CARBON PARKS: A NEW CONSERVATION TOOL TO PROTECT PEATLANDS

An Undergraduate Research Scholars Thesis

by

KIRSTEN EMERY

Submitted to the Undergraduate Research Scholars program at
Texas A&M University
in partial fulfillment of the requirements for the designation as an

UNDERGRADUATE RESEARCH SCHOLAR

Approved by Research Advisor: Dr. Julie Loisel

May 2020

Major: Environmental Geosciences

TABLE OF CONTENTS

ABSTRACT

Carbon Parks: A New Conservation Tool to Protect Peatlands

Kirsten Emery
Department of Environmental Programs in Geosciences
Texas A&M University

Research Advisor: Dr. Julie Loisel
Department of Geography
Texas A&M University

Peatland ecosystems are the most effective long-term terrestrial carbon sinks on Earth. They accumulate large quantities of carbon over thousands of years in the form of thick organic-rich soils. However, there are no policies enacted to ensure their protection. Today, these soils contain about the equivalent of 1/3 of the quantity of carbon dioxide (CO_2) that's in the atmosphere. If this carbon, which is locked away in these soils, were to get back to the atmosphere, it could dramatically accelerate ongoing climate warming. There are two main ways this can happen: (1) climate change, and (2) land management. To reduce these risks and help mitigate climate change, natural carbon sinks such as peatlands could be protected. International protection mechanisms would limit anthropogenic activities that destroy peatlands. Currently, however, such protection status is typically given to (a) unique landscapes (e.g., Yellowstone), and (b) ecosystems that are needed to maintain a species that is rare or threatened of extinction.

CHAPTER I

INTRODUCTION

A peatland ecosystem can be defined as an area of terrestrial land where the soil has a high level of organic content, often above 90%, because of environmental conditions that result in incomplete decomposition of said organic matter. These environmental conditions are: cold soil temperatures, water-saturated soils, low pH, and low nutrient content (Leifeld and Menichetti. 2) (Weider et al. 1). These areas encompass nearly 3% of Earth's land area yet they may contain up to 30% of its organic soil carbon stock (Leifeld and Menichetti. 2).

Peatlands are valuable carbon sinks that can be used to help mitigate climate change. Even peatlands that have already been disturbed but are currently being restored, whether passively or actively, have the potential to continue their carbon storage (Hapsari et al. 2484). Carbon sequestration in soil that is used for agricultural purposes has been proposed, but using restored peatlands is less costly (Leifeld and Menichetti. 1). So, the protection of peatlands is something that cannot be ignored when formulating ways to decrease and negate our current emissions. However, many countries which harbor these precious ecosystems either do not have plans to protect them or their plans were highly disputed (Salomaa et al. 694). Even worse, peatlands are actively being destroyed by a number of economic activities, including peat mining for horticulture and fuel as well as peat drainage and burning for conversion to agriculture and silviculture.

Worldwide, the relatively few places that have established protections for peatlands are in countries such as Finland and France. In France the national government has certainly played a role in the protections of these areas, but the EU Habitats Directive has also had a part in their protection (Francis. 11). This directive established could prove valuable when formulating more international plans for preservation of peatlands all over the world. In Finland there has been more conflict surrounding the conservation of peatlands for various reasons including (but not limited to): economic value of peat extraction, water quality issues in peat absent areas, and agricultural use of the land that peat occupies. Due to the amount of conflict, several studies have been to done to try and find ways to bridge the gap between landowners' and governments' understanding of the pros and cons of peatland conservation (Heli et al. 17) (Salomaa et al. 694). These studies also provide important information in which methods to communicate why and how peatlands can be protected.

Preserving peatlands by protecting the land they cover is a relatively new concept. To my knowledge, there exists only one location where a park was created with the purpose of conserving peatlands. It is located on the Island of Tierra del Fuego in southern Chile and it is a private park. This park is known as Karukinka and is stated to protect about 30,000 hectares of land, including peatlands (Figure 1). This park was the result of a partnership between Goldman Sachs and the Wildlife Conservation Society. Although the park protects peat bogs, its also meant to protect vulnerable species and primary forests that reside there.

