

An Ecological Study of Ecuador's Intag Region:

The Environmental Impacts and Potential Rewards of Mining

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The authors are responsible for the content of this report.

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Table of Abbreviations

CO ₂	Carbon Dioxide
DOP	Date of Production
EE	Earth Economics
EIS	Environmental Impact Study
ESV	Ecosystem Service Valuation
GDP	Gross Domestic Product
GHGs	Greenhouse Gases
GIS	Geographic Information System
Ha	Hectare
IUCN	International Union for Conservation of Nature
LME	London Metal Exchange
M	Meter
NGO	Non-governmental Organization
PES	Payment for Ecosystem Services
PV	Present Value
Rcs	Refining Charges
REDD	Reducing Emissions from Deforestation and Forest Degradation
ROI	Return on Investment
Tcs	Treatment Charges

Executive Summary

The Intag region of Ecuador spans two of the world's 34 most biologically important areas. With diminishing oil reserves and an increasing demand for minerals from emerging economies, leaders in the provincial and national government are under tremendous pressure to expand state incomes through natural resource extraction.

Notably, a report carried out by the Japanese International Co-operation Agency (JICA) in 1998 estimates that Intag may have as much as 318 million tons of copper ore in the ground. Copper is in high demand worldwide and offers an attractive opportunity to increase national incomes. Yet copper mining has significant downstream landscape and social costs which have often been excluded from mining economic analysis. More importantly, the majority of Intag's population have worked over a decade to develop and implement an alternative and prosperous vision of the region's economy, which does not include mining.

The following study examines the economic value of the region's unique natural goods, which include water, timber, and agricultural products, as well as the services such as flood protection, drinking water filtration, local weather and climate stability, aesthetic value, and recreation. The objective is to examine the viability of two development pathways: copper extraction and alternative eco-development. We also identify options for pursuing economic prosperity with practical development strategies that live within the physical limits of the local and global ecosystems, and are sustainable.

The ecosystem services examined in this report include climate stability, flood protection, drinking water purification and supply, wildlife habitat, pollination, soil erosion control, soil formation, biological control, nutrient cycling, raw materials, waste treatment, food production as well as aesthetic and recreational values. The forests of Intag include



lower montane humid forests, pre-montane forests and montane very humid forests. The seven land-cover types analyzed are: cloud forests, agricultural lands, pastures, mix of agricultural and pastures, rivers and lakes, native Andean alpine grasslands (páramo in Spanish), and native bamboo.

In our research, we found that 17 of 23 ecosystem services across the land-cover types in Intag provide the regional and national community an average of \$447 million in yearly benefits. These figures are based on cutting-edge economic analysis tools that were developed, in part, with a United States National Science Foundation grant.

One way of determining economic value is to estimate the asset value of the natural capital providing this annual flow of value. This is like comparing house payments (flow of value) to the market value of the house (asset value). The value of an asset can be estimated from the flow of benefits it provides. If the natural capital of the Intag region were treated like an economic asset, the asset value of the natural systems would be an average of \$15.5 billion at a three-percent discount rate, which recognizes the renewable nature of ecosystem services and that there will be people in the future benefiting from them.

It is becoming increasingly clear that economic sustainability relies on environmental sustainability. The loss of nature's bounty has real regional and global economic costs. The analysis of economic benefits of natural systems has advanced very rapidly

with the realization that natural systems are vital to the health and development of economies. Economics is re-tooling for the 21st century with three essential goals: **sustainability, justice, and economic progress**. Sustainability requires living off the natural systems in such a way that they can continue to provide the goods and services they produce indefinitely. Justice and rights are core democratic values. Rights frame and help define economic value. Economic progress provides a global approach to sustainable economic growth, alleviates poverty, and achieves social progress.

The value of the economic benefits the Intag region provides is enormous; indeed, it is priceless. The benefits provided are local, national and global. The economic value of the watershed is larger than its built economic assets or the underground minerals. This conclusion may be surprising given the price of copper in today's market, however, as this report illuminates, the social and environmental costs of copper extraction are much higher than the value of copper itself.

