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Case Example: Panama Canal Watershed

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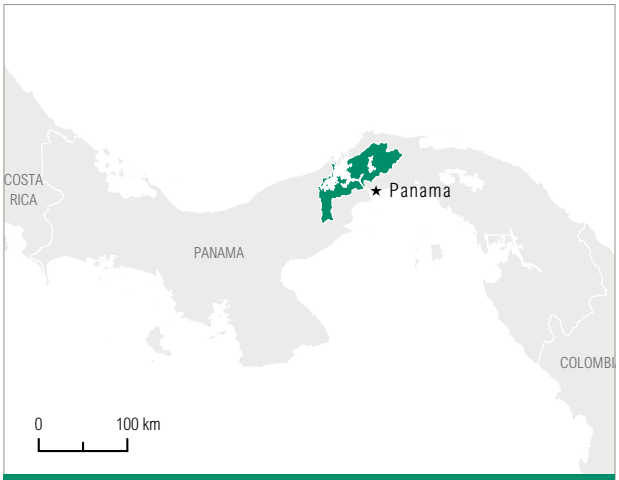
SUMMARY

The Panama Canal, created between 1904–1914, was a significant feat of engineering. The Panama Canal Zone—a quasi-colonial U.S. territory that surrounded the Panama Canal—aimed to act as a transportation enclave for the U.S. government. The transport route was constructed by over 50,000 people moving earth and redirecting water from the Atlantic-bound Charges River to the Pacific (Carse 2014a). Within the larger landscape, the Panama Canal Watershed is a 375,000 hectare[1] area (Dale et al. 2010); approximately 47 percent of the territory (about 175,000 hectares) is covered by forests (ACP 2006a). The watershed surrounds the Panama Canal at the isthmus (the narrow strip of land between the Caribbean Sea and the Pacific Ocean) and is in one of the most biodiverse areas in the world (Condit et al. 2001).

Much of the original forest within the Panama Canal watershed has been cleared over the past 200 years. Clearing took off during construction of the railroad across the isthmus in the 1850s and then later in the 1880s, when work on the French attempt to build a canal started (Ibáñez et al. 2002).[2] Throughout the 1960s and early 1970s, Panamanian state institutions actively developed a program called "Conquest of the Jungle," where people were encouraged to clear forests (Carse 2014a). Deforestation accelerated after 1979 with the dissolution of the Panama Canal Zone, when the government of Panama received control of the canal from the United States. After 1979, the main drivers of deforestation were growing crops, cattle ranching, and urbanization (World Bank 2009). Between 1974 and 1991, forest cover in the watershed decreased by 43 percent—from 275,550 hectares to 157,000 hectares (Dale et al. 2010).

Since the 1970s, diverse actors—administrators, scientists, politicians, and conservationists—came together around a common concern about potential water scarcity and watershed deforestation (Carse 2012). They recognized that watershed management—natural or "green infrastructure"—was essential to protect the canal watershed in order to preserve the functioning of the canal. For example, 52 million gallons of water are released into the oceans during the passage of the 35–45 ships that transit the canal daily. Each passing ship accounts for an amount of water equivalent to roughly two-thirds of the daily water consumption of 320,000 Panamanians (Carse 2010). Maintaining this water flow capacity is a significant challenge.



TIME PERIOD: 1980s to present

AREA RESTORED: 18,000 hectares

TYPE OF RESTORATION: Active restoration with passive restoration in protected areas

PANAMA CANAL WATERSHED BEFORE

PANAMA CANAL WATERSHED AFTER

The tide started to turn in the 1980s with regard to forest cover. First, the government started enforcing legislation that prohibited deforestation and mandated land conversion back into forests within the region (Canal de Panama 2012). Second, in 1987, the Panama Canal Commission (PCC) began a reforestation project in canal operating areas using nonnative acacia (*Acacia mangium*) and melina (*Gmelina arborea*) species because of their seed availability and rapid growth characteristics (Cerezo 2011). Third, in 1991, the governments of Panama and the United States signed an agreement to protect and monitor the watershed. This agreement operationalized the first LandSat-based monitoring and analysis of deforestation in Panama (Heckadon-Moreno et al. 1999).[3]

These efforts resulted in a sustained reduction in the rate of deforestation; the period between 1985 and 1998 had an average - 0.5 percent deforestation rate (CDP 2012). In 1998, the Panama Canal Authority (ACP) identified the need to only use native species in restoration (Cerezo 2011). In 2001, the Panama Canal Authority formally initiated a reforestation program with the objective to protect dry season flows required for the Panama Canal operation and to secure water provision for nearby communities (ACP 2006b). In some areas, forests started to recover. Since 2001, the ACP has engaged in strategic partnerships with the Reforestation with Native Species Project (PRORENA)—a scientific research project led by the Smithsonian Tropical Research Institute (STRI) and Yale University—to collect data on the behavior of native species used in ACP Projects (Cerezo 2011). By around 2010, forest area had climbed back by about 18,000 hectares to a total of 175,000 hectares within the Panama Canal Watershed (MGM Innova 2010).

WHICH FEATURES AND KEY SUCCESS FACTORS WERE EXHIBITED?

The recovery of forest area in the Panama Canal Watershed exhibited several of the features and key success factors of forest landscape restoration.

Motivate

Factors motivating restoration included:

- **BENEFITS.** Restoration was expected to provide important environmental, economic, and social benefits. Environmentally, deforestation has a direct impact on water resources by altering temporal patterns of flow. In deforested areas, a higher proportion of rain enters the streams immediately, increasing wet season stream flow and decreasing dry season stream flow (MGM Innova 2010). One motivating benefit of restoration was the expectation that it would ensure a more even flow of water across seasons and prevent soil erosion (Calder 2007). This is important for several economic and social reasons. The watershed provides drinking water for approximately 1.3 million people (TNC n.d.), or approximately two-thirds of the country's population, including the two largest cities in the country (Panama City and Colon City) (World Bank 2004). The watershed serves as a source of freshwater for electricity generation and for the operation of the navigation locks of the canal. Furthermore, sedimentation from soil erosion could make the canal too shallow for large ships to pass through and reduces the capacity of the reservoir to store water. This impact could trigger additional costs of dredging in the canal (Ibáñez et al. 2002).

  The canal itself plays a key role in the Panamanian economy, generating $700 million in foreign exchange and contributing $215 million to the national treasury annually (World Bank 2004). Global maritime transportation remains the cheapest way to move large amounts of cargo, accounting for approximately 90 percent of the volume of global trade (Carse 2014a). Over one million vessels have passed through the waterway since it opened for business in 1914. The Panama Canal Authority and the quasi-autonomous Panamanian state institution that administers the waterway charge tolls calculated according to ship capacity. In 2012, some fees have exceeded $300,000 in revenue and contributed 1 billion dollars in profits to the Panamanian government, while employing 10,000 people. Therefore, regional water shortages have national and international implications (Carse 2014b).

  Even after the U.S. handover in 1999, the United States still had an important economic and political stake in the canal's operations (Zien 2013). For example, nearly 40 percent of canal traffic by tonnage in 2012 traveled between Asia (mainly China) and the eastern United States. Ships plying the second-most traveled route between the eastern United States and western South America made up 9 percent of canal traffic (Carse 2014b). It is therefore essential that the canal is protected. Restoration has the ability to provide needed green infrastructure to support the canal.

- **LEGAL REQUIREMENTS.** The Torrijos-Carter Treaty of 1977 established the return of all canal operations by the year 2000 to the government of Panama, and thus the duty to protect the water resources in the Panama Canal Watershed. In 1997, the General Plan for the Use, Conservation and Development of the Canal Area—"Law No. 21"—required the conversion of 95 percent of 142,000 hectares of grasslands being used for ranching to be restored into forests (72 percent) and sustainable agriculture (23 percent) (World Bank 2004).

