



Private Rainforest Reserves

Executive Summary

Private actors have been actively preserving natural spaces for hundreds of years. Yet while groups such as the Nature Conservancy in the US have developed an extensive network of privately held forests, in the developing world such initiatives are less common. The recent global focus on the perils of climate change have brought new attention to the question of how to create mechanisms – both public and private – to preserve the world’s existing rainforests.

This Columbia SIPA case looks at two innovative private rainforest reserves in Costa Rica, The Monteverde Cloud Forest Reserve, and the Children’s Eternal Rainforest, and places their history within the wider context of the policy debate on tropical forests’ role in mitigating climate change. It explores how Costa Rica developed an innovative program that served as a precursor to “Climate Finance” initiatives being debated in ongoing attempts to mitigate climate change. Interviews with local stakeholders and two Columbia University professors, Ruth DeFries and Ralph Schmidt, are included. This case is based off field research conducted by a team of Columbia School of International of Public Affairs (SIPA) students.

The case includes the following elements;

- a) Video Intro and Discussions – Available Online
- b) Written Case Study (This Document)
- c) Annex A – Original Documents
- d) Annex B – Selected Interviewee Bios and Interview Transcripts (not needed for core case, presented for research purposes)

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Private Reserves

The history of privately held reserves dates back almost 1,400 years, to the creation of royal forests or “Kingswoods” in Merovingian France. These forests were vast areas preserved by royalty for hunting purposes. In the 1000s, English royalty adopted the practice from continental Europe, converting as much as 25% of England’s land to royal forests by the 1300s.¹ But by the 17th Century, royal forests had lost appeal in light of the revenues the Crown could raise from disafforestation. Most of the land was sold to private owners, which allowed for deforestation.² However, some forests were preserved; for example, Sherwood, an English Kingswood famous as the site of Robin Hood folklore, is today jointly conserved by a private charity and local authority.

Though private reserves maintained by royalty and aristocrats had faded from popularity by the 19th century, the idea of private preserved lands did not die. Rather, it took new forms, with non-profit conservationist groups such as the Trustees of Reservations in the U.S., and the National Trust in the U.K. entering the scene. These groups collected donations and developed dues-paying member models in order to buy thousands of acres of land for their stewardship.

But the biggest player in the movement for private reserves would not be established until the 1950s, when the Nature Conservancy was founded. In 1951, it began purchasing vulnerable lands for protection. In the coming decades, it pioneered a scientific approach to conservation that focused on ecological and biological goals in addition to appreciation of natural beauty. In the 1980s, it began focusing its approach on newly-coined “biodiversity,” the maintenance of variety in the lifeforms in the ecosystems the Nature Conservancy protected. Through a variety of arrangements, the Nature Conservancy has today protected over 119 million acres of land in 72 countries. Smaller land conservation organizations also hold significant amounts of land, typically publicly accessible. For example, the Trustees of Reservations own roughly 27,000 acres in Massachusetts,³ and the National Trust owns over 610,000 acres in the U.K.⁴

In some parts of the developing world, private reserves came about in similar ways.

For example, Indian royalty and nobility traditionally owned large plots of land reserved for personal hunting purposes. Landowners in the Princely States received protection under the British Raj in return for their loyalty; they therefore lost their land rights when India gained independence in 1947. Many of the lands were converted into private reserves, held by small communities, individuals, and organizations. More common in postcolonial states, however, was the creation of national parks out of the extensive lands previously held by colonists, their descendants, or their collaborators. For example, Virunga National Park was created in the Belgian

¹ Nicholas A. Robinson, *The Charter of the Forest: Evolving Human Rights in Nature*. Pace Law Faculty Publications. p. 318

² Hughes, J. Donald. *An Environmental History of the World: Humankind’s Changing Role in the Community of Life*. Routledge, 2001. p. 123.

³ “Land.” the Trustees of Reservations, 2019.

⁴ “National Trust Annual Report 2018/19,” p. 56. National Trust, 2019.

Congo in the 1920s by colonists' eviction of Hutus and Tutsis, but is today maintained by the Democratic Republic of the Congo.

Yet a mechanism for creating privately held reserves remained uncommon in the developing world. Efforts by international groups – such as the Nature Conservancy – to buy lands abroad often were met with local political opposition, and relatively few local groups emerged. Privately owned rainforests did become common, but for lumber, mining, and farming rather than for conservation. For instance, in 2003, roughly 35 percent of the land in Brazil's Amazonian states was privately owned.⁵ Much of the remainder was either indigenous lands or national reserves, but even after the difficulties in winning these designations, protection of the land was often underenforced.

Alabaman Quakers in the Costa Rican Rainforest

The history of private nature reserves, however, did not always play out in a predictable way. Nowhere was this more the case than in the unexpected story of the Monteverde Cloud Forest and the Children's Eternal Rainforest in Costa Rica.