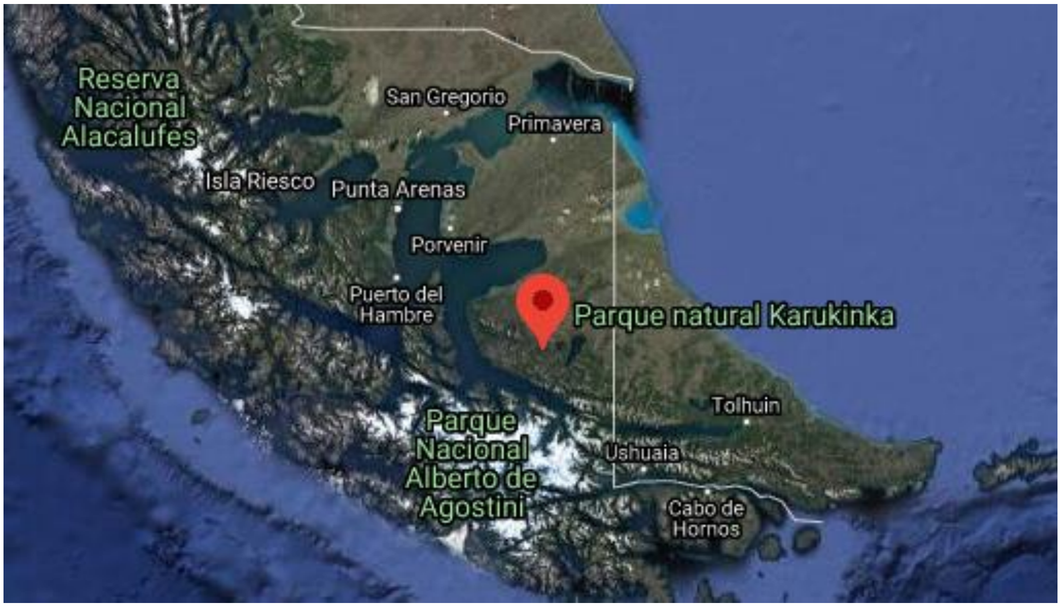

Figure 1: Location of Karukinka Park, in Tierra del Fuego, southern Chile (source: Google Earth).

The reason for analyzing a core from this Chilean peatland complex is to quantify the amount of carbon its storing. This area is unique because it is not a boreal nor a tropical peatland, but still contains large amounts of carbon similar to peatlands in nearby Argentina (Grootjans, et al. 1). Northern boreal peatlands have received more attention in the past primarily because of their large land areas, but the importance of these smaller areas of peatland cannot be overstated. The potential carbon sequestration that can be achieved by protecting this area, and other peatlands, is significant and can serve as an example of a new type of national park: a carbon park.

CHAPTER II

METHODS

The main objective of this study is to estimate how much carbon is found in the Karukinka Park peatlands. To complete this task, three pieces of evidence are needed: (1) peatland surface area, (2) peat depth, and (3) peat density and carbon content. This thesis focuses on the third aspect of the research; it also brings together all three components. The following paragraphs briefly describe how these different types of data were obtained.

The peatland surface area for Karukinka was calculated by an undergraduate student from our research group (Anthony Sherman). He completed a map of the regional peatland deposits using Landsat imagery (30m resolution) and standard classification procedures in ArcGIS. The map methodology being beyond the scope of this thesis, I will not further explain how it was created. The map is shown in the Results section. The total area of peatlands that was obtained from Anthony's map is 910 km^2. This value will be used in subsequent calculations.

Peat depth is the second essential component to estimate the total peatland carbon content. Peat depth was estimated for the entire Park on the basis of probing that was done by our team in the field, in 2018. It was complemented by a literature review. In total, 31 sites have been probed within the Park. The list of sites and associated peat depth is presented in Table 1; the average peat depth is 400cm and I will use this number to determine the Park peat volume.

Table 1: Peat coring sites and their respective depths.