In Intag and elsewhere, economic progress depends on healthy communities, healthy people, and sustainable ecosystems, along with the political empowerment of local residents to choose and develop their own model of well-being. Development progress must be resilient to price fluctuations in single commodities and extend beyond the life of traditional extractive industries. Strategic investment in conservation, developing and enhancing the actual and potential sustainable economic alternatives, along with finding ethical markets for the rich diversity of ecosystem goods and services is key to the long-term viability of this special region of Ecuador.

Ecuadorian leadership has critical investment decisions to make. The term "investment" describes the choices we make today to place resources for returns in the future. An economy is the product of previous decades of investment. Future generations will benefit or suffer from the choices made today.

This report provides several recommendations for stabilizing and promoting the social and economic conditions in Intag, which include the following:

- Include ecosystem service valuations (ESV) to environmental impact assessments (EIA).
- Initiate mapping and modeling of ecosystem services in the region.
- Use ESV data to fund further region-specific service value transfer studies through local universities, and to implement broad changes in asset accounting practices.
- Perform an initial analysis of a restoration and conservation funding mechanism, and work with local and regional stakeholders to further refine the sustainable plan to ensure ongoing funding and policy support for basin-scale restoration and conservation efforts.
- Given mining's social, economic and environmental impacts in areas like Intag, it should be considered as a last resource for development.
- Consider the creation of a special development area to ground the area's economy on Intag's exceptional water, forests and biodiversity resources.

The overall conclusion of the report is that economic development within the Intag region is best achieved by tapping the vast value that ecosystem goods and services provide and that this approach is aligned with the development vision of Intag communities. Copper development will carry great costs. It is a risky venture dependent upon global economic trends and pricing, and competition from well established and planned mines could undercut expected profits and tax revenues. In addition, mining is inherently unsustainable. One day, a large pile of mine tailings will be left and the mine closed. World Bank studies confirm that most often the benefits of mining accrue to few while the costs are borne by many and overall, extractive industry dependence is associated with economic decline.

The Intag region is blessed with a flow of benefits on the order of \$447 million per year. This is sufficient to build a robust economy given advancement in agroecology, markets and the development of local to international funding mechanisms. Well managed, the resources of the Intag region can provide for sustainable, equitable and prosperous development in the region and nation.



Introduction

Economies need nature. Water, flood protection, recreation, minerals, materials, aesthetic value, and food are just a few among many services natural systems provide to the human economy. No economy, big or small, can function without nature's provision of economic goods and services.

Placing a dollar value on nature's work is not commoditizing nature. Rather, it is recognizing value that is often lost if not counted. Nature is invaluable just as the life of a person is invaluable. Yet, people also receive pay for work, and we need to understand the full value of nature's work.

This report provides a comprehensive view of the economic value of Intag's natural systems. It aims to better inform Intag's community, local, regional, and national governments and mining companies of the economic and social impact of copper extraction and the economic value the natural systems provide.

Report Organization

This report should be used as a tool to help the decision-making process of Intag's development strategy, and is organized into five major sections:

Part I: Development in Intag provides an overview of the geographic, historical, and current perspectives on economic development of the region. It also provides an overview of the current legal framework for natural resource management.

Part II: Copper Extraction and Revenue describes copper markets, production, and pricing, and explores projected costs and income from copper mining in Intag. A discussion of regulatory framework and remediation is provided with case study examples.

Part III: Ecosystem Services in Intag reviews the current ecosystem services present in the Intag region.