In 1950, eleven Quaker families decided to leave the United States after four of their men were jailed for refusing the draft during the Korean War. The families decided to move to Costa Rica, which had recently become the first country to abolish its military after a bloody civil war in 1948. The Quakers were drawn to the central highland area around Monteverde, at an altitude of 1.4 kilometers, for a number of reasons as dairy farmers; these were primarily its suitable pastureland and temperate climate, with an average high temperature of 80°F and low of 65°F. The Quakers cleared some forest for pasture and buildings, which remain in the town today, but they preserved most land – about two thirds of the initial 1,500 acres – to maintain the watershed. These 1,000 densely forested and biodiverse acres were “the seed that gave rise to the Monteverde reserve, and eventually the Children's Eternal Rainforest,” as Monteverde Conservation League executive director Lindsay Stallcup explains.⁶

Though the Quakers had unwittingly begun Costa Rica's largest private rainforest reserve when they decided to protect the watershed, they were at the same time a “threat to the Cloud Forest, because for dairy farms you needed pasture land, and the forest was being cut down,” as tour guide Ricardo Guindon Standing explains.⁷ In fact, one of the leader farmers of the group, Wolf Guindon was also the area's first chainsaw dealer.⁸ Though initially his “vision of development

⁵ Bastiaan Philip Reydon and Vitor Bukvar Fernandes, “Brazilian Amazon Deforestation and land governance,” Symposium on Land Consolidation and Readjustment for Sustainable Development, November 2016.

⁶ Interview with Lindsay Stallcup on March 13, 2018. All further quotes from Stallcup, unless otherwise attributed, are from this interview.

⁷ Interview with Ricardo Guindon Standing on March 14, 2018. All further quotes from Standing, unless otherwise attributed, are from this interview.

⁸ Monteverde Tours. “History of Monteverde and the Quakers.” 2013.

was clearing pastures and building roads and schools," he became the most instrumental figure in the Quaker's decision to protect Monteverde for environmental reasons.⁹ The key reason for this change was George Powell and Harriet McCurdy, two biologists who temporarily resided on Wolf Guindon's farm and taught him the importance of preserving the area's biodiversity. In 1972, they formally founded the Monteverde Forest Reserve, and three years later, it was combined with Quakers' watershed reserve.¹⁰ They arranged for the Centro Científico Tropical, Costa Rica's first environmental non-profit, to manage the reserve.

Monteverde Cloud Forest

After the Quakers established Monteverde ("Green Mountain," so named because of its verdure), it became of interest to scientists due to its unique ecology. The area's position directly atop the Continental Divide, coupled with its location in the tropics, translates to an incredibly biodiverse ecosystem. Due to Northeasterly winds in the Caribbean, Costa Rica's Atlantic slopes are extremely rainy, whereas its Pacific side has dry and wet seasons. (The town of Monteverde, in the middle, has an average 230mm of precipitation monthly.) The country's diversity of flora and fauna due to variety in elevation and climate, along with its many biological corridors due to Costa Rica's isthmic location, are additional reasons why the country has 6% of the world's biodiversity despite accounting for only .03% of its area. These environmental factors, in addition to Costa Rica's reputation as a peaceful democracy and academic center in Central America, attracted many Western universities' researchers and students to the country.

The Monteverde Friends established good relations with visiting Western scholars and biologists who were interested in the area for researching the local ecosystem and endemic species. By 1986, Canadian researchers had grown concerned about ecological degradation due to agriculture that was threatening the Pacific side of the surrounding forest. Partnering with Monteverde residents, they responded by founding the Monteverde Conservation League (MCL) in order to buy the land with donations and prevent its deforestation.

By the late 1990's, the private reserve had developed a very successful ecotourism model, with the Monteverde Cloud Forest Reserve receiving over 50,000 visitors a year.¹¹ By 2005, that number had grown to 77,000, and the reserve had to cap the number of people in the park at one time. Stallcup explains the appeal to tourists: "In addition to the fact that you will be immersed in a spectacular habitat and have an amazing time, your money is going to an organization that is really doing its work on the ground to protect the forests."

⁹ Martha Honey. *Ecotourism and Sustainable Development: Who Owns Paradise?*, p. 152. Island Press, 1999.

¹⁰ Joseph Franke. *Costa Rica's National Parks and Preserves: A Visitor's Guide*, p. 115. The Mountaineers Books, 1999.

¹¹ Jason Davis, "The Creation and Management of Protected Areas in Monteverde, Costa Rica," p. 111. *Global Environment* 3 (2009).

Though ecotourism had been promoted as a green alternative to mass tourism since the 1970s, it became the fastest growing tourism sector in the early 1990s.¹² MCL reaped the benefits, gaining a relatively stable source of income from ecotourism into the 2020s. In 2018, MCF was one of the premier destinations for ecotourism in Costa Rica. As MCF guide Giuliano Gigli explains, “The country receives about 3 million people; we receive in this area about ten percent of that, like 300,000 people.”¹³ Through ticket sales

Children’s Eternal Rainforest

While the Monteverde Cloud Forest Reserve secured reliable institutional revenues from scientific research, eco-tourism, and the government, the Monteverde Conservation League would later establish its neighbor, the Children’s Eternal Rainforest (CER), whose creation and management have a very different story.

In the late 1980s, the fight against cutting down and burning rainforests had become a cause célèbre across the West. Chico Mendes, a Brazilian labor unionist and rubber tapper, had gained recognition throughout Latin America for fighting the clearing of the Amazon for ranching. In 1988, he was assassinated, sparking international rage and inspiring popular support for his cause, leading the Brazilian government to withdraw its support for logging and ranching. Similarly, in 2005, Dorothy Stang, an American-Brazilian nun and environmental activist, was also assassinated. The crime moved the government to strengthen its commitment to protecting Brazil’s forests, until recently. (See below, “An Open Question.”)

