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Remote Sensing of Land Cover Change on Indonesia's Bird's Head Peninsula After the Creation of Marine Protected Areas

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**Remote Sensing of Land Cover Change on
Indonesia's Bird's Head Peninsula After the
Creation of Marine Protected Areas**

Daniel Auerbach

May 2016

A GISDE Final Internship Paper

Submitted to the faculty of Clark University, Worcester,
Massachusetts, in partial fulfillment of the requirements for
the degree of Master of Science in the department of International Development,
Community, and Environment

And accepted on the recommendation of

Yelena Ogneva-Himmelberger, Academic Advisor

Abstract

This report is an account of my time spent on a summer internship at the World Wildlife Fund's Washington, DC office. I interned there for 9 weeks from June to August 2015. I worked for the science team under Dr. Louise Glew. The official title of the internship was "Land-Use Change Remote Sensing Intern." My task was to remotely sense land cover change on a remote peninsula of Indonesia, and to see if any significant changes occurred following the creation of Marine Protected Areas (MPAs) in the traditional fishing grounds surrounding the peninsula.

The internship was an opportunity for me to apply my GIS and remote sensing skills away from academia. While I was unable to finish my analysis in Washington and will have to complete it remotely, it was an excellent experience for me. I now have experience working behind the scenes at a prominent NGO that relies on GIS and remote sensing to fulfill its conservation goals, and I can now say that I could see myself working in an NGO setting. If anyone else is considering this internship, I would tell them that it is a great opportunity.

Academic History

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Dedication

I dedicate this paper to my family, particularly my mother, sister, late father, and grandmother, who have no choice but to put up with me.

I also dedicate this to the people who aren't related to me, and still choose to put up with me despite the copious cynicism and bad puns.

Acknowledgements

I would not be where I am academically without the help of a few people. My undergrad advisors, Dr. Jody Emel from the Geography Department, and Dr. John Baker, from the Biology Department, who assisted me during my undergrad years at Clark and were kind enough to write letters of recommendation for me when I applied for grad school there. Jeanette Spires, who first told me about Clark nearly a decade ago, helped me with both my applications there, and wrote a letter of recommendation for me. I would also like to thank Jane Daigneault for the considerable help she gave me when I was an undergraduate.

Special thanks also goes to my graduate advisor, Yelena Ogneva-Himmelberger, who has been a great help to me in grad school, and was one of my references when I applied for this internship. I would also thank Erika Paradis for the advice and help she has given me during my graduate years at Clark.

Finally, I would like to acknowledge Dr. Louise Glew of the World Wildlife Fund, who offered me the opportunity to work there, was always willing to discuss my work, and had a dry sense of humor that meshed perfectly with mine.

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Introduction

Ever since I was first introduced to Geographic Information Systems (GIS) and remote sensing as a first-year at Clark University, I have been absolutely fascinated by the topic. It combines two of my passions: maps and computers. In 2013, I graduated from Clark with a Bachelor of Arts in Geography, with a Minor in Environmental Science. While I thought this degree would get me a job after graduation, all the listings asked for a Master's. As a result, I returned to Clark in 2014, a student in its Geographic Information Science for Development and Environment (GISDE) Master of Science program, part of the department of International Development, Community, and Environment (IDCE). As a Master's student, I could have gone the traditional route and written a thesis, but the GISDE program also offered an internship track. I did not have a lot of work experience on my résumé, so I wanted a chance to bolster my real world experience by getting a summer internship.

I was privileged to be offered a two-month summer remote sensing internship with the science team at the US headquarters of the World Wildlife Fund (WWF) in Washington, DC. The WWF is one of the world's leading wildlife conservation organizations, recognized worldwide by its panda logo. The team I worked with was researching a region in Indonesia known as the Coral Triangle and possible measures to protect the sensitive coral. My responsibility was to remotely sense land cover change on a nearby peninsula in order to determine if the creation of marine protected areas

nearby had forced former fishermen to turn to plantation agriculture, which would lead to clearing of the rain forest and threatening rich ecosystems. I used TerrSet to analyze the data, and did identify several areas of the peninsula where rainforest showed signs of anthropogenic disturbance, such as palm plantations and clearcutting. Because I had to return to Clark before I could finish the analysis, I have not yet completed the analysis. Working at WWF was a valuable opportunity, and showed me that I can use GIS outside of the university setting.

About the Organization

The World Wide Fund for Nature (WWF), known as the World Wildlife Fund in the United States and Canada, is an internationally-renowned non-governmental organization (NGO) dedicated to conservation. The international WWF was founded in Switzerland in 1961, and the US national organization was founded the same year, making it the second oldest national office after the United Kingdom's (Our History). The WWF is the world's largest conservation NGO, with 5 million members around the world, including 1.1 million in the United States (Our History). Their US headquarters is located near George Washington University, in the Foggy Bottom neighborhood of Washington, DC. Although individual WWF offices are organized at the national level, individual national offices assist with conservation and research around the world.

World Wildlife Fund considers its mission “to conserve nature and reduce the most pressing threats to the diversity of life on Earth.” (Our Work) To do so, they approach conservation using teams focused on thematic areas like climate, food, forests, fresh water, oceans, and wildlife conservation. With these teams, WWF takes a four-pronged approach to conservation: engaging with businesses; forming partnerships with donors, charitable foundations, and corporations; influencing public policy to aid conservation efforts on the government level; and working with WWF teams of scientists to forecast future threats to conservation and to come up with ways to deal with them (Our Work). With businesses being blamed for climate change, deforestation, and other threats to biodiversity, why would WWF work with them? As WWF puts it, “Rather than trying to educate 7 billion consumers or improve the practices of 1.5 billion producers, the most efficient way to effect change is to work with this handful of companies – about 100 in total.” (Our Work) The WWF assists these companies with sourcing their raw materials and/or producing their products in a sustainable manner; for example, WWF has for several years been helping paper and cardboard manufacturers to get wood pulp that has not been illegally harvested from threatened rainforests. Working with WWF can be beneficial to some major corporations who recognize the value of conservation. Coca-Cola, which is reliant on access to fresh water for its product, partners with the WWF to conserve fresh water supplies in threatened watersheds. In return, Coke works with WWF to source its ingredients sustainably, and

works to convince other companies that sustainability is a good investment. On the political side of the equation, in the US, the WWF lobbies state and national governments, as well as international organizations like the World Bank, on sustainability and conservation matters. The science team researches conservation techniques, identifies places and species in distress, and brings together scientists from around the globe together to further their research. (Our Work) The science team assists the other thematic teams, providing data and analysis to support other operations.

At WWF, remote sensing is used to monitor forest loss, agricultural expansion, and ecosystem health. Geospatial data, as well as GPS data about species range, can be used to map habitats, identify gaps in preserved areas, and to measure biodiversity. Changes in these factors over time allow researchers to predict which areas need protecting in the near future. Conversely, this technology can also be used to advise governments and companies of which areas can be utilized with a less substantial effect on local ecosystems and biodiversity. In this way, GIS and remote sensing are used to strike a balance between conservation, WWF's priority, and profit, the priority of many businesses.

Internship Responsibilities

The internship WWF offered me was for a "Land-Use Change Remote Sensing Intern," to be based at their Washington headquarters. My supervisor, Dr. Louise Glew, wanted

someone to look into land cover change on the northwestern-most portion of the island of New Guinea, known as the Bird's Head Peninsula (*Kepala Burung* in Indonesian and *Vogelkop* in Dutch), and surrounding islands; the purpose of this was to aid Dr. Glew and local researchers looking to protect the Coral Triangle of Indonesia without harming the local fishing industry. Since most of the peninsula is dense rainforest, it is quite difficult to map land cover, and remote sensing allows for the classification of the entire peninsula at once. WWF has been instrumental in working with the government of the province of Papua Barat (West Papua), creating Marine Protected Areas (MPAs) around the peninsula. In these areas, fishing is banned in order to protect marine life. While at first it may seem counterintuitive to look at land change in order to understand changes in the ocean, WWF reasons that the closing off of certain areas of reef to fishermen forces locals to obtain income in other ways. Fishermen who can no longer ply their trade may transition to agriculture, and in order to do that, rainforest must be cleared. In other words, by protecting the reefs, the MPAs may destroy the rainforest, a biodiversity hotspot, counteracting WWF's mission of wildlife conservation. They wished to get an idea of how much of an impact the creation of these MPAs may have had. Because the study is not finished, I cannot, unfortunately, share any results from my internship at this time.

Upon my arrival at World Wildlife Fund, Dr. Glew and I discussed what exactly she had in mind for this project and what sort of results I should aim for. I have done

many projects involving detection of land change using remote sensing, so I suggested something similar. I had submitted, with my application, a similar project from my junior year at Clark, in aid of the Biology Department: they were looking for lakes from which they could extract new samples of Threespine Stickleback (*Gasterosteus aculeatus* L.), a species of fish sensitive to environmental change around their individual lake, to compare with previous samples from the same lake. My project looked for lakes around which land cover change occurred during a period of interest.

With this in mind, I set out to acquire data for the project. The analysis would look at changes between three points in time: the early to mid-2000s, the late 2000s to early 2010s, and the mid-2010s. While a single MODIS image would have covered the entirety of the study area, the 1 kilometer spatial resolution of MODIS can be too coarse for accurate land cover classification. Landsat, with its 30 meter spatial resolution, is much finer and would be more useful for the analysis. Unfortunately, Landsat has a much smaller footprint than MODIS: compared to MODIS, there were 13 individual images needed for Landsat for each time period. This added up to 39 scenes, and with 6-7 useful bands per scene, added up to, at minimum, 234 scenes to project, process, and combine into a single composite. The Landsat imagery was also projected into two different UTM zones, meaning that I couldn't display the entire map in TerrSet. To deal with this, I created my own projection, a Transverse Mercator with a central meridian through the heart of the peninsula---although area is the subject of the analysis, the

study area is close enough to the Equator so as to minimize any distortions. To avoid confusion between the 39 images, I named each footprint after rival neighborhoods of Siena, an Italian city I once lived in, and added an A, B, or C depending on when the image was acquired. A few weeks in, I discovered that this complex plan would not work. There were massive gaps in the USGS EarthExplorer's collection of Landsat imagery, in some cases no imagery for a certain section that had a small amount of cloud cover, or even cases where there was no imagery at all. Add to that the fact that Landsat 7 images look striped due to the failure of its scanline corrector, and that all this work would have required using images from 3 different sensors --- Landsats 5, 7, and 8 --- I seriously considered if there were a way forward with Landsat data.

A colleague of Dr. Glew's saved the day: he got me access to Google Earth Engine, and I am now a trusted tester there. Earth Engine is an online platform for downloading and analyzing spatial data (FAQ). Being a trusted tester means that I can download satellite imagery covering vast areas of land (selecting images that had less cloud cover) that have already been stitched together by Google. I downloaded the imagery in 4 parts for each year (I hadn't managed to capture the entire study area), naming them for their apparent position on a bird's head: Head, Neck, Beak, and Tuft. After importing all these images into TerrSet (for which WWF graciously purchased a license), I used the macro-modeler to project them from WGS84 into the projection I had

created earlier. I then concatenated the four parts of each band of each year into single images.

The next step in the analysis is the land cover classification, but I cannot really say much about the results. The plan is to do a supervised classification, but during early runs I ran into some questionable areas, which on closer examination I could not identify by sight or by inferring from the composite images. Dr. Glew explained that she would need get information from “the Cousins Network,” cousins of her Indonesian staff who live in the interior of the peninsula. By the time we realized this, my time in Washington was up. As a result, I have not yet created a land cover map, but I hope to do so when she gets back from her next trip to Indonesia.

When this analysis is done, the hope is that I will be able to show Dr. Glew the changes in the landscape since the marine protected areas were established --- have fishermen, having lost their source of livelihood, turned to farming or started plantations? Some changes were apparent, like the appearance of large non-rainforest areas in places that were rainforest in previous scenes, but I cannot quantify these changes at this time. WWF seeks to conserve biodiversity, but also seeks to avoid destroying livelihoods in the process. In this case, there is a distinct possibility that saving the reefs have doomed the rainforests, but I cannot say just yet.

Assessment

Clark offers GISDE masters candidates three tracks to a degree: the research track, which involves writing a thesis; the portfolio track, which requires assembling a portfolio of created maps; and the internship track, which I took, requiring students to get an internship. An internship track was my first choice for one very compelling reason: I have next to no job experience, and the experience I do have is not in GIS. For this reason, I was quite lucky to be given the opportunity to intern at WWF. Interning at WWF allowed me to apply my GIS and remote sensing skills outside of the academic setting, in the real world. The internship, for me, was less about learning new skills than it was a chance to apply the ones I already had after 5 years at Clark.

But there was more to this internship than just getting to use GIS in the real world. Working at WWF gave me a brief glimpse into the inner workings of a major multi-national non-governmental organization. Every other Wednesday, I attended meetings of the science team, which were held in the GIS lab/conference room, where everyone gave progress updates about their various projects. Members of the team were constantly traveling around the world, to places like Indonesia and Myanmar (which had only recently opened up to WWF) to work on conservation. I listened to the other GIS project members discuss their work involving a new road being constructed in the jungles of Myanmar. The other members of the science team were quite helpful for my project, offering suggestions when it became clear that certain imagery did not exist.

Most notably, one of them gave me access to Google Earth Engine, and its plethora of satellite images around the world.

I was first introduced to GIS, using IDRISI, in the spring of 2010 when I was a first-year taking Intro to GIS at Clark. In the years that followed, my knowledge of the software greatly increased and learned more about its features. I even was pleasantly surprised to find that IDRISI was used at a major Australian university on a semester abroad. My extensive experience in using IDRISI was one reason, I think, that I was offered this position. Dr. Glew mentioned in our phone interview that it was her GIS software of choice. When I arrived at WWF, I discovered that the software was not installed on the computers in the GIS lab, but since I had arrived at the end of the fiscal year, a license could easily be procured the first day of the new fiscal year. Incidentally, that was my first exposure to the budgeting that is *de rigueur* in modern science.

The World Wildlife Fund internship was the only one to which I was accepted. Although an interesting proposition, it was not my first choice. Make no mistake, I wanted to work with GIS remote sensing, but in the context of hazards, disasters and risk. But I really wanted work experience, and the WWF was offering that. Working at WWF had plenty of perks: flexible hours, every other Friday off, free coffee and tea, and a shuttle to the local Metro stations. One major downside was Washington itself: it is a very expensive city, and this is an unpaid internship. Food and housing are expensive. During times when I did not know how to move forward, I was basically on pause until

I received an answer. This could last a few minutes or a few days. That's one part of work in the field of science that I had not expected.

WWF is an organization with an organization problem. They took so long to get back to me, I was essentially in internship purgatory for over a month. Despite repeated attempts to get in touch with them (my contact was out of the country), including enlisting the help of a cousin at another environmental NGO, I was only officially confirmed for the internship right before I began it. This delay caused many difficulties with my relocation to Washington. In terms of subject matter and opportunity to work in the field, it's a great place to work. If they offered me another position there, one with a salary, I would take it. And I would tell the next person from GISDE considering this internship to go for it. It's a great opportunity, Washington is a world-class city, and WWF is a great organization to work for.

Conclusion

Before my two months at WWF, my only work experience was volunteering at my local public library near Chicago, and a weeklong volunteer position cataloging plant specimens behind the scenes at the Smithsonian Museum of Natural History, also in Washington. I also interned with my biology professor at Clark. My work at WWF, although brief, shows me that I can work in the GIS field when I graduate Clark with my Master's degree, and that I can apply the skills I learned over 6 years in college and

graduate school in the real world. I didn't take the internship at WWF because I'm interested in conservation, I took it because it was a great opportunity. My real interest is to use GIS and remote sensing in a hazard/disaster/risk context. With my internship at WWF, I have now gotten a glimpse of how an NGO works from the inside, and now, when I look for work, I can look for work at another; that does not preclude me from looking into government or private sector work. The opportunity that WWF gave me now offers me more opportunity than ever.



Figure 1: WWF US Headquarters, 1250 24th Street NW, Washington, DC



Figure 2: The GIS lab at WWF-US



Figure 3: My workstation, showing a comparison of various composite images.

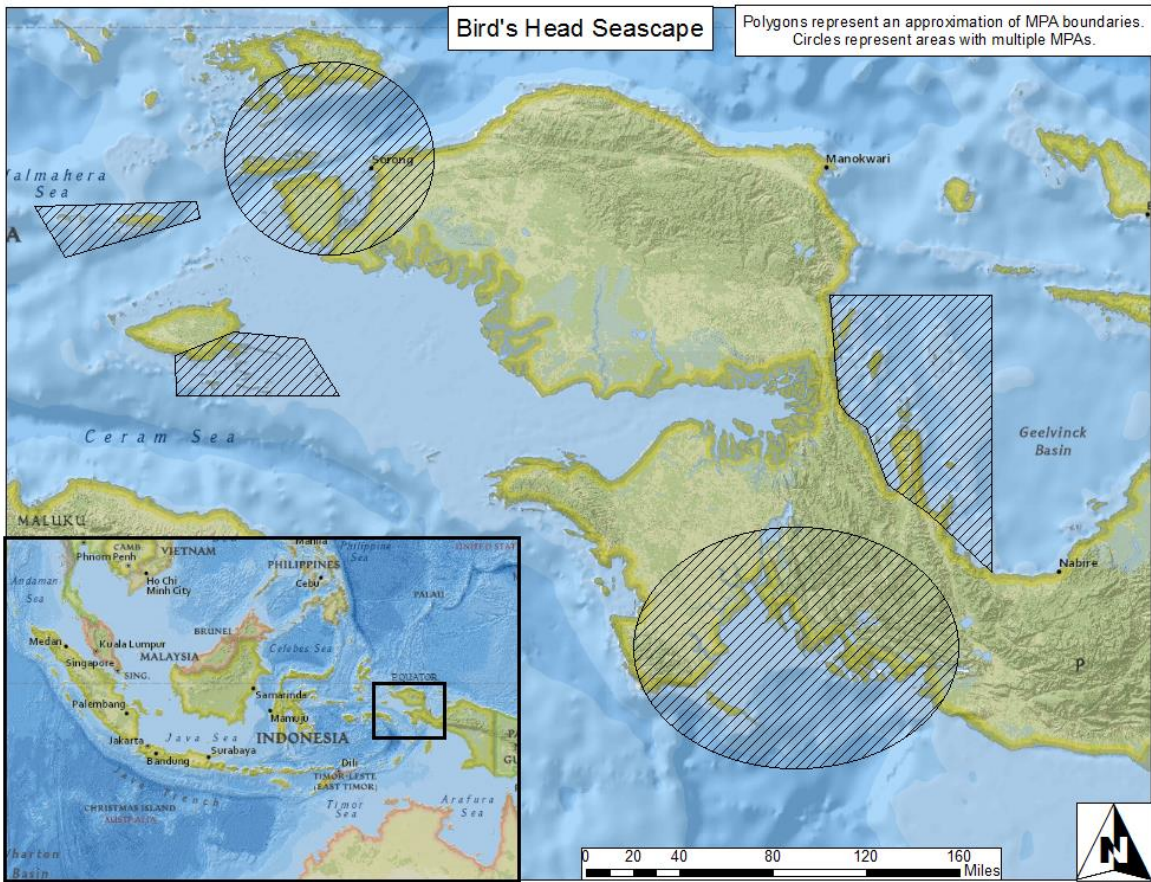


Figure 4: Study area map. Polygons are based on actual Marine Protected Area (MPA) boundaries, circles are areas containing multiple MPAs.

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