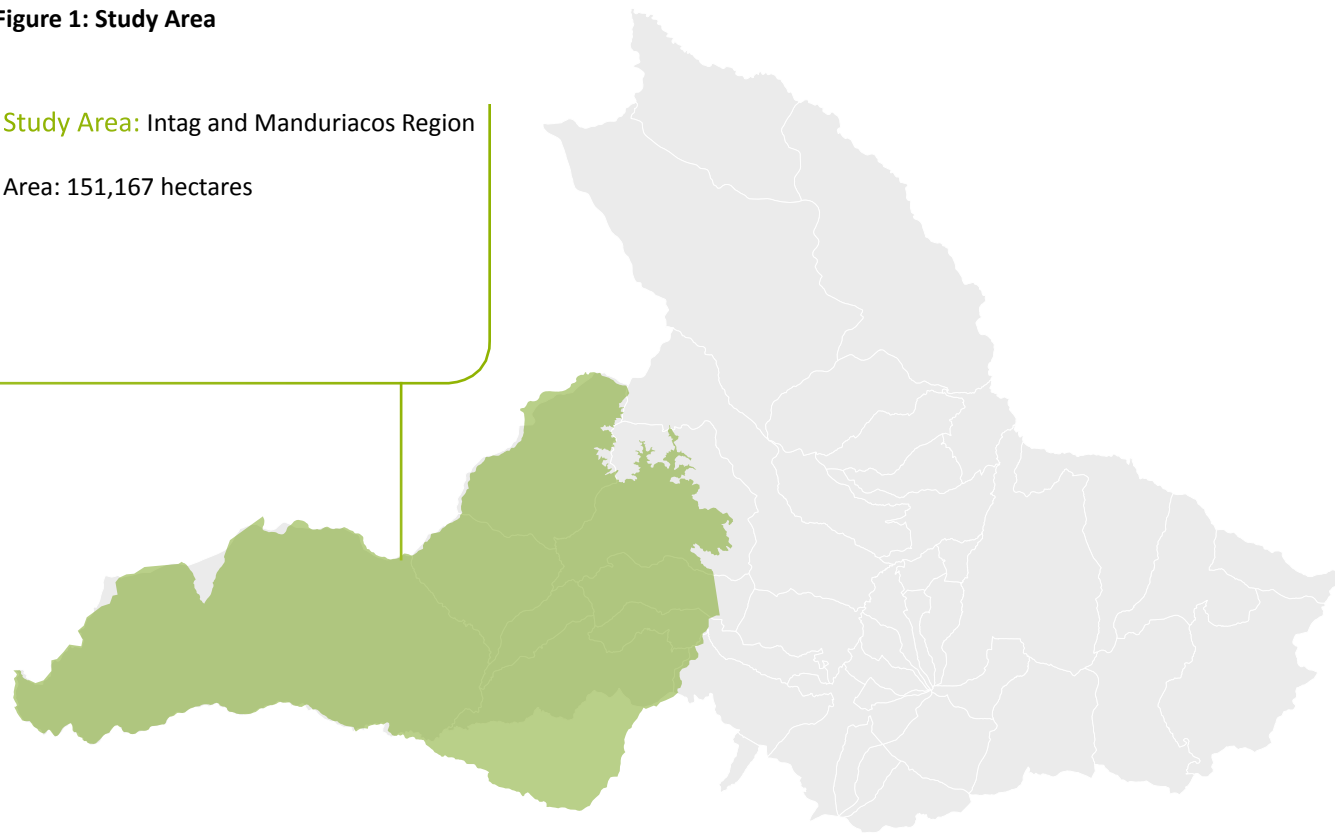
Part IV: Valuation Analysis of the Intag Region puts ecological economics into action, determining dollar values based on concepts developed in the previous two sections.

Part V: Implications and Recommendations creates a platform to advance an economics approach to sustainable development and provides recommendations based on the results.