At the same time, the rock star Sting was successfully focusing public attention on the issue. After Raoni Metuktire, an indigenous Brazilian chief, petitioned Sting to help protect his tribe’s land, he established the Rainforest Foundation Fund in 1987. As of 2020, the it funded projects preserving over 33 million acres of rainforest by protecting indigenous rights. The Fund quickly took up the “Save the Rainforest” rallying cry, a movement campaign throughout the 1990s that brought conservation greater visibility with t-shirts, posters, celebrity endorsements, and even fundraising concerts. Between 2002 and 2017, it spent \$18.9 million on rainforest preservation programs.¹⁴

This upsurge in international concern about the rainforest’s destruction proved fertile ground for the MCL to grow. In 1987, Sharon Kinsmen, an American biologist who had worked in Monteverde, traveled to Sweden to present to primary schoolchildren on the issue of tropical deforestation. The children were so concerned that they decided to help; with the help of their teacher, Eha Kern, they raised funds to buy six hectares of land adjacent to the MCF. Kern established Barnens Regnskog (Children’s Rainforest) as a non-profit to continue fundraising, and its charming story attracted the attention of more and more Swedes locally, then nationally.

¹² Martha Honey. “Treading Lightly: Ecotourism’s Impact on the Environment,” p. 7. *Environment*, Vol. 41, Iss. 5 (Jun 1999).

¹³ Interview with Giuliano Gigli on March 14, 2018, at Columbia University SIPA, New York City. All further quotes from Morris, unless otherwise attributed, are from this interview.

¹⁴ “Charity Navigator: Historical Data, Rainforest Foundation US.” 2019.

Between 1988 and 1992, it raised over \$2 million, in addition to winning grants from the Swedish government.

Despite not having websites, email, or social media, students in all corners of the globe, from Japan to the U.K., were similarly concerned by disappearing rainforests. After hearing Barnens Regnskog's story, they started fundraising too. Sister groups popped up in 44 countries, raising many millions of dollars. To recognize the efforts of the students from around the world, the MCL named the land it acquired as a result the Children's Eternal Rainforest (CER), and it grew rapidly with time. The unprecedented amount of support allowed the CER to grow to five times the size of the MCF. By 2020, it spanned 23,000 hectares, about four times the area of Manhattan.¹⁵

As the CER expanded, it developed differently than the Monteverde Cloud Forest. The CER was run as a cooperative, with nine MCL board members, some of whom were descendants of the Quaker settlers, others of whom were increasingly local. Whereas the MCF has had secure finances due to the history of institutional support for research conducted at its stations, and enough ecotourism revenues to self-finance, the CER has faced greater challenges due to its rapid expansion. Since the outpouring of donations from abroad were earmarked for land acquisition, the issue of finding operational funds to maintain the new protected areas quickly arose. To this day, the problem persists, as donors' preferences do not always align perfectly with the reserve's needs. Tour guide Alexa Stickle explains, "People want to donate money for land purchase. But with the land that we have right now, it's so much, and we don't have enough staff to consistently monitor it and protect it from loggers, from poachers."

Nonetheless, the CER was able to successfully grow throughout the 1990s to surround the smaller MCF on three of four sides (See Annex A-1). Additionally, the two lodges in the CER for ecotourists, constructed field stations for researchers, built a nursery, and created an environmental education program that today teaches students in about 20 nearby schools. Throughout the 2000s and 2010s, CER has been able to focus on acquiring plots of land needed to consolidate "biological corridors." These corridors, spanning adjacent reserves also, allow free movement of wildlife, which many animals, such as sloths and jaguars, need to survive.

CER's sustained growth and successful maintenance of its land despite the uncertainty accompanying donor-based funding, and donors' disproportionate desire to fund land purchases rather than operations, was made possible by significant shifts in how and why the public paid attention to conservationism. Since MCL established the CER in 1987, a new cause for concern in environmentalism, global warming, grew, creating a greater sense of urgency from both public and private actors that areas like the CER and MCF needed to be protected.

Global Warming Emerges as a Key Issue

¹⁵ Leslie J. Burlingame. "History of the Monteverde Conservation League and Children's Eternal Rainforest," p. 1. Bosque Eterno de los Niños, 2016.

In 1992, Rio de Janeiro, Brazil, hosted the Earth Summit, a U.N. conference to address member states' growing ecological concerns. The Summit attracted 117 world leaders and addressed issues ranging from sustainable agricultural practices to protecting biodiversity. Yet a common thread began to appear among the Summit's many topics. A new term, "Global Warming," was just beginning to enter common parlance to explain the idea that human-emitted greenhouse gases were causing Earth's atmosphere to heat up. In 1988, NASA climate scientist James Hansen had popularized the idea by using the term while testifying to Congress. The resulting wave of concern over the issue heavily influenced delegates the Earth Summit, so that they paid attention to fossil fuels in particular. The delegates opened for signature a treaty, the United Nations Framework Convention on Climate Change (UNFCCC), whose members now meet annually for the Conferences of the Parties (COPs), which serve as fora for discussing climate change.