- **AWARENESS.** Fear that deforestation and climate change may render water provision for the canal unstable, especially during the dry season, made conservation of forest cover in the Panama Canal watershed a key priority by the government (Schweizer 2012). As a result, the government of Panama sought to communicate the nationwide importance of the watershed to the public.

- **CRISIS EVENTS.** Crisis events were leveraged to advance restoration. Intense urbanization and industrialization between 1950 and 1990 saw the watershed population increase five-fold, from 21,000 to 113,000 inhabitants (Heckadon-Moreno et al. 1999). In 1977, increasing use of water resources by canal operations, domestic use, and agriculture—plus a severe drought—significantly reduced the water level of Gatun Lake (an artificial lake to the south of Colon that forms a major part of the Panama Canal).[4] This water crisis led to strong reactions within the Panamanian and U.S. governments for the need to improve management of the canal watershed for water protection. The government of Panama, which previously saw deforestation as progress, thereafter started creating laws that made forest clearing practices illegal (Schweizer 2012). Water shortages remain a priority and a concern for the government (La Estrella De Panama 2015b).

Enable

Several enabling conditions were in place to facilitate restoration in the canal watershed, namely:

- **POLICY CONDITIONS.** A number of laws have impacted restoration. During the 1980s, laws to curb deforestation were strongly enforced by the Panamanian army.[5] A policy called "Forest Law 13" legally protected second-growth forests older than five years. The law allowing for natural regeneration and enforcement was strict; many people in the watershed went to jail for practicing slash-and-burn agriculture, which they had previously been encouraged to practice (Schweizer 2012).

  Other laws—such as the Reforestation Incentives Law (Law No. 24, 1992),[6] the Forestry Act (Law No. 1, 1994),[7] the General Plan for the Use and Conservation and Development of the Canal Area (Law No. 21, 1997), the Certificate for Forestry Incentives (CIF, Law No. 58, 1999), and the Tax Equity Law (Law No. 6, 2005)—all contributed to creating enabling conditions for restoration. Together they provided small incentives for restoration and protected areas. The laws prohibited deforestation, therefore allowing for regeneration. Due to a combination of the afforestation and deforestation policy interventions, recent data indicates that 105,440 hectares of forest are found in national parks (namely Soberanía and Chagres), representing 67 percent of the watershed's forests (MGM Innova 2010). Restoration efforts have focused on allowing for reforestation through conserving forests inside these protected areas (allowing for natural regeneration), as well as increasing forest cover (through active planting), especially around river and creek borders (ACP 2006a).

  Land tenure policies played a critical role. The Forestry Act established that deforestation would not be considered as proof of ownership of land (Article 14, Resolución de Junta Directiva 05/1998). This is an important article because deforestation was commonly practiced among farmers in order to prove ownership of a certain piece of land or to obtain a property title. Despite all these policies, until around 2007 land tenure remained insecure. In fact, as recently as 2007, only 8 percent of the western side of the Panama Canal's 35,000 inhabitants had land title. Insecure land tenure likely slowed the implementation of restoration up to that point. Since then, more than 12,000 land titles have been secured and the remaining titles are in the processing phase. The Panama Canal Authority has invested about $4.5 million in securing tenure for local residents, which would enable restoration to be more locally driven (MGM Innova 2010).[8]

- **INSTITUTIONAL CONDITIONS.** Responsibility for restoration has been clearly defined and effective coordination is in place. A number of institutions have been created to facilitate coordinated restoration activities. For example, the 1994 Forestry Act created the National Institute of Renewable Natural Resources (INRENARE), which was later replaced by the National Environmental Authority (ANAM) in 1998. This agency was responsible for the protection and management of natural resources in Panama. In 2015, this agency was finally replaced by the creation of the Ministry of Environment. In 2000, the Panama Canal Authority created the Interagency Watershed Commission (CICH) to coordinate the activities of governmental and nongovernmental agencies with responsibility and interests in the hydrographic basin of the Panama Canal (Schweizer 2012).

  The Panama Canal watershed is the only one in the country that is managed by the Panama Canal Authority in coordination with other governmental institutes and NGOs. This fact gives it a comparative advantage over the rest of the country's watersheds, which are managed solely by the Ministry of Environment. This ministry lacks human resources and has far less financial capacity than the Panama Canal Authority (Arauz, L. 2015. pers. comm., 25 April). The Panama Canal Authority also has successfully created thirty-one local committees and six watershed advisory councils, which work in six subbasins.[9] These committees and councils have allowed for strategic and direct participation of communities living within the watershed, thus facilitating an integrated watershed management focus (El Faro 2014). The creation of these advisory councils and local committees has made an enormous difference in watershed management, since it is one of only two watersheds in the country to have these advisory bodies. The other is the Rio La Villa Watershed (Iagua 2013).

  The Panama Canal Authority not only has a legal mandate to protect the watershed, but also has a constitutional mandate (Article 316) which gave it exclusive administration rights over the watershed and first established the authority's duty to protect the water resources there (Arauz, L. 2015. pers. comm., 25 April).

Implement

Some capacity and resources were in place that helped with implementation of forest landscape restoration, including:

- **LEADERSHIP.** In the late 1970s, Dr. Frank Wadsworth was a champion forester for restoration. He believed that water shortages were the direct result of deforestation. With his narrative of "water scarcity" and the "death of the Canal," he triggered the awareness of the government, which catalyzed intervention by the state in managing the Panama Canal watershed for water conservation. An important result of this was when INRENARE (currently the Ministry of Environment) initiated a USAID-funded reforestation plan for the watershed in 1979. That same year, the U.S. government created the Panama Canal Commission to manage operations and the watershed, which drove forward restoration plans (Schweizer 2012; Wadsworth 1978). Another champion— Stanley Heckadon-Moreno—emerged later in the 1980s. Moreno was a sociologist who summarized and communicated the canal's environmental issues to the interested Panamanian public. He was very influential in creating parks and protected lands, which contributed to the restoration of the area (Carse 2014a).

- **TECHNICAL DESIGN AND KNOWLEDGE.** In recent times, the Canal Watershed has been making efforts to ensure technically grounded and climate resilient design. The Panama Canal Authority and the Ministry of Environment signed a monitoring project for the Panama Canal Watershed in 2001. Since 2002, data collection has focused on water quality, hydrological monitoring, and adaptation, as well as social and environmental indicators (ACP 2006b). From 2006, the Panama Canal Authority has provided funding and support to various projects that have developed knowledge and helped research appropriate restoration strategies. For example, Arbol University created a gene pool of native species in the Panama Canal area for the

purposes of education and scientific study. The project received a concession of 200 hectares of land degraded by the invasive grass *Saccharum spontaneum* for the purpose of restoring it to native forest (Proyecto Ciudad de Arbol. n.d). The Panama Canal Authority also has supported and funded the Agua Salud Project. The project is an experiment that seeks to understand and quantify the diverse set of ecological, social, and economic services provided by tropical forests in the Panama Canal watershed. Its primary research is on the effects of various land uses (forest, pasture, and invasive grass) on hydrological services. It is a collaboration among the Smithsonian Tropical Research Institute, the Panama Canal Authority, Panama's Ministry of Environment, and the HSBC Climate Partnership. Since 2007, the project has planted more than 150,000 trees (Smithsonian Tropical Research Institute n.d.).

