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WATER FUNDS: FINANCING NATURE'S ABILITY TO PROTECT WATER SUPPLIES

A reliable supply of clean, safe water is essential to life, agriculture, and business. Nature plays an important role in maintaining the flow and purity of water. Human activities often degrade the quality and/or quantity of water flowing to downstream users, whereas maintenance of functioning ecosystems can help provide a clean, reliable supply of water for downstream water users. Water funds are a way for downstream water users to preserve their water supply by paying to restore and conserve natural ecosystems.

ECOSYSTEM SERVICES AND WATER

Just 2.5 percent of the water on earth is fresh, and two-thirds of that is frozen in glaciers and ice caps. Of all the water on earth, only 0.77 percent is held in lakes, rivers, underground aquifers, soil, plant life, and the atmosphere.

Ecosystem Services

The term "ecosystem services" refers to "the conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfill human life."[1] Freshwater systems, such as rivers, lakes, aquifers, and wetlands, provide three basic types of ecosystem services. They are a source of water for uses such as drinking, cooking, irrigation, and manufacturing processes. They supply goods such as fish and waterfowl. They also provide

[1] Gretchen Daily, "Introduction: What Are Ecosystem Services," in Gretchen Daily, ed. *Nature's Services: Societal Dependence on Natural Ecosystems*, (Washington, D.C.: Island Press, 1997), p. 198.

David Hoyt and Professors Erica Plambeck and Gretchen Daily prepared this case as the basis for class discussion rather than to illustrate either effective or ineffective handling of an administrative situation.

services such as flood control, transportation, recreation, power generation, and protection of water quality.[2]
Human activities can threaten the benefits provided by freshwater ecosystems in many ways. For instance, building dams changes the timing and quantity of river flows, changes water temperature, alters nutrient and sediment transport in river systems, and interferes with fish migration. Deforestation reduces the ability for underground aquifers to recharge, enhances erosion, filling rivers and lakes with silt, and reduces natural flood control. Grazing livestock near streams degrades stream banks, increasing erosion and sediment flow into streams, as well as introducing microbes and nutrients into the streams. Draining wetlands reduces natural flood control, habitat for fish and waterfowl, and natural water filtration.[3] (See **Exhibit 1** for a more complete description of human threats to freshwater ecosystem services.)

Payment for Ecosystem Services

In recent years, the economic value of ecosystem services has begun to be recognized, and a number of "payment for ecosystem services" (PES) programs have been instituted. Many of these have been government programs. For instance, since 1997, the government of Costa Rica has paid landowners to conserve and restore forest in order to sequester carbon, and to protect watersheds, biodiversity, and scenic beauty.[4]

China has implemented PES programs to restore ecosystems and reduce erosion, retain water, and control floods. In addition to paying farmers and loggers to restore damage, the programs also compensate them to engage in ecologically beneficial forestry and farming practices.[5]

Another example of government-supported PES is watershed preservation by New York City. From 1997 to 2010, the city spent $541 million to preserve more than 110,000 acres in the watersheds that supply its drinking water. This investment allowed New York to avoid building a water filtration plant estimated to cost about $10 billion.[6]

WATER FUNDS

In addition to situations in which governments pay for ecosystem services, groups of public and private stakeholders can combine to fund ecosystem projects that further their interests. This is increasingly happening in the quest to protect water quality and quantity. These "water funds" are long-term financial mechanisms that restore and preserve natural ecosystems that supply fresh water.

These funds pay for projects that preserve or restore natural ecosystems' ability to filter and store water, reducing the need for expensive treatment facilities and dams.

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[2] Sandra Postel and Stephen Carpenter, "Freshwater Ecosystem Services," in Gretchen Daily, ed. *Nature's Services: Societal Dependence on Natural Ecosystems*, (Washington, D.C.: Island Press, 1997), p. 198.
[3] Ibid., p. 208.
[4] Gretchen Daily, et al., "The Value of Nature and the Nature of Value," *Science*, July 21, 2000, p. 1.
[5] Jianguo Liu, et al., "Ecological and Socioeconomic Effects of China's Policies for Ecosystem Services," *Proceedings of the National Academy of Sciences*, July 15, 2008, p. 9477.
[6] "NYC Buys More Upstate Watershed Land," Crain's New York Business.com, July 19, 2010.