In the mid-1990's, climate change received yet more attention as then-Vice President Al Gore publicly campaigned for greater U.S. action to combat it. As Vice President, Gore advocated for a carbon tax with limited success and launched an initiative to educate students about climate change, but most important was his support of the Kyoto Protocol, a coordinated international effort to mitigate global warming, described below. Ultimately, the United States would not adopt the Protocol due to unanimous Senate opposition.¹⁶ However, its eventual adoption by every other state made it the landmark treaty in combatting climate change. After leaving office, Gore would later make the Academy Award-winning documentary "An Inconvenient Truth." Widely considered one of the most influential films about global warming, it cemented the issue in the American public's conscious.

The Carbon Credit Movement

In 1997 (COP 3), the U.N. took the first step in codifying what had been discussed in Rio in 1992 under an international system. The Kyoto Protocol recognized global warming was occurring and was almost certainly the result of human activities. To tackle this goliath challenge, the Kyoto Protocol created reduction targets for states' emissions of six greenhouse gases, including carbon dioxide. Targets were binding for developed countries and applied for an initial commitment period from 2005 to 2008, subject to renewal. The Kyoto Protocol had 84 signatories when it was first opened for signature and today has 192 parties.

Crucially, the Kyoto Protocol allowed for carbon credits. Parties to the treaty could allow major polluters that emitted too many greenhouse gases in their country to buy credits from major entities who did not use all their emission credits (how much they would be hypothetically allowed to if the national reduction targets were divided among entities within national borders. This "flexibility mechanism" would allow environmentally responsible firms and organizations in developing countries to be paid by private polluters, incentivizing low emissions.¹⁷

¹⁶ Byrd-Hagel Resolution, S. Res. 98, 105th Cong. (1997).

¹⁷ F. Laroui , E. Tellegen and K. Tourilova. "A Flexibility Mechanism of the Kyoto Protocol – First Explorations of JI between the EU and Russia," p.168-169. *Environmental Sciences*, Vol. 1, No. 2 (2004).

Where exactly forests would fit into the creation of a global carbon credit market, however, was unclear. Given forests' vital role in global carbon sequestration, delegates in Kyoto discussed the possibility of integrating forestry efforts into the protocol, but they ultimately decided not to incorporate them, as the issue of measuring carbon offsets from various forestry activities was considered prohibitively difficult.

In 2005, however a group of fifteen forested countries, including Costa Rica, decided that needed to change. These tropical nations were dissatisfied that the UNFCCC focused disproportionately on fossil fuel emissions, doing little to address the 20% of greenhouse gas emissions due to deforestation and forest degradation.¹⁸ In order to raise the issue of forestry carbon credits again, at the Eleventh Conference of Parties, they created the Coalition for Rainforest Nations.

The Coalition called their proposal "reducing emissions from deforestation and forest degradation in developing countries" (REDD+). It attempted to create a framework for developing countries to receive funding for preserving rainforests, whether through carbon credits or any other financial mechanisms. REDD+ became the most discussed proposal at COP 11, and two years later, at COP 13, the UNFCCC "encouraged Parties ... to address the drivers of deforestation relevant to their national circumstances, with a view to reducing emissions from deforestation and forest degradation and thus enhancing forest carbon stocks due to sustainable management of forests."¹⁹ This formal call for REDD+ action resulted in the creation of programs which today facilitate REDD+ policies, including carbon credits; most notably, the Forest Carbon Partnership Facility was established by the World Bank, and the UN-REDD Programme was formed in 2008.

A Costa Rican Plan

Even before international climate negotiators were working toward developing incentive programs for preserving rainforest, Costa Rica was moving ahead with its own plan to create a financial mechanism for private rainforests' stewards to receive funding for the "environmental services" they render. By the 2010s, Costa Rica's had become a global leader in environmental policy due to successful implementation of the below programs.

In 1995, the Costa Rican legislature created the National Forestry Financing Fund (FONAFIFO, after the Spanish *El Fondo Nacional de Financiamiento Forestal*), and tasked the agency with securing and disbursing national forestry funds. FONAFIFO would administer many programs intended to incentivize small to medium-sized landowners to preserve rainforests, replant in deforested areas, and use forest resources sustainably. But its most important programs are Costa Rica's REDD Secretariat and payment for environmental services (PES).

¹⁸ Gregory Asner. "Measuring Carbon Emissions from Tropical Deforestation: An Overview," p. 1. Environmental Defense Fund, 2012.

¹⁹ "Report of the Conference of the Parties on its thirteenth session." United Nations Framework Convention on Climate Change. December 2007.

The REDD Secretariat provides REDD-related support to Costa Rica in the form of research on land use and forestry policy, consulting with stakeholders on regulations, and liaising with international organizations like the Forest Carbon Partnership Facility on behalf of Costa Rica. The scope of the PES program, on the other hand, is contained within Costa Rica's borders. The program pays landowners, primarily small farmers, to maintain forests rather than cutting them down to open up more land for agriculture. But PES has also been vital to reserves like the CER and the MCF, as it makes revenues more predictable from year to year. For example, in 2018, each of the 10,000 hectares eligible for PES in the CER received about \$80. In Costa Rica as a whole, between 1997 and 2015, PES disbursed \$318 million to forestry projects.