Figure 1: Study Area

Study Area: Intag and Manduriacos Region

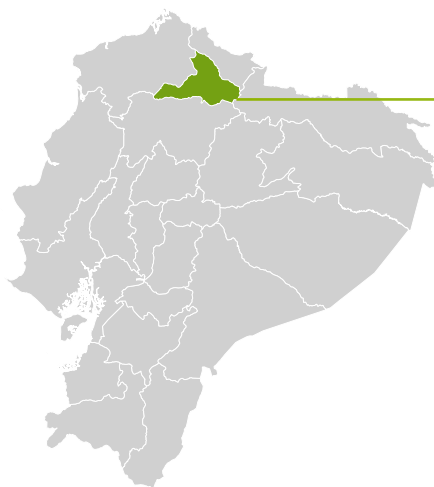
Area: 151,167 hectares



Province: Imbabura

Capital: Ibarra

One of 24 provinces in Ecuador



Country: Ecuador

Capital: Quito

Population: 15,007,343

(July 2011 est.)



Part I

Development in Intag

Section Summary: *This section provides an overview of the geographic, historical, and current perspectives on economic development of the region, and summarizes the current legal framework for natural resource management.*

Overview

The Intag region is located in the Andes in the Imbabura province of northern Ecuador, in the confluence of two of the world's 34 most important biological hotspots: the Tropical Andes hotspot and the Tumbes-Chocó-Magdalena hotspot.^{i 1} Seven parishes make up the Intag zone, an area totaling 150,000 hectares (ha). Here, approximately 17,000 people live in 76 sparsely scattered rural communities where small-scale agriculture is the region's economic base.

The region has been developing an eco-tourism economy and is home to fair-trade, shade-grown coffee plantations. The region's agriculture is self-sufficient and emerging into export markets. Local handicrafts are also entering new markets.

Geography

At an altitude of 650 to 4,000 meters (m), Intag/Manduriacos mostly contains cloud forests and agricultural lands.² Cloud forests make up no more than 2.5 percent of the world's tropical forests.³ There are two types of mountainous forests in this area: cloud forests, seasonal forests (moist forests with deciduous trees).⁴ Tropical Montane Cloud Forests are forested areas with frequent cloud and

mist present. Typically covered with orchids, mosses, and other plants on each branch.³ There are many species found in cloud forests that are not found elsewhere, therefore this ecosystem is known for containing a high incidence of endemic species. Cloud forests are fragile and threatened by climate change, logging and slash-and-burn agriculture.⁵ Many livelihoods worldwide are dependent on cloud forests, particularly for water supply.

The Esmeraldas watershed covers 20,000 square kilometers along its way to the Pacific Ocean. It is fed by rainwater as well as many tributaries sourced in the Andean mountain range. The hydrographic system of the Esmeraldas River is formed by the Blanco, Guayllabamba, Toachi and Quinindé rivers.

At the Esmeraldas River's mouth is the port City of Esmeraldas. The City is an important commercial center for the region's agricultural, oil, and lumber sectors. The land in the lower river basin is very fertile; plantains, cacao, coffee, banana, and tobacco are the dominant agricultural practices in this region. The jungle in the lower and middle river basin provides an important source of lumber for the country. Traditionally, this is an important aspect of the province's economy. The river provides a way

ⁱ To qualify as a hotspot, a region must contain at least 1,500 native species of vascular plants (> 0.5 percent of the world's total), and it has to have lost at least 70 percent of its original habitat. Collectively, hotspot areas support 44 percent of the world's plants and 35 percent of terrestrial vertebrates in an area that formerly covered only 11.8 percent of the planet's land surface. The habitat extent of this land area had been reduced by 87.8 percent of its original extent, such that this wealth of biodiversity was restricted to only 1.4 percent of Earth's land surface. www.biodiversityhotspots.org.

of transporting forest products downstream into the city.⁶ The oil industry represents an important economic activity for the region as well. Esmeraldas is the site of Ecuador's largest oil refinery with a capacity to process 110,000 barrels per day. It is the terminal of the Trans-Ecuadorian Pipeline coming from the oil fields in northeastern Ecuador.