- **KNOWLEDGE.** Restoration "know-how" exists in the watershed and is transferred via extension services. For instance, the Panama Canal Authority has provided training for farmers on financial management, forestry and agroforestry, seedling planting and maintenance, surveying and mapping, community organization, and capacity building. This has been supported by livelihood alternatives such as selling seedlings and planting materials from restoration operations (MGM Innova 2010). In order to guarantee the suitability of restoration projects, restoration plans need to be developed by forestry professionals and presented to the Ministry of Environment for approval (Schweizer 2012).

- **FINANCING AND INCENTIVES.** Positive incentives and funds for restoration now outweigh negative incentives. Over time, various laws were created to establish financial incentives for restoration, but many were later repealed. Table 1 identifies the laws that created or otherwise supported incentives for restoration in the Panama Canal watershed.

Table 1 | **Laws that impacted incentives for restoration in the Panama Canal Watershed**

LAW	DATE	INCENTIVE	DATE TERMINATED	IMPACT
Reforestation Incentives Law (Law No. 24)	1992	Farms that exclusively use more than 75 percent of their land for reforestation are exempt from property and transfer taxes, as long as they are registered with the Ministry of Environment.	This incentive was repealed through the Reforestation Incentives Law in 2005 (Law 6). The reasoning behind this was to avoid abuses in the use of tax incentives; however, this resulted in a decreased participation of local investors.	Assumed largely unsuccessful since repealed.
The Immigration Law	1992	The granting of status* to foreign investors who direct a minimum of U.S. $60,000 into reforestation projects (MSPSNM 2009), as well as modified tax breaks from Law 24 (MSPSNM n.d.).		Considered successful in stimulating reforestation activities; between 1992 and 2000, the private sector planted 31,000 hectares nationally, but it is not clear how many trees survived or what proportion occurred within the Panama Canal watershed (FAO 2002).
The Reforestation Incentives Law (Law 6)	2005	Income tax deductions and forestry investor visas		Although many of the incentives for reforestation identified in Law No. 24 were repealed in 2005, there are still some considerable incentives. For example, restoration products can be exempt from taxation based on certain conditions.**
The Certificate for Forestry Incentives (CIF) (Law No. 58)	1999	Designed to financially support small (subsistence) agricultural producers, with funds administered by the Bank of Agricultural Development*** (FAO 2002). ****		While this law helped to extend reforestation incentives to poorer producers, it was designed for a very narrow group (subsistence farmers) and did not provide for middle class landowners or small farmers (non-subsistence) who could otherwise contribute to reforestation (FAO 2002).

Notes: * There is a minimum investment criteria for foreign companies operating in Panama—this extends to restoration investments. ** Article 4 of Law 6, 2005 establishes that "Utilities of natural persons or companies, derived exclusively from the marketing of products extracted from forest plantations, and whose establishment is performed within thirteen (13) years from the enactment of this Act, shall be exempt from payment of income tax, provided that the farms are registered in the Forest Registry of the National Environmental Authority." *** Law No. 58 of 1999. Online at: <http://www.asamblea.gob.pa/legispan/Pdf_LEY/1990_LEY/1999_LEY/1999_DOC/1999_058_LEY.doc>. **** Recipients must have landholdings no larger than 50 hectares and dedicate no more than 5 hectares to reforestation. Within the law, 80 percent of the cost of reforestation and maintenance is provided by the state for the first 3 years, and the remaining 20 percent is paid by the landowner.

In order to promote active participation of local communities for long-term maintenance and protection of restoration project activities, in 2010 the Panama Canal Authority created the Environmental Economic Incentives Program,[10] a 20-year program covering 20,000 hectares in the canal watershed. The Panama Canal Authority invested an estimated 20 million balboas[11] (U.S. $20 million) over the duration of the program in an effort to protect existing forest, recover degraded areas, and promote commercial reforestation. Participants were paid an economic incentive annually to cover the costs of forest establishment and maintenance for three years between 2010 and 2013 (MGM Innova 2010). It consists of six modalities (Table 2).

Donor funding was key to making restoration in the Panama watershed a success. The World Bank, for instance, was instrumental in assisting the government of Panama to develop the overall strategy for the management of rural lands in the Panama Canal watershed (World Bank 2004). Other donors and agencies—such as the Smithsonian Institution, USAID, and HSBC—have provided significant funding to assist in restoration activities such as performance monitoring systems (see below).

- **FEEDBACK.** Effective performance monitoring and evaluation systems are in place. The Meteorology and Hydrology Branch of the Panama Canal Commission established the Agua Salud research site in the early 1980s with the objective of determining whether flood peaks were reduced in forested landscapes compared to deforested landscapes. Three weirs were installed and data has been collected (Stallard et al. 2010).[12]

  In 2006, the Smithsonian Tropical Research Institute and the Republic of Panama's Environmental Authority created the Panama Canal Watershed Monitoring Program[13] with support from USAID (Ibáñez et al. 2002). The program aims to improve understanding of ecosystem services provided by tropical watersheds (Ogden et al. 2011).[14] It has provided critical socioeconomic, biophysical, and hydrological information via field visits and satellite imagery, providing feedback that can improve restoration project designs. Research found that even in the largest storms, runoff in the pasture and rural land-cover mosaic was 25 to 50 percent greater than in the forest, demonstrating a major ecosystem service from the perspective of the Panama Canal Authority and other watershed users (Ogden et al. 2013).

Table 2 | **Modalities of the Panamanian Environmental Economic Incentives Program**

RESTORATION TYPE	FINANCING OBJECTIVE	AMOUNT (BALBOAS)
Continuous areas	To recover continuous forest areas, now fragmented, particularly patches currently covered by *Saccharum spontaneum*	2,500 per ha over 2 years
Agroforestry	To engage small and medium agricultural producers (1–30 ha) by promoting agroforestry through the integration of forest species and agricultural species such as shade-grown coffee and fruit trees	1,900 per ha over 3 years
Silvopastoralism	To protect forest corridors by engaging cattle farmers (5–50 ha) to use living fences and trees as windbreaks	1,129 per ha over 19 months
Commercial reforestation	To use soils with low agricultural productivity for the timber industry and its derivatives, thus discouraging felling of natural forest	5,000 per ha over 4 years
Natural regeneration*	No data	No data
Forest enrichment	To plant native species—which increase the value of the forest—primarily in national parks and degraded lands	1,600 per ha over 2 years

Source: Departamento de Ambiente, Agua y Energía. 2010.
Note: * For the first two years of the program (2009–10), there was no natural regeneration. In the five-year plan, 500 hectares were programmed for natural regeneration from 2011 to 2013. The study was conducted in 2010.

LOOKING FORWARD

According to reports, 18,000 hectares of forest to date have been restored, but much more could be restored in the watershed. Through the 2000s, forest cover increased in Panama. Data from 2008 suggest that 6,000 hectares of the Panama Canal have been planted with forest plantations (Stefanski et al. 2015). However, more recent data suggest that the earlier trend in reforestation in Panama has been reversed (Hansen et al. 2013). The Panama Canal Authority has initiated a joint nationwide project along with the Ministry of Environment to reforest 1 million hectares (Telemetro 2015). Some of the key challenges for improving and scaling up effective watershed development in Panama include:

- **ECOLOGICAL CONDITIONS.** Ecological conditions are a challenge for restoration in the Panama Canal watershed. Plants that impede restoration create five barriers to natural regeneration: exotic invasive grass competition (*Saccharum spontaneum*), lack of quality seed, limitations with seed dispersal, fire, and soil nutrient deficiency (Hooper et al. 2005). Invasive grass poses significant challenges to restoration areas because they suppress native species (Ogden et al. 2011) and increase the likelihood of wild fire because it is highly flammable. Areas that had been colonized by invasive grasses had poor seed banks, therefore species diversity is limited. Due to increases in fire, the soil is less nutrient rich, reducing potential for native seedling growth (Hooper et al. 2005).

- **MARKET CONDITIONS.** There is an absence of well-organized farmers' groups or networks to provide access to information regarding market opportunities for forest products and non-timber forest products from restored areas (MGM Innova 2010).

- **FINANCIAL INCENTIVES.** There is a lack of access to credit for many smallholders, prohibiting them from investing in seeds or necessary equipment (MGM Innova 2010).

- **SOCIAL CONDITIONS.** Initially harsh penalties such as imprisonment were levied on farmers for land conversion, which raises human rights concerns. In recent times, local communities in the Panama Canal watershed have expressed frustration with the limited involvement of local communities in restoration projects (Schweizer 2012). This is due to restoration efforts being focused largely on conservation and protection rather than community participation (MGM Innova 2010). More recently, communities have expressed concern regarding extractive industries inside the Panama Canal watershed—specifically near the Chagres National Park—that are causing deforestation, therefore counteracting restoration efforts (La Estrella de Panama 2015a). Uncertainty remains over the net benefits of reforestation, in particular regarding the relative net benefits of profit-maximizing timber rotations compared to the net present value of incumbent land uses such as cattle ranching (Stanski et al. 2015).

- **TECHNICAL DESIGN AND KNOWLEDGE.** Farmers and communities lack the necessary skills for commercial timber or agroforestry plantations, access to quality seeds, and technical knowledge to further scale up restoration efforts (MGM Innova 2010).[15]

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ENDNOTES

1. Estimates of the area of The Panama Canal watershed vary between 279,000 hectares (ACP 2006a; Ibanez et al. 2002), and 375,000 hectares (MGM Innova 2010).

2. Clearing was not a linear process. It was followed by natural regeneration, and then followed by clearing. Changes were linked to large construction projects and agricultural development (Carse, A. 2015. pers. comm., 29 October).

3. There were environmental provisions related to watershed management in the 1977 treaties between the U.S. and Panama that began the transfer of the Canal and Canal Zone to Panama between 1979 and 1999 (Carse, A. 2015. pers. comm., 29 October).

4. Droughts at this time, as well as the early 1980s and late 1990s, are often associated with El Niño events (Glynn 1990).

5. Strong military enforcement of the law was not encouraged, but was part of the historical reality of the governance process in Panama at the time.

6. Several of this law's most important incentives were eliminated in 2005.

7. Law No. 1 of 1994. Online at: <http://www.anam.gob.pa/images/stories/normasambientales/Ley_1_de_3_de_Febrero_de_1994.pdf>

8. Data for the western side is not available. However, the western side is a much smaller area. The eastern side is estimated at 339,638 hectares (Dale et al. 2010), so the western side is therefore approximately 35,300 hectares. It may be more populated and have a smaller forested area.

9. The six sub-basins are: Hules, Tinajones and Caño Quebrado; Chagres-Alajuela; TransístmicoColón Corridor; Chilibre-Chilibrillo; Pescado, Cañito and Paja; Cirí Grande and Trinidad.

10. PIEA (Programa de Incentivos Economicos Ambientales)

11. Panama's currency, the balboa, circulates alongside the U.S. dollar at a fixed exchange rate of U.S. $1.00 = B/. 1.00.

12. However, funding ended in 1983. The study was reactivated from 1997 to 1999. In 2007, the project was awarded five years of funding from the HSBC Climate Partnership, including $4M–$5M for the Agua Salud Project.

13. Proyecto de Monitoreo de la Cuenca del Canal (PMCC)

14. The Panama Canal Authority also has a monitoring program for suspended sediments in ten stations located in major rivers of the PCW. The information contained in this yearbook is the basis for the calculation and prediction of water storage capacity of reservoirs (ACP 2005). This information feeds into the research to gauge how important forests are in the watershed.

15. Forest Law 13 protects second-growth older than 5 years.

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