Water Fund Components

Several components have been identified as necessary for an effective water fund:[7]

1. An ecosystem services mechanism, including nature and people. For instance, in watersheds in the northern Andes, high altitude grasslands (páramo) and forests are important for water filtering and storage, but are subject to alteration by upstream rural communities of farmers and ranchers.

2. A sustainable financial mechanism, with transparent management. Water funds have often been established in the form of trusts, in which a board had the fiduciary responsibility to manage the funds to achieve a set of specified benefits. Water fund agreements have generally been of long duration—more than 80 years—in recognition of the fact that ecosystem projects must be sustained over the long term in order to provide the desired services.

3. An institutional mechanism to organize public and private fund participants. Water funds have typically been governed by a board of directors, with each major contributor to the fund receiving a board seat.

4. A set of specific conservation activities that the fund could finance to generate benefits for both upstream communities and downstream water users. These have typically been in the form of protection, reforestation, restoration, silvopastoral practices, and fencing, and are described below.

5. A system of accountability to ensure that services are delivered and natural ecosystems protected. As of 2010, water funds could account for money spent and the progress of projects. However, methods of monitoring the effectiveness of water fund projects in improving water quality and flow were still being developed.

6. Stakeholders with the financial means and interest to participate. Water fund investors in various funds active in 2010 included: public agencies, such as water utilities; private companies such as beer companies and bottled water companies; agricultural associations; environmental organizations; and citizens, either through voluntary donations on their water bills, or through taxes and fees. In locations where downstream stakeholders are poor (as in many African watersheds), any funding for ecosystem services must come from private donors or development funds.

A set of enabling conditions for water funds is provided in **Exhibit 2**.

The Challenge of Uncertainty Regarding Effectiveness

A challenge faced by water funds has been measuring outcomes, and demonstrating that the benefits achieved justify the investment. Much of the justification has related to avoided costs,

[7] Based on Rebecca Goldman, Silvia Benitez, Alejandro Calvache, and Aurelio Ramos, "Water Funds: Protecting Watersheds for Nature and People," The Nature Conservancy, Arlington, VA, 2010, p. 6. The sixth component was added by the case author.

as demonstrated by New York City's purchase of watershed in order to avoid building a treatment plant. Calculating the economic benefit of a particular conservation project was a very inexact science in 2010. Water funds could tell stakeholders that they had installed a specific amount of fencing, but could not yet answer the question of how much benefit this was providing to the stakeholders, and how soon the benefits would be achieved.

Scientists were researching the effectiveness of water fund projects at a micro-scale, studying the impact of various interventions (such as fencing) on parameters such as sedimentation and bacteria levels. Taking this to the level of the overall impact on the downstream users was a more difficult task, as many factors influenced water quality and quantity, and it was difficult to definitively attribute changes to water fund projects—particularly during the fund's early phases, when conservation projects impacted only a small part of the watershed.

This uncertainty contrasted with engineering solutions—engineers could state with great confidence how much a treatment plant would cost, the quality of water after treatment, and when the benefits of the plant would be enjoyed.

The Challenge of Diverse Stakeholder Objectives

A second challenge for water funds has been that different stakeholders have different objectives. For example, a brewery is interested in water quality, a farm's priority may be dry season water flow, and a conservation organization's priority might be preserving biodiversity. Each water fund had a limited amount of money to invest, and had to make tradeoffs between possible conservation projects in order to address the needs of its various stakeholders.

Water Fund Activities

Water funds can undertake a wide range of activities to meet their various ecosystem services objectives. To illustrate, we will consider funds created in the northern Andes watersheds of Colombia, Peru, and Ecuador. Much of the natural ecosystem in this area is forest and páramo (high altitude grasslands).

Páramo and forests are both important to water quality and flow, and both provide effective erosion control and water retention. When rain falls on bare ground, it flows rapidly, eroding the soil and carrying sediments to the nearest river or stream. However, roots of páramo and trees bind soil, retain water during wet periods and release it during dry seasons. They help water seep into the ground, where it will replenish rivers, streams, and lakes during dry periods, rather than being wasted as runoff during storms. Forests and grasslands are effective in capturing water from fog. They are also important habitats for supporting the region's biodiversity.

These ecosystem services have been threatened when forests and páramo were converted to ranch or farmland. This led downstream water users, governments, and conservation organizations to consider developing water funds. Conservation activities included fencing, reforestation, restoration, silvopastoral practices, and enforcement of protected areas. (**Exhibit 3** provides representative impacts of various activities on different terrains.)

Fencing

Fencing to keep cattle and other livestock out of streams and protect stream banks was a highly effective activity financed by water funds to prevent erosion and to filter water runoff.[8] Fencing also kept livestock out of forests, grasslands, and other environmentally sensitive areas. In areas served by water funds, fencing was often in the form of "live fencing," in which trees were planted, and barbed wire strung between the trees. Use of trees provided environmental benefits compared to conventional fence posts, as they captured water and grew roots that bind soil. Live fences also lasted longer, and required less maintenance than conventional fences.

Vegetation on stream banks prevented erosion, and trapped sediments that might be picked up by rainwater and otherwise transported to the stream. When livestock were allowed access to streams, they damaged vegetation and loosened soil on stream banks, which eroded and sent sediment into the river system. Sediment degraded drinking water quality, necessitating costly treatment facilities. Sediments also reduced reservoir capacity, requiring dredging.

Vegetation on stream banks filtered nitrates and phosphates from fertilizer used in agriculture and from the waste of grazing animals. When the vegetation was removed, these chemicals contaminated the stream, necessitating treatment downstream. Livestock contaminated the river and stream water with nutrients and bacteria. This harmed downstream users and was also unhealthy for the livestock, which could acquire disease from standing in, and drinking, contaminated water.

Reforestation and Restoration

Forests and natural vegetation could be degraded by logging, conversion to agriculture or pasture, building of roads or trails, collection of firewood, or other human activities. As described above, forests and natural vegetation were important for decreasing erosion and improving water retention.

Two activities that reversed these negative impacts were reforestation (restoring forest from in heavily deforested areas), and restoration (restoring native vegetation to degraded areas, which could include tree planting or restoring native understory plants).[9] The effect of this was seen in the case of the Poza Honda Reservoir in Ecuador, which was built in 1971. Deforestation in the watershed feeding the reservoir resulted in sediment flow that would have left the reservoir useless well before its planned 50-year lifespan. A reforestation program was implemented that extended the reservoir's lifetime to its planned term. The program cost just $1.8 million, generating an estimated $30 million in benefits.[10]

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[8] Cattle with restricted access to rivers and streams must be given alternate sources of water. This is typically beneficial to the cattle, as a dedicated, clean drinking water supply is healthier than drinking out of a contaminated river.

[9] These definitions are based on usage by The Nature Conservancy and the Natural Capital Project. While reforestation is more commonly defined as replanting trees in deforested areas, in this case study we will use the TNC definitions.

[10] Norman Myers, "The World's Forests and Their Ecosystem Services," in Daily, op. cit., p. 281.

Silvopastoral Systems

Without careful management, livestock degraded the land they grazed on. When the land was degraded, it could support fewer animals, thus decreasing the rancher's economic efficiency. This led to a cycle of expansion of grazing land, and degradation of the natural ecosystem.

Converting degraded land into efficient "silvopastoral systems," allowing livestock to be raised without degrading the environment, required several investments. First, fencing (preferably live fencing) was installed to keep grazing animals out of environmentally sensitive areas. Second, the grazing land was improved, for instance, by planting trees that boosted water retention and forage growth in the pasture. When this was done, the pasturelands could be more productive supporting cattle despite the cattle having access to less land.

Ranchers often wanted to develop silvopastoral systems, but lacked training and investment capital. In addition, the transition to silvopastoral systems took at least a year to accomplish. Water funds could provide the required capital, as well as training and ongoing support.

Preservation of Protected Areas

Some watershed land was protected as part of a national park or other area of restricted use. However, these were often underfunded, and an important goal of water funds was to ensure the long-term financial stability of these protected areas.

Designation did not prevent damage from human and animal activity. Local villagers could cut down trees for firewood or other uses. Cattle could stray into protected areas to graze, or drink from streams, thus degrading grassland and stream banks. Water funds were able to hire guards to help protect these areas from unlawful and damaging use. These guards were typically hired from the local communities, bringing money into the communities and helping align them with water fund objectives.

Modeling Ecosystems and Conservation Activities

Deciding which set of conservation activities would be most effective for a given water fund depended on the landscape, threats, and objectives of the fund. Technical experts advised water fund boards on these issues, but optimization was impossible without detailed computer models. The Natural Capital Project[11] developed a computerized modeling tool that could be used to determine how best to achieve the fund's conservation goals. This tool, called InVEST (Integrated Valuation of Ecosystem Services and Trade-offs) divided the landscape into many parcels. Each parcel was defined based on the vegetation, soil depth, current use, distance to the nearest water body, elevation, slope, and other important parameters. Conservation activities, such as reforestation, restoration, fencing, or silvopastoral practices, were assigned to parcels based on past behavior of landowners, and previous successful investments by water fund investors. (See **Exhibit 4** for sample InVEST maps.)

The model helped determine the conservation projects that would optimize ecosystem service returns, given the constraints of the fund's budget. The optimization was displayed in the form

[11] The Natural Capital Project is a partnership of TNC, Stanford University's Woods Institute for the Environment, the World Wildlife Fund, and the University of Minnesota Institute on the Environment.

of a map, showing the sectors that were impacted by various potential activities. The model also generated trade-off curves that showed relationships between alternative uses—for instance, how much timber could be harvested before causing serious financial or resource damage to others (such as flood damage, loss of hydroelectric power, or habitat needed to sustain biodiversity).

Involvement of Upstream Communities

Projects to protect or restore watersheds could not be successful without the active involvement of the upstream communities that implemented the projects. These communities often obtained tangible benefits directly from the conservation projects. For instance, fencing to prevent livestock from using streams improved water quality for the ranchers, and also improved the health of the livestock. However, upstream communities often received other benefits as part of water fund projects. For instance, the water fund might conduct education programs to help farmers and ranchers increase productivity.

Water funds also provided farmers and ranchers with sustainable incremental sources of income. In the northern Andes, water funds provided benefits to upstream communities such as providing seeds and training to families to grow vegetables that improved the family's nutrition and food security, or giving them guinea pigs to farm (guinea pigs are a common food source in the Andes).

Many water funds in operation or under development in 2010 did not make ongoing cash payments to farmers and ranchers participating in conservation projects. This raised a question about long-term sustainability and the potential penalties for participants who failed to follow through with their commitments—such as a rancher who removed a fence to increase the grazing space and number of cattle on his ranch. Rebecca Goldman, at the time The Nature Conservancy's primary scientist working on water funds, said, "What's to keep those people from tearing up their fences in two years? We don't have a credible threat of enforcement."[12] As of 2010, however, the funds had not seen problems due to lack of ongoing cooperation.

A water fund in Brazil, however, made monthly payments to upstream participants as a way of providing continual compensation—payments that could be terminated if the conservation projects were not sustained by the farmer or rancher. Although there had been no problems as of the end of 2010, compensation opened the possibility for water users being held hostage to monetary demands from upstream communities.

Examples of Water Funds

By 2010, water funds were planned or already operating in many parts of the world. In Santa Fe, New Mexico, the U.S. Forest service joined with the city's water utility to provide fire management for the forested watershed that supplied the city. The investment of about $200,000

[12] Interview with the author (Hoyt).

per year in management was estimated to prevent water-supply related costs of about $22 million that would have resulted from a single 7,000-acre fire.[13]

In 2010, there were 13 water fund projects either in operation or development in the northern Andes (see **Exhibit 5**). The oldest, established in 2000, was in Quito, Ecuador. Stakeholders included the city, the Quito water utility, an electric company, a beer company, a water bottling company, and environmental organizations. The water and electric companies each made annual contributions based on their sales or profits. The Quito fund used contributed money to build an endowment, with payments for ecosystem services made from income generated by the endowment. This limited the money that could be spent during the fund's early years, when the endowment was small. Later funds typically used money from early contributions both to fund projects and to build an endowment.

Two other funds in the northern Andes served Bogotá, Colombia, and the East Cauca Valley of Colombia. The largest stakeholder of the East Cauca Valley fund, established in early 2010, was a sugarcane growers' association that was interested in preserving the páramo grasslands high in the watershed in order to improve dry season water flow. The focus of the Bogotá fund, also established in early 2010, was to reduce sediment in the city's water supply, thereby avoiding the need to add treatment facilities. The largest corporate stakeholders in this fund were the city's water utility and a local beer company that required a steady flow of high-quality water.

STUDY QUESTIONS

1. What metrics should one use to evaluate the success of a water fund? What are the merits of, and potential issues with, each metric?
2. What are the relative merits of a water fund model that pays upstream communities on an ongoing basis, versus making initial investments but no cash payments?
3. What other ecosystem services could the water fund model be used for? Which ones are more conducive to this model, and why?
4. Imagine starting an ecosystem service fund in an area where you have lived or worked. In addition to the sorts of investors mentioned in the case, who else might be interested? What would their incentives be for participating in your fund? What time horizon would each investor take?

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[13] These costs came from dredging rivers of soot and sediment, and from accessing an alternative water source while the primary source was unavailable. Data from: Laura McCarthy, "Financial Management Plan" chapter of *Santa Fe Municipal Watershed Plan, 2010-2029,* February 19, 2009.

Exhibit 1
Human Threats to Aquatic Ecosystem Services

Human Activity	Impact on Ecosystem
Dam Construction	Alters timing and quantity of river flows, water temperature, nutrient and sediment transport, delta replenishment. Blocks fish migration. Harms habitat, fisheries, and maintenance of deltas.
Dike and Levee Construction	Destroys water connection between river and floodplain habitat. Harms habitat, fisheries, natural floodplain fertility, natural flood control.
River Diversions	Depletes stream flows. Harms habitat, fisheries, recreation, pollutant dilution, hydropower, transportation.
Draining Wetlands	Eliminates key component of aquatic environment. Damages natural flood control, habitat for fisheries and waterfowl, recreation, and natural water filtration.
Deforestation	Alters water runoff patterns, inhibits natural groundwater recharge, fills water bodies with silt. Damages water quality and quantity, fish and wildlife habitat, and flood control.
Uncontrolled Pollution	Reduces water quality. Harms water supply, habitat, fisheries, and recreation.
Overharvesting	Depletes living resources. Damages fisheries, waterfowl, other living resources.
Introduction of Non-Native Species	Eliminates native species, alters production and nutrient cycling. Harms fisheries, waterfowl, water quality, habitat.
Release of Metals and Acid-Forming Pollutants	Alters chemistry of rivers and lakes. Harms habitat, fisheries, and recreation.
Greenhouse Gas Emissions	Potential for dramatic changes to runoff patterns from increase in temperature and changes in rainfall. Harms water supply, hydropower, transportation, habitat, pollution dilution, recreation, fisheries, and flood control.
Population and Consumption Growth	Increases pressure to dam and divert water, drain wetlands. Increases water pollution, acid rain, potential for climate change. Harms virtually all aquatic ecosystem services.

Source: Adapted from Postel and Carpenter in *Nature's Services*, op. cit., p. 208.

Exhibit 2
Conditions That Enable Water Funds

Based on their experience developing water funds, primarily in South America, staff members from The Nature Conservancy developed the following list of eight conditions that enable water funds to succeed:

- Strong leadership. There needs to be a local leader that can mobilize the interests of the various stakeholders, including water users, local governments, and the private sector.
- Several water users sharing the same watershed. If there is only one water user (or one dominant user), that user can undertake conservation activities on its own, as seen in the case of New York City. When there are multiple users, cooperative efforts through a water fund may be needed.
- Clear and tangible image of where water comes from. Water users must understand the source of their water, so they will be able to identify threats and opportunities for benefit, as well as activities that will enhance water quantity and quality.
- Water is being used from surface flows, rather than wells. Modeling of ground water flows is difficult, so it is easier to focus on surface flows that can be more systematically studied and monitored to ensure that conservation actions produce the anticipated benefits.
- Engaging major water users from the start. A water fund is more likely to be successful if the major users are involved in early feasibility studies, rather than being asked for money late in the process.
- Existing work in the watershed. If conservation work is already underway in a watershed, both upstream and downstream communities are more likely to perceive the benefits of a water fund, and be willing to participate.
- There is some threat to water quality and/or quantity that has negative consequences for water fund participants. Water fund participants need a reason to invest in the fund. They need to view existing practices as damaging to their future, and conservation activities as important to securing essential water supplies.
- Transaction costs are relatively low. It would be difficult to establish a water fund in an environment with a complex network of organizations involved in water distribution and regulation. Also, water funds are more practical when there are few large downstream users with significant financial dependence on the water supply. In this situation, transaction costs are relatively low in organizing and operating the fund.

Source: Based on a draft list of conditions developed by Silvia Benitez, Alejandro Calvache, Rebecca Goldman, and Aurelio Ramos at TNC.

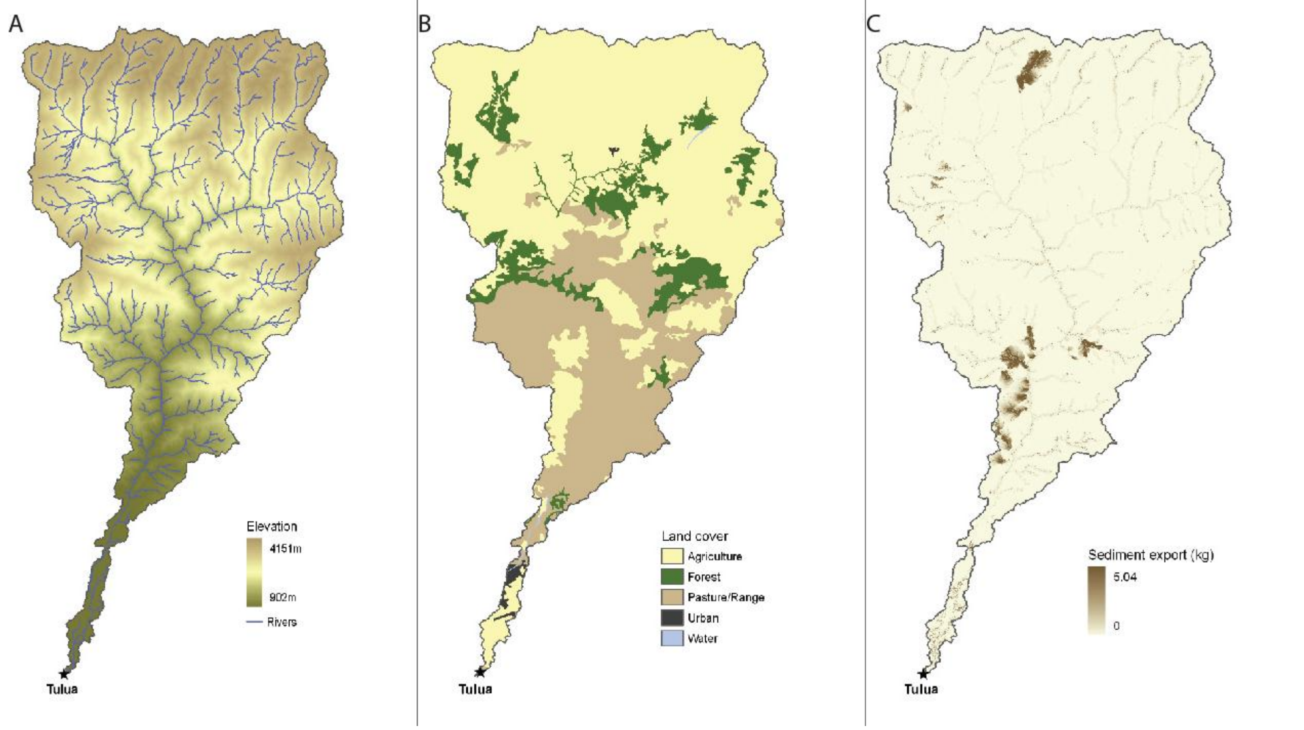
Exhibit 3
Impact of Conservation Activities on Erosion and Water Yield

Approximate impact of various activities on water yield and erosion. This data is directional in nature, and is intended only to represent the relative impact of the activities. The actual impact depends on the precise nature of the terrain and other considerations. The "condition" column refers to the terrain. "Flat upper" refers to páramo high in the watershed. "Steep mid" refers to heavily sloped terrain between the páramo and cities. "Flat lower" represents terrain close to the city at the lower portion of the watershed.

Activity	Condition	Water Yield (mm/yr)	Erosion (tons/yr)
Silvopastoral	Flat upper	-700	-0.001
	Steep mid	60	-0.01
	Flat lower	-200	-0.005
Reforestation	Flat upper	-800	-0.005
	Steep mid	-300	-0.05
	Flat lower	-200	-0.01
Fencing	Flat upper	-600	-0.01
	Steep mid	-200	-0.1
	Flat lower	800	-0.05
Preservation	Flat upper	-800	-0.005
	Steep mid	-300	-0.05
	Flat lower	-200	-0.01

Source: Estimates from Natural Capital Project, 2010.

Exhibit 4
InVEST Optimization Map



Typical watershed involved in Andean water funds. The digital elevation model (A) emphasizes the pattern of relatively flat high elevation areas at a river's headwaters followed by a steep intermediate area mid-watershed and a flat lowland area closest to the city. In this representative case, all beneficiaries (members of the water fund) are located in the city of Tulua. The land use and land cover map (B) shows a simplified view of the range of management options used in a typical landscape and (C) shows the amount of erosion (kg/pixel/yr) associated with the current land use situation (B).

Source: Natural Capital Project 2010.

Exhibit 5
Water Funds in the Northern Andes, 2010

Water funds in operation or planning in the Northern Andes in 2010.

Watershed or Associated City	Area in Water Fund (hectares)	People Benefitting (2008)	Creation Date	Funds (2010) ($ 000)	Anticipated Funds in 2016 ($ 000)
Quito, Ecuador (FONAG)	500,000	2,093,000	2000	6,500	11,500
Zamora, Ecuador	30,000	25,000	2006	36	2,600
Amaluza, Ecuador	20,000	15,000	2008	6	1,300
Paute, Ecuador	300,000	800,000	2008	490	4,400
Ambato, Ecuador	526,000	350,000	2008	460	1,100
East Cauca Valley, Colombia ("Water for Life")	125,000	920,000	2009	1,800	7,100
Bogotá, Colombia	150,000	6,840,000	2009	1,500	8,900
Medellin, Colombia	116,000	2,700,000	Feasibility studies underway	TBD	TBD
Cartagena, Colombia	12,000	892,500	In design	220	2,200
Cali, Colombia	206,000	2,100,000	In design	TBD	TBD
Sierra Nevada de Santa Maria, Colombia	400,000	600,000	Initial phases of development	TBD	TBD
Catamayo-chira, Ecuador-Peru	92,000	TBD	Initial phases of development	TBD	TBD
Puerto Lopez, Ecuador	60,000	20,000	Initial phases of development	TBD	TBD

Source: Goldman, et al., "Water Funds," op. cit., p. 5.