FONAFIFO has been credited as a large contributor to Costa Rica's massive reforestation between the late 1980s and 2010 – from 21% of its land to 53%.²⁰ Its success in environmental reform has comprised not only incentivizing positive behaviors but also discouraging negative ones. For example, FONAFIFO receives funds from its programs from a surcharge on high water use, timber taxes, and, most notably, Costa Rica's 3.5% tax on fossil fuels. Due in part to these disincentives, Costa Rica reduced carbon emissions 92% from 1988 to 2013.

PES and financial deterrents have been the main driver behind these improvements; whether REDD+ will be as successful in Costa Rica, however, is uncertain. Since FONAFIFO launched its REDD program in 2016, it has faced the challenge of tumultuous international carbon credit markets. Volatile prices for credits and unpredictable demand made it difficult that carbon credits would not be a reliable addition to Costa Rica environmental policy toolset, unless a standard like REDD+ became widely adopted across industries and borders.

The Rise and Fall of Carbon Markets – Official and Voluntary

While the REDD+ talks stalled, the basic market outlined in the Kyoto Protocol moved forward. Emissions trading systems, which mandated carbon credits in line with Kyoto, became law at the national and subnational levels throughout the 2000s and 2010s. For example, in 2008, the New Zealand Parliament passed the New Zealand Emissions Trading Scheme, and in 2006 the California legislature set emissions reduction goals which the executive would turn into a cap-and-trade system. By far the largest and most effective, however, was the European Union Emissions Trading Scheme (EU ETS), created in 2005. In 2007, the EU ETS began to regulate emissions in not only the 28 EU member states but also Lichtenstein, Iceland, and Norway.²¹

By 2018, carbon taxes and emissions trading systems had grown widespread enough to apply to 11 gigatons of carbon dioxide, or 20% of global greenhouse gas emissions. The value of the carbon credits traded on mandatory markets and taxes amounted to \$80 billion. While developed

²⁰ Doreen Allasiw et al. "Field Survey Key Informant Interviews in Sustainability Science: Costa Rica's PES Policy of Changing Focus from Quantity to Quality," p. 42. *Sustainability Science: Field Methods and Exercises*, 2016.

²¹ "The EU Emissions Trading System (EU ETS)," p. 1. The European Commission, 2018.

countries such as Japan and EU ETS members had made the largest reductions, developing nations were increasingly become key players in the effort to reduce emissions.

For example, after COP-21 in 2015, China began considering an ETS which, if implemented, would curb emissions from one of the world's top CO₂ contributors. Though details were heavily delayed, China announced in 2019 that the ETS would be mandatory for the power sector, with additional sectors to follow.²² In 2013, China also began ambitious pilot programs in several provinces targeting industries ranging from steel to hotels. The programs covered major cities such as Beijing and Shanghai; in 2014, prices peaked at over 80 RMB (around \$13) per ton of carbon, in Shenzhen.

Parallel to carbon markets run by governments and international organizations like the U.N., voluntary markets emerged. In these markets, companies and groups that wanted to sell their products as "carbon-neutral" could buy carbon credits to offset their emissions. By the early 2010s, the Kyoto Protocol had never been adopted by the U.S., had been withdrawn from by Canada in 2011, and was scarcely enforced by its signatories. Further, in 2009, COP 15 in Copenhagen had failed to deliver a binding agreement for reducing emissions from 2012 onwards. Doing so had been the goal because of the Kyoto Protocol's being perceived to do too little.

As credit prices in government markets plunged, the prospect of voluntary markets became increasingly attractive.²³ Initially, prices in voluntary markets were depressed by the opacity around their real value absent government verification. But throughout the 2010s, a governance network formed in which groups offered certification for credits after validating the efficacy of sequestration efforts and other green projects offering credits. In 2018, Pamela Castilo, the executive director of Centro Científico Tropical, the NGO which administers the Monteverde Cloud Forest Reserve, explained the reserve's efforts at entering the voluntary market: "We are looking for this global conservationist standard that is actually a voluntary market for carbon ... They do type of a measure of your biomass," *i.e.*, the amount of carbon held by vegetation.²⁴

Yet gauging biomass, and in turn the sequestration achieved by a reserve like Monteverde, was no easy task. Generally, measuring how much carbon dioxide an organization or project took out of the atmosphere was a major obstacle to stable pricing in the voluntary markets, even with the positive effects of certification standards.

The Challenge of Measurement

Scientists at Columbia's Lamont-Doherty Earth Observatory have been at the forefront of the efforts to solve this issue. "Carbon markets rely on accurate information," explained Ruth Defries, a professor sustainable development and ecology, in 2016. "People need to know what the actual

²² Peter Zaman and Katherine Yang. "Update on the Chinese National Emissions Trading Scheme – some progress but more questions than answers." Reed Smith LLP, 2019.

²³ "State of the Voluntary Carbon Markets 2019." Ecosystem Marketplace, 2019.

²⁴ Interview with Pamela Castilo on March 9, 2018. All further quotes from Castilo, unless otherwise attributed, are from this interview.

carbon changes are that they are paying for ... There's a very clear application for satellite data because you can see where forest is being cleared, and now we're getting better with satellite data in estimating the biomass."²⁵

As the frequency and quality of satellite coverage improved in the 2000s, researchers began creating geographic information systems (GIS's). Using GIS technology, organizations verifying carbon sequestration could map the topography, soil type, and vegetation in a given plot of land. Then, by overlapping the three layers, they could demarcate strata, *i.e.*, units of land similar segregated by these criteria.²⁶ These strata comprise a sample, and by tracking each over time, researchers could accurately gauge whether a sequestration project was working. Given large enough a sample size, a reliable range could be created for the sequestration by each "carbon pool," *e.g.*, humus or understory vegetation, and these ranges could then be summed.²⁷ As changes to strata were tracked over time, the permanence and growth of carbon sinks could be gauged, in order to ensure apparent successes were not transient.²⁸ Though satellite and aerial technology still required complementary groundwork to get a full picture of sequestration, advances in these technologies nonetheless were key in making monitoring financially feasible.

An Open Question

Though these improvements were an important step forward in strengthening voluntary carbon markets, it was clear by the early 2020s that the private sector's growing desire to invest responsibly would be only part of the solution to climate change and deforestation. Environmentally sound policy was a necessary complement, both to support private carbon mitigation and sequestration, and to provide public measures such as national reserves.

In 2014, the landmark Paris Agreement was developed. 175 Parties initially signed onto the agreement, which committed to limiting global warming to a further 2 °C. Eventually, the agreement garnered the signature of every country in the world and was ratified in all but a handful. However, in 2017, President Donald Trump announced his administration's intent to withdraw from the agreement, effective November 2020. This was a major blow to the agreement, as the United States was to account for the largest share of greenhouse gas reduction.

The primary role of the U.S. in global climate change was that of an emitter; in 2019, only China released more greenhouse gas into the atmosphere. But countries with vital roles as carbon sinks also displayed a concerning lack of leadership in 2010s. Perhaps most notably, Jair Bolsonaro

²⁵ Interview with Ruth Defries on August 16, 2016. All further quotes from Defries, unless otherwise attributed, are from this interview.

²⁶ Timothy R.H. Pearson, Sandra L. Brown, and Richard A. Birdsey. "Measurement Guidelines for the Sequestration of Forest Carbon," pp. 4-6. United States Department of Agriculture, 2007.

²⁷ *Ibid.*, 13-16.

²⁸ Naomi B Schwartz, María Uriarte, Ruth DeFries, Victor H Gutierrez-Velez, and Miguel A Pinedo-Vasquez. "Land-use dynamics influence estimates of carbon sequestration potential in tropical second-growth forest," pp. 1-2. *Environmental Research Letters*, Volume 12, Number 7 (2017).

entered office as President of Brazil in 2019, beginning a process of opening protected areas of the Amazon rainforest to agriculture, in addition to dismantling government departments tasked with combatting climate change. A year-to-date comparison in June 2019 found an astounding 88% increase in deforestation.²⁹ With the environmental futures of the two countries that were arguably the most critical in carbon emission and sequestering, prospects for global warming were not bright at the turn of the decade.

On the other hand, some countries were able to realize their commitments to mitigating climate change. France, Finland, Sweden, Switzerland, and Lichtenstein were the outliers that, as of 2018, had implemented carbon taxes consistent with their Paris targets.³⁰ Some countries realized the dependence of their future on decisive policy, as seen in Costa Rica's innovative policy. In addition to a solidified scientific consensus about anthropogenic climate change and mounting political pressure to protect the environment, private leadership in environmentalism was growing. While it was unclear if these factors would be enough to combat global warming, there were at least some promising successes in history: the rise of previously unimaginable voluntary markets, and the growth of some would-be pastureland into Costa Rica's largest private rainforest reserve.

²⁹ Jake Spring. "Brazil deforestation exceeds 88% in June under Bolsonaro." Reuters, 2019.

³⁰ C. Ramstein, R. Goyal, S. Gray, A. Churie Kallhauge, L. Lam, N. Klein, L. Wong, M. Quant, S. Nierop, T. Berg, and P. Leuschner. "State and Trends of Carbon Pricing 2018," p. 22. World Bank Group, 2018.

ANNEX A: Original Documents

Annex A-1: Map of Monteverde Cloud Forest and Children's Eternal Rainforest

Annex A-2: Map of countries participating in REDD+

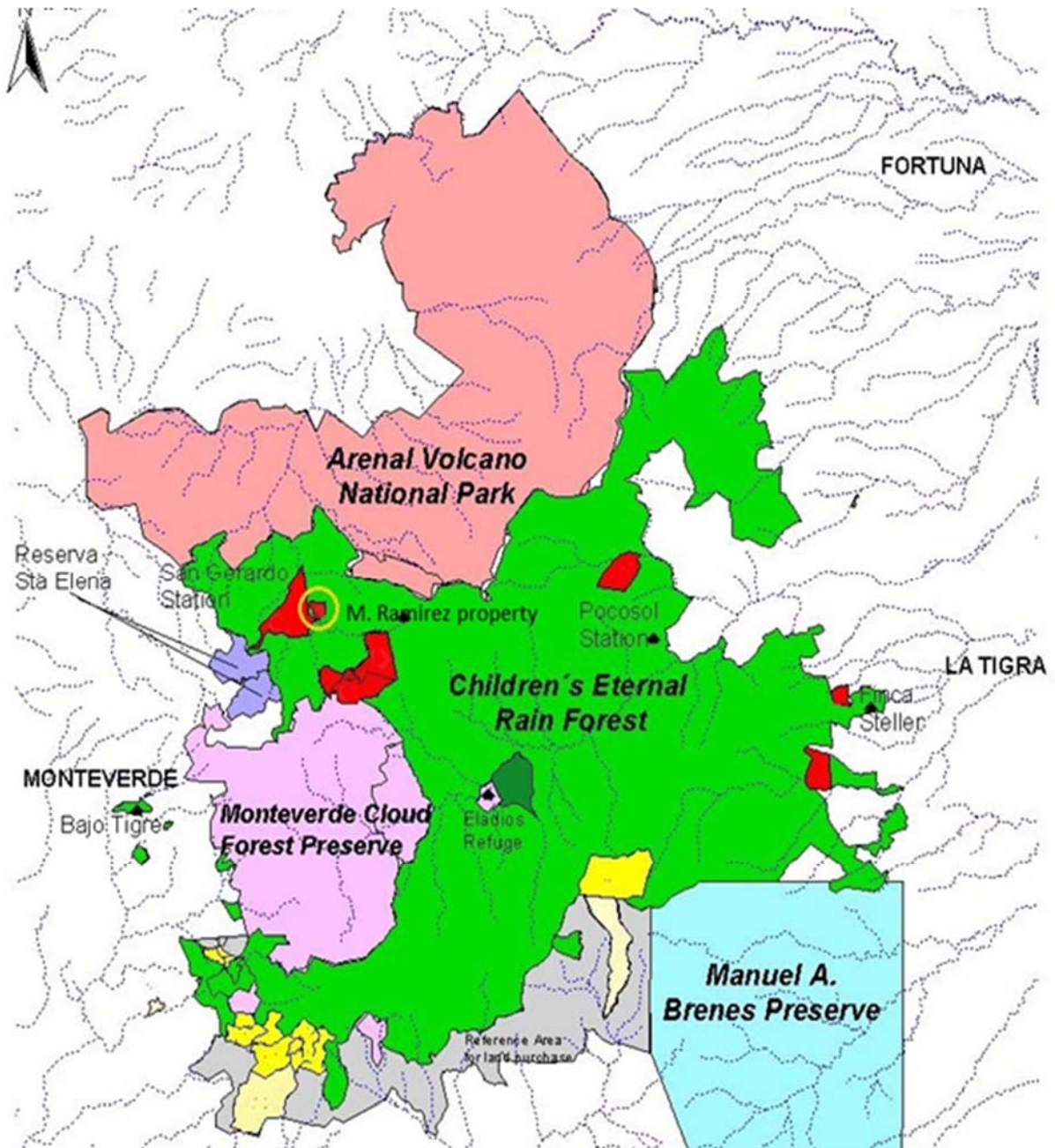
Annex A-3: EU ETS Price Data, 2008-2019

Annex A-4: Map of global ETS's and carbon taxes

Annex A-5: Example of advertisement with carbon neutrality

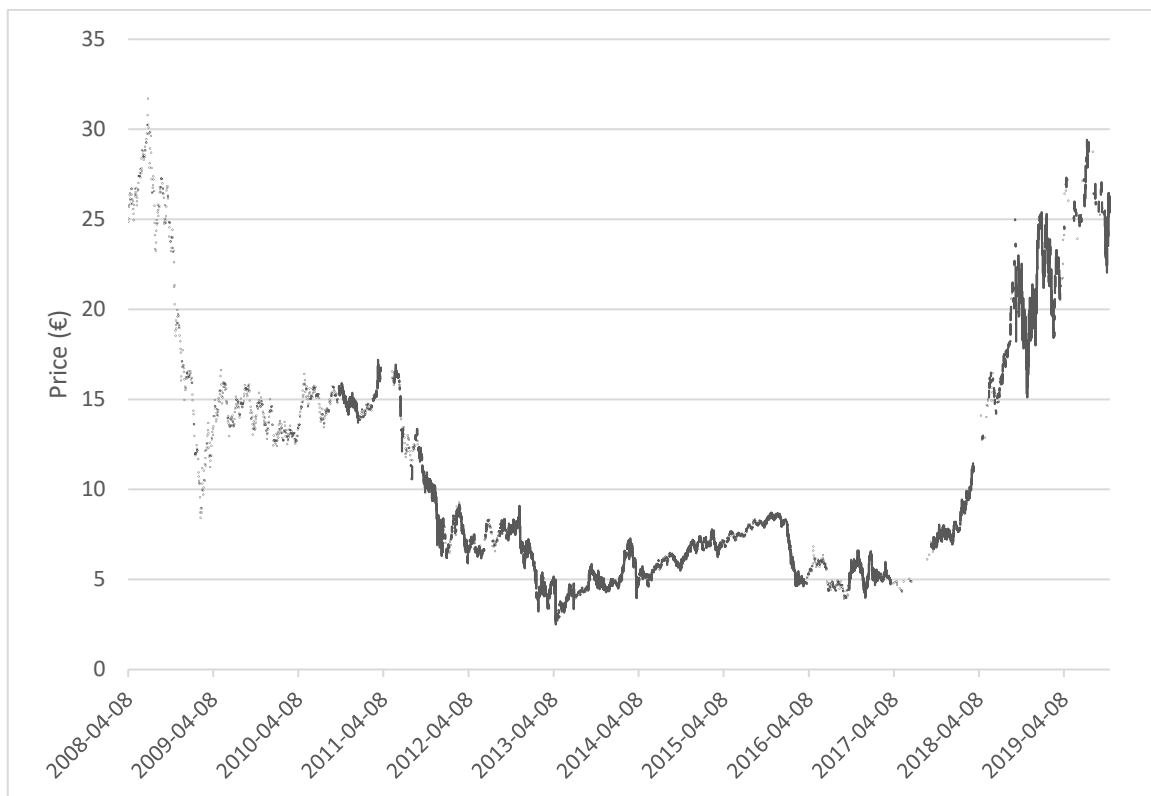
Annex A-1

The Monteverde Cloud Forest and Children’s Rainforest border a number of smaller reserves and a large national park.



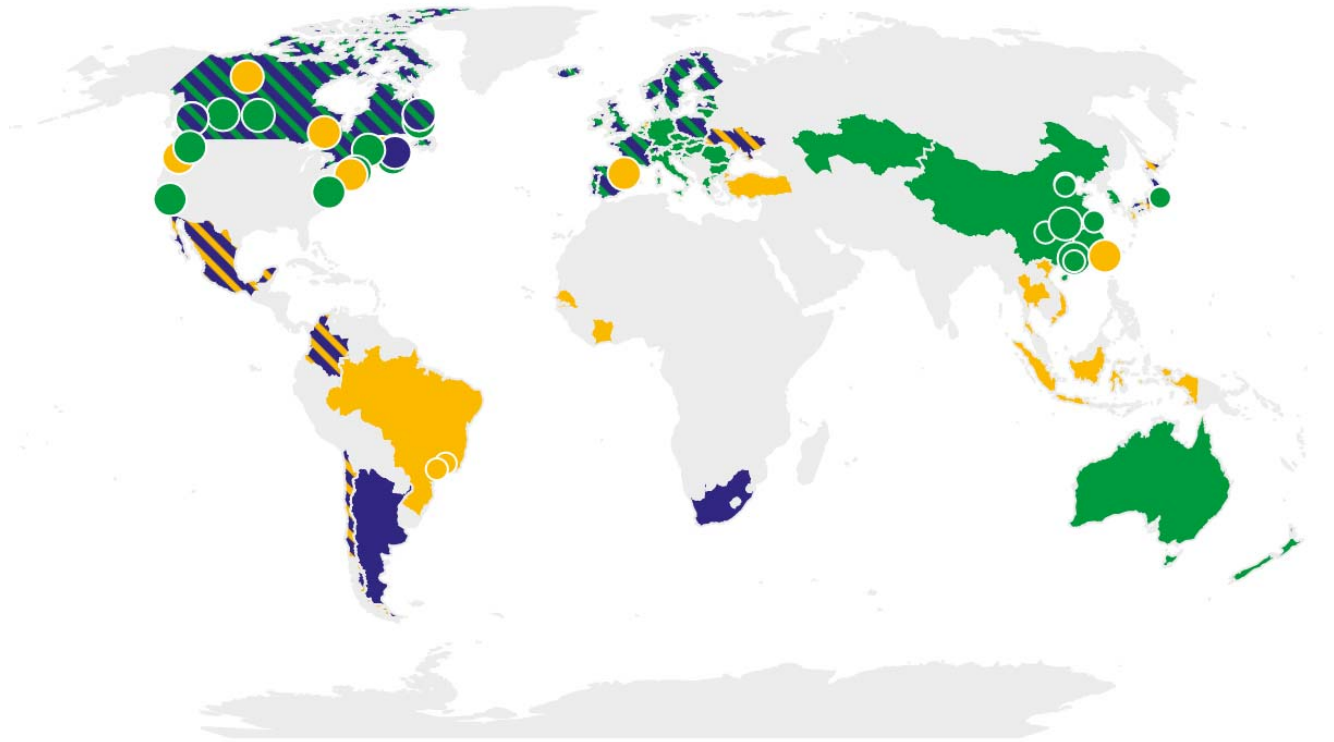
Annex A-3

Prices for carbon credits in the European Union Emissions Trading System from April 2008 to October 2019. The European Union Emissions Trading System represents the largest share of global greenhouse gas emissions of any cap and trade system. Prices are not adjusted for inflation. Available from https://www.quandl.com/data/CHRIS/ICE_C1.



Annex A-4

Map of national and subnational Emission Trading Schemes (often cap and trade systems) and carbon taxes. Available from the World Bank at carbonpricingdashboard.worldbank.org



- ETS implemented or scheduled for implementation
- Carbon tax implemented or scheduled for implementation
- ETS or carbon tax under consideration
- ETS and carbon tax implemented or scheduled
- ETS implemented or scheduled, tax under consideration
- Carbon tax implemented or scheduled, ETS under consideration

Annex A-5

A mining equipment dealer's billboard in Beckley, West Virginia, advertises the company's carbon neutrality. Available from <https://flic.kr/p/cLqtzo>.