Core Name	Peat Thickness [cm]	Source
Rasmussen RP_1	291	This study
Flarks FP_1	360	This study
Ariel AP_2	386	This study
Cura CP_2	378	This study
Pan's PAN_1	503	This study
Karukinka	450	DeVleeshouwer 2014; Van Bellen 2016
T1	400	Auer 1965
T2	450	Auer 1965
T3	800	Auer 1965
T4	700	Auer 1965
T5	500	Auer 1965
T6	300	Auer 1965
T7	600	Auer 1965
T8	500	Auer 1965
T9	300	Auer 1965
T10	400	Auer 1965
T11	100	Auer 1965
T12	300	Auer 1965
T13	600	Auer 1965
T14	400	Auer 1965
T15	300	Auer 1965
T16	300	Auer 1965
T17	300	Auer 1965
T18	300	Auer 1965
T20	100	Auer 1965
T21	200	Auer 1965
T22	200	Auer 1965
T23	400	Auer 1965
T24	300	Auer 1965
T25	500	Auer 1965
T50	100	Auer 1965

The third type of data needed relate to the peat itself. To estimate peat density and carbon content, I analyze a peat core (CP_2) that is 250 cm long. The code CP refers to the site name, Cura Peatland. It was sampled in the Karukinka Park as part of an expedition funded by the National Geographic Society to determine the quantity of carbon contained in the Karukinka peatlands. A Russian coring device was used to retrieve the core. The core was then wrapped in plastic film and placed in a PVC pipe to secure it for travel. The core was stored at Dr. Loisel's lab at Texas A&M University in a fridge at a temperature of 4 ^{o}C.

In the lab, the core was sectioned into 2cm-thick slices that were placed in individual plastic bags to maintain their water content and integrity. To determine peat density, a series of standard geochemical analyses were performed along the core. Loss-on-ignition (LOI) was conducted on every sample. I used 2cm^3 aliquots that were dried overnight in an oven at 105° C, weighed, then sequentially burnt at 550° C in a furnace for 4 hours, and weighed again. Samples lose their water during the first step, allowing us to determine peat dry bulk density (BD). Carbon dioxide (CO_2) from organic matter is then combusted during the second step, allowing us to determine organic matter content (OMC) (Dean, 1974).

To determine carbon (C) content, the peat core was cut into 2 cm thick slices starting from 9 cm below the surface. Samples were taken from each slice and placed into ceramic dishes and into an oven at 30 ^{o}C for 2 days to dry them. After drying, a ball mill was used to grind the samples until they became a homogenous powder. The samples were then taken to Texas A&M University's Stable Isotope lab for weighing and processing.

About 0.125-0.175 mg of each sample was placed in tin capsules and pressed closed. The samples were analyzed using a Thermo Scientific Flash EA Isolink Elemental Analyzer that is attached to a Thermo Scientific Conflo IV and a Thermo Scientific Delta V Advantage isotope ratio mass spectrometer (IRMS). The samples were combusted using pure O_2 at a temperature of 1020 ^{o}C. The samples then passed through a reactor bed and then passed through a reducing reactor filled with copper wire that has been reduced and is held at a temperature of 650 ^{o}C. The samples were then separated chromatographically at a temperature of 55 ^{o}C before being introduced to the Conflo IV and then the IRMS. The lab then analyzed the outputs given by this analysis to calculate percent carbon and percent nitrogen for each sample. I will only report %C in my study.

Lastly, the total carbon value for the entirety of the peat in the Park was calculated. This was done by multiplying the peatland surface area by the mean depth of the sites previously probed and then by the organic matter density and %C estimated from core CP-18. To reiterate, the surface area (910 km^2) was estimated from a map created by Anthony Sherman, an undergraduate from our research group. The mean depth (4m) was found from coring and probing of the cores from the trip as well as using estimations from a literature review conducted by a member of the expedition. The %C was calculated by me.

CHAPTER III

RESULTS

The mean depth of peat in the Karukinka Park was found to be 400 cm using the peat depths from this study and the literature review. As stated earlier, the surface area of peatland as calculated by Anthony Sherman is 910 km^2. The organic matter content of these samples up to 200 cm was analyzed by another member of the team (Michael Bunsen) who found that the organic matter density of the peat samples was 0.09 g/cm^3 (Figure 2). The average %C of the core was found by averaging all samples except those from: 166-168 cm, 168-170 cm, 230-232 cm, 232-234 cm, and 248-250 cm. These samples were omitted at the suggestion of the lab manager due to a measurement sample intensity less than 500 mV. The average %C content for CP_2 was found to be 50.6% (Figure 3). Given this information, the total amount of carbon in the park is about 0.1658 GtC.

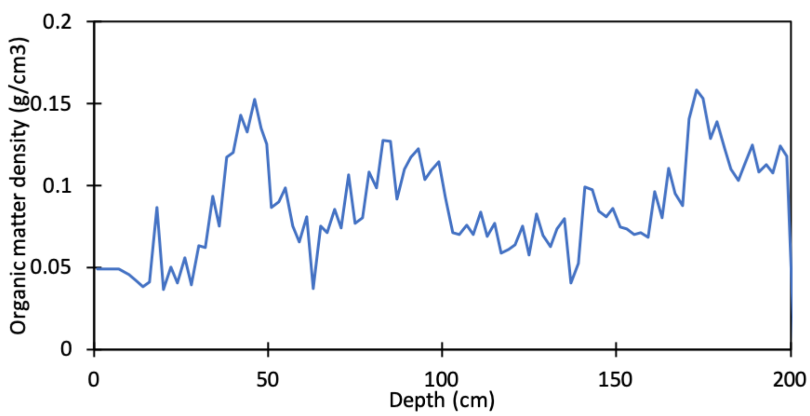

Figure 2: Organic matter density vs. depth along core CP_2.

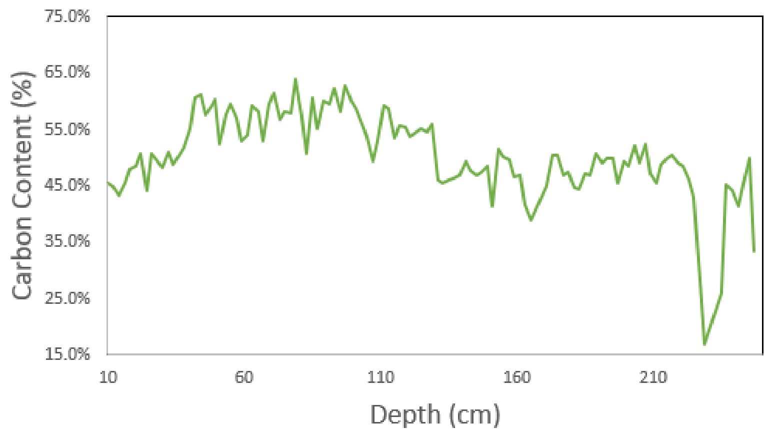

Figure 3: Carbon content vs depth along core CP_2.

This study also found that the surface area of peatland in Karukinka was larger than previously thought (Figures 4-5). The map created by Anthony Sherman illustrates this difference by contrasting the original peatland map of the area with his new one.

Figure 4: Original peatland classification (in red) map vs. our new peatland classification (in orange) map.

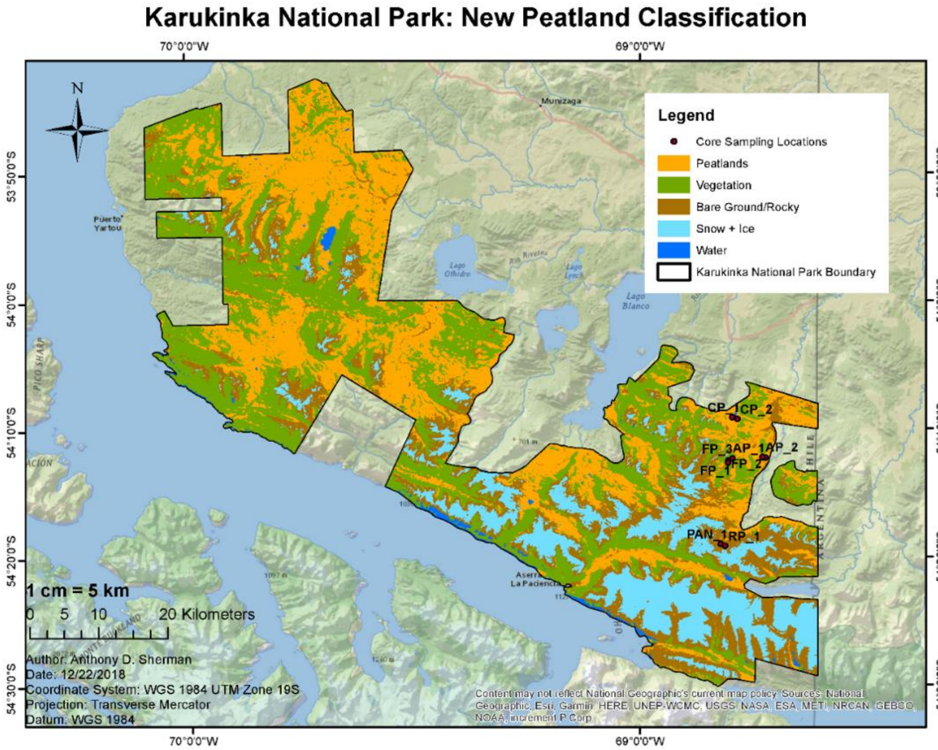

Figure 5: Final peatland map for Karukinka Park.

CHAPTER IV

DISCUSSION AND CONCLUSION

Human activity emits an average of about 9.9 GtC per year (Friedlingstein, et al. 1.). Since the amount of carbon that is contained in the Park was found to be 0.1658 GtC, Karukinka Park alone contains about 2% of what humans emit annually. Karukinka's carbon is a small amount when compared to the worldwide carbon stock of peatlands, which is 500 GtC (Yu, at al. 1). To put this number in perspective, the IPCC has stated that humans have a 50% chance of keeping Earth's average temperature increase since pre-industrial times below 1.5 ^{o}C if no more than 580 GtC is emitted (IPCC. 12).

Peatlands contain vast amounts of carbon, but they also provide valuable ecosystem services. Ecosystem services in this case is defined as the benefits that humans obtain from peatlands, including: provisioning, regulating, cultural, and supporting services. The most significant of these services are the regulating and supporting services. Peatlands provide regulating services such as the regulation of climate and water, water purification, and protection from erosion. The supporting services they provide are soil formation, nutrient cycling, and providing of habitats that support a great amount of biodiversity (Kimmel and Mander. 494.)

Historically, land has only been protected if it possesses a unique landscape or is home to vulnerable or endangered species. This study has shown that a Karukinka Park, which is only a small percentage of total land area of worldwide peatlands, contains a significant amount of carbon. I propose that due to the abilities that Karukinka and peatlands worldwide possess, national parks should be formed on them to protect them. Protecting peatlands worldwide is vital to mitigate climate change and not exceed our recommended carbon budget to stay under 1.5 ^{o}C of warming.

REFERENCES

Friedlingstein et al. (2019) Global Carbon Budget 2019. Earth System Science Data. https://doi.org/10.5194/essd-11-1783-2019.

Grootjans, A, et al. “Mires and mire types of Peninsula Mitre, Tierra del Fuego, Argentina.” Mires and Peat, vol. 14, 2014, pp. 1-20.

Hapsari, Kartika A., et al. “Resilience of a peatland in Central Sumatra, Indonesia to past anthropogenic disturbance: Improving conservation and restoration designs using palaeoecology.” *Journal of Ecology*. 2018, pp 2473-2490.

Heli, Saarikoski, et al. “Participatory multi-criteria decision analysis in valuing peatland ecosystem services—Trade-offs related to peat extraction vs. pristine peatlands in Southern Finland.” Ecological Economics, vol. 162, 2019, pp. 17-28.

IPCC, 2018: Summary for Policymakers. In: *Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty* [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)]. *World Meteorological Organization, Geneva, Switzerland, 32 pp.*

Kimmel, Kai, and Ülo Mander. "Ecosystem services of peatlands: Implications for restoration." *Progress in Physical Geography* 34.4 (2010): 491-514.

Leifeld, J, Menichetti, L. “The underappreciated potential of peatlands in global climate change mitigation strategies.” *Nature Communications*, vol. 9, 2018, pp. 1-7.

Muller, Francis. “Strategies for peatland conservation in France – a review of progress.” *Mires and Peat*, vol. 21, 2018, pp. 1-13.

Salomaa, Anna, et al. “The case of conflicting Finnish peatland management – Skewed representation of nature, participation, and policy instruments.” *Journal of Environmental Management*, vol. 223, pp. 694-702.

Yu, Zicheng, et al. "Global peatland dynamics since the Last Glacial Maximum." *Geophysical Research Letters* 37.13 (2010).