History

It is believed that the first settlers arrived in the Intag region around 150 years ago. Archeological discoveries, in Intag and the adjacent province of Pichincha, provide ample evidence of the habitation of the Yumbos, a pre-Incan people that made their home in the area's cloud forests.⁷

In 1964, agrarian reform promoted the colonization of forestlands in Ecuador. Properties that had 80 percent forest coverage were deemed "unproductive" and could be occupied or expropriated under the reform laws. Colonizers and landowners were forced to deforest 50 percent of their land to prove that the earth was being put to a productive use.⁸

In addition to being an area rich in water resources, native forests, orchid and bird diversity, copper deposits were also discovered in the Intag area. In the 1990s, the Japanese company Bishi Metals explored and discovered copper deposits in the Intag's Toisan mountain range in northwest Ecuador. An estimated 318 million metric tons of copper ore, containing 2.26 million tons of pure copper are believed to lie in Intag's biodiverse forests and watersheds.⁹ The Japanese report reported that the impact to forests would be "massive deforestation" which would contribute to "desertification" to the local climate. Local communities concerned about large-scale mining began uniting to request international support.¹⁰ Organizations including Asociación Agroartesanal de Caficultores Río Intag (AACRI), Mujer y Medio Ambiente, and Defensa y Conservación Ecológica de Intag (DECOIN), are providing an alternative economic model to that of the extractive

model based on copper mining. Bishi Metals gave up the project in 1997 due to local opposition. These grassroots organizations continued to develop national and international links, mobilize resources, and elaborate on practical proposals for alternatives to mining.¹¹ Strong community organizing and support from NGOs led to the withdrawal of the company and the sale of the area to a Canadian mining company called Ascendant Copper Corporation.

In 2004, Ascendant Copper Corporation, now known as Copper Mesa, acquired a full mining concession to resume exploration activities. Their strategy was to raise enough capital to develop mining operations, which would create incentives to persuade local populations to depend on jobs created by the mine.¹⁰ But after several petitions from locals and instances of violent confrontations between anti-mining groups and paramilitary forces hired by the corporation, the Ministry of Mines and Petroleum ordered Ascendant to suspend all activities in September 2007.¹² Following his election as the president of Ecuador, Rafael Correa cancelled Ascendant's concessions in Intag due to human rights violations.¹³

In 2010, the Toronto Stock Exchange (TSX) delisted Copper Mesa for "failure to meet the continued listing requirements of TSX." DECOIN worked for nearly six years to address the human rights violations by the corporation. Copper Mesa's shares lost around 60 percent of their value within days of the TSX delisting.¹⁴

Constitutional Protection for Nature

Upon taking office, President Correa called for a constitutional assembly to create a new constitution for the country. A referendum was held for this measure on April 15, 2007, and was approved with just over 80 percent of the vote count. The Ecuadorian Constituent Assembly was formed through democratic elections held on September 30, 2007. The Ecuadorian Constituent Assembly, initially led by Alberto Acosta of Correa's PAIS Alliance, first convened on



DECOIN members and supporters at their office in Apuela.

November 29, 2007, with a mandate to write the new constitution in six to eight months.¹⁵

The Constitution of 2008 is Ecuador's 20th constitution since its independence in 1830, and is noteworthy for being the first constitution in modern history to give rights to nature.¹⁶ This addition changed the legal status of nature from simply being property to being a rights-bearing entity in the sense that humans are, and essentially provides a framework for sustainable development.¹⁷ The new constitution places Ecuador on the forefront of both international law and sustainable development.

The "Rights of Nature" section of the constitution begins with Article 71, stating: "Nature, or Pachamama, where life is reproduced and exists, has the right to exist, persist, maintain and regenerate its vital cycles, structure, functions and its processes in evolution."¹⁸ There will be challenges to enforce the law, as well as contradictory laws, such as the mining law, but it is still important that it exists.

In addition to the rights of nature, the entire section on rights in Article II of the Constitution is noteworthy for its thoroughness. The discussion is driven by an important, sophisticated concept: Buen Vivir (in Spanish) or Sumak Kawsay (in Kichwa), variously translated as "Good Living" or "Living in Harmony."

