic and policy scenarios. "Average Forest Cover 2011" is the average forest cover the farmers estimated on their properties in the year 2011. "Projected Forest Cover 2021" is an average of estimated forest cover reported by interviewed farmers for the year 2021. "Business as Usual" is based on farmers reported rates of forest clearing and regrowth from 2006-2011 and extrapolated to the year 2021 using forest cover in 2011 as the base year. "Agriculture Increase 2021" is based on the average increase in forestland farmers reported they would bring into production each year with increased crop prices and extrapolated to 2021. "PES 2021" is based on the average amount of forest cover farmers interested in PES payments said they would enroll in a hypothetical PES program (Scullion, In review).

Appendix A:

Image #	Image	Photographer	Description
1		**W.F. Lauarnace (2012 Making conservation more relevant)**	These images show the destruction that takes place when roads are made to access forests for logging and other extractive activities
2		**Sophia Winkler-Schor**	Drone packaging for travel from Seattle to Peru

3		**Sam Zwicker**	Diagnosing motor problems on the drone
4		**Sam Zwicker**	Balancing drone to make sure the front and back weight is evenly distributed.
5		**Sophia Winkler-Schor**	Setting up and testing the software and telemetry unit before take-off.

6		**Sam Zwicker**	Setting up wings of the drone.
7		**Sam Zwicker**	Drone's first successful flight with Jason Scullion launching the Wild Eye

Appendix B: List of tangible products and other materials completed and presented as part of Capstone in fall quarter 2014.

Deliverable Title	Recipient	Description
Video made for WFF to promote and publicize the Big Tree Project and drone work in Peru	Doug Sorin (WFF Executive Director); Jason Scullion (Site Supervisor); Kristiina Vogt; P. Sean McDonald	Video tells the story of WFF's trip to Madre de Dios, Peru to collect data using a done. It promotes their latest project known as The Big Tree Project.
Monitoring Plan for Heart of the Healer Lands for ARCAmazon	Jason Scullion, David Johnston (ARCAmazon), P. Sean McDonald	Monitoring plan includes several GIS maps illustrating our finding such as, habitat types, vulnerable areas and projected drone monitoring plan.
Two presentations of conservation policy recommendations	P. Sean McDonald (1st) Unknown (2nd)	Oral presentations outlining the findings of my research concerning the inefficacy of conservation policy.
Annotated Bibliography	Kristiina Vogt; P. Sean McDonald	An annotated bibliography of sources to synthesize information to help answer capstone analysis paper questions.
Progress Memorandums (2)	P. Sean McDonald	Two memos to provide Capstone Instructor with critical information about my progress as well as serve as personal reflection and self-assessment.
Journal	Available upon request for P. Sean McDonald	Detailed journal recounting my capstone project, including notes of research conducted, daily synopses, and conclusions about experiences.
Tumblr Blog Post	P. Sean McDonald via PoE Tumblr page.	The blog post provided an update of my internship progress for the class and incorporated pictures of my fieldwork.