Water Law

In Ecuador, as in most Latin American countries, water is a national good for public use, with some exceptions made for certain indigenous communities with ancestral rights. The institutional structure pertaining to water resources is complex, and includes a number of institutions, regulations, and jurisdictions. In a recent study, a prominent environmental lawyer identified 25 laws and regulations as having direct relevance and 11 institutions as having direct or indirect jurisdiction over water resources.¹⁹ The Water Law of 1972 is currently the primary legislation governing water rights in Ecuador. Article 36 establishes a hierarchy of uses in which the highest priority is provisioning for communities and wells; followed by agricultural and cattle grazing practices; and finally energy, industry, mining and other uses.

Since the approval of the 1972 water law, there have been a number of conflicts in defense of indigenous water rights. Because of this, one aim of the 2008 Constitution was to provide greater autonomy and legitimization to public and collective community water management, and to depart from neoliberal policies, which attempted to privatize water. The 2008 Constitution essentially recognizes water as a public good to be managed, for the most part, by the state and local community groups. Significantly, water rights are also given to nature. This was in recognition that natural systems are of intrinsic and economic value and require water to function. Water laws based on the 2008 Constitution will be expected to redistribute water rights more fairly and to meet critical social needs. However, at the time of this writing, the new water law is still being debated.

Mining Law

Ecuador is the only Andean Nation free of large-scale metallic mining. Exploration by large multinationals in Ecuador did not begin in earnest until the early 2000s, after a mining law was passed in 2000 that encouraged foreign corporations to explore for minerals.²⁰ However, most mining activities were suspended in April 2008 when the National

Constituent Assembly passed a mining decree that ordered the Ministry of Nonrenewable Natural Resources to revoke most mineral concessions for reasons such as failure to pay yearly fees to conserve their concessions, or because the concessions overlapped with protected natural areas or impacted sources of water. It is estimated that approximately half of Ecuador's peasant communities, specifically in rural areas, had been affected by mining concessions as of 2008.¹⁰ Current figures suggest that: "according to the Ministry of Energy and Mines, there are 1,990 registered mining concessions in the country, causing serious concerns among civil society, particularly campesinos and indigenous people."²¹ The mining decree also gave the government 180 days to rewrite Ecuador's mining law.²² In January 2009, the Ecuadorian National Assembly passed a new mining law, which allowed a number of mining corporations to resume or begin operations.²⁰

As a part of the mining law, the Mining Control and Regulation Agency is in charge of ensuring all interested rights are met. As an institution of public rights they are allowed to supervise all mining actions and, if required, adopt administrative actions to safeguard the rightful exploitation, as well as social and environmental obligations appointed by law. Article 87 in the mining law states the rights to information, participation, and consultation. The state government is responsible for executing all social participation and consultation processes using public institutions that correspond according to the constitutional rights and the effective norms. These actions have the objective to promote sustainable management within the mining activity, rationalizing the exploitation of the resource and maintaining the communities' interest and support. In cases where the majority of the community is opposed to such mining activities, the Sectorial Ministry will handle the development decision. All mining investors must respect the right to the communities' information, participation, and consultation regarding environmental management of all mining activities.

Indigenous and non-indigenous groups alike remain divided as to whether the new mining laws will result in net positive impacts for the people and natural environment of Ecuador.²² On December 31, 2009, Ecuador's first state mining company (ENAMI EP) was created by executive decree.

Economic Development Options

The Extractive Industry

Ecuadorian oil production peaked in 2006 and has since been declining.²³ With high-quality oil reserves depleted, the Correa Administration began considering mining for metals as a substantial source for future state revenues. By 2007, the Ecuadorian Ministry of Energy and Mines had granted licenses for over 4,000 new mines.²⁴

Economic Arguments For and Against Mining

Mining was historically a crucial part of national development in many of today's wealthiest nations, and many believe that it can become an equally important sector in developing countries. Major arguments used to advocate for mining projects focus on economic development, including the following:

- **Job Creation.** The World Bank Group estimates that for each large-scale mining job creates 2–25 downstream jobs if suppliers, vendors, contractors, and others are included.²⁵
- **Revenue Generation.** It is often argued that mining can supply revenue to government through taxes, revenues, and royalties, which can then directly be spent on poverty reduction.
- **Technology Transfer.** Using the case of the United States as an example, the World Bank Group postulates that mining can contribute to a nation's knowledge of the economy by fostering the transfer of technology to other sectors.
- **Infrastructure Development.** Mining and other large-scale resource extraction projects may lead

to improvements in public infrastructure. For example, mining projects involve the transport of heavy equipment, which often requires the construction of new roads or upgrades to existing roads.

- **Downstream Industry Creation.** The World Bank Group believes that eventually, instead of merely exporting raw materials to be processed in wealthier countries, industrializing countries will develop “value-added” sectors that ensure a greater proportion of downstream mining revenue is retained within the country. Value-added products can include copper wiring or copper piping, which are typically sold for a greater profit margin than copper ore.

With the experience of the last decade, however, there is accumulating evidence that mining has slowed development and caused substantial long-term damaging impacts. This has spurred increasing debate over whether mining projects really support, or hinder, development.²⁶ The World Bank has produced several reports that document the negative effects of mining, although, as of this writing, it continues to support the mining sector as part of the solution to poverty reduction. Major arguments used to advocate against mining projects focus on sustainable economic development, including the following:

- **Surface Water Pollution.** It is well documented that mining contaminants such as arsenic and heavy metals leach into rivers. This creates public health hazards as rivers carry pollutants dissolved in particulate form to estuaries and, finally, to coastal oceans.
- **Air Pollution.** Both miners and nearby communities are exposed to known airborne carcinogens in the form of heavy metals such as lead and arsenic when blasting and grinding are used to expose ore. In addition, recent evidence suggests that another type of particle found in copper tailings, actinolite, forms asbestos-like

particles that can be blown towards nearby residents. In a 2010 study, actinolite in copper mining tailings was correlated with higher rates of pulmonary disorders such as mesothelioma.²⁷ Pollutants such as lead (Pb) are also emitted as a result of the mining process. For example, the copper smelters in La Oroya, Peru emitted 1,077 cubic meters of gas per second in 2000, which equaled more than 44,000 kg of lead per month.²⁸

- **Volatile Waste Creation.** The term “Acid Mine Drainage” refers to the outflow of acidic water from (usually abandoned) metal or coal mines. The impacts of acid mine drainage can last for hundreds of years, affecting multiple generations.²⁹ The waste produced from the mining process, known as tailings could contain high concentrations of lead, cadmium, zinc, sulfur, arsenic, and manganese. Also, sulfide-bearing minerals found in the parent rock, when exposed to air and water, change sulfide (S^{2-}) to sulfuric acid (H_2SO_4), which is a clear, colorless, odorless, viscous liquid that is very corrosive. The pH of water outflow from a copper mine can be highly acidic—measured at 2.77 on average in one study, compared with a typical pH level range of 5.5-7.5 for freshwater.³⁰
- **Impact on Ground Water.** Soils and rock containing copper may include uranium, thorium, and radium. These radioactive materials can leach into the groundwater.³¹ Additionally, a common occurrence in deep open-pit mines is the accumulation of ground water from the surrounding land, thus drying up streams and underground water systems downstream of the mine.
- **Impact on Fish and Shellfish.** Non-biodegradable hazardous substances, elements, and compounds present the greatest risk as they can remain within food chains and ecosystems for extended periods of time.³²
- **Risk of Ecological Disaster.** Residents in Marinduque, Philippines, an area with geography

similar to Intag, are still struggling to recover their economy after a mine tailings spill in 1996.³³ In Kolontar, the toxic red mud that spilled from an alumina tailings reservoir into the Hungarian countryside in October 2010 could make the soil too salty for plants to grow well into the next millennium.³⁴

- **Widespread Deforestation.** Large-scale mining operations, such as open-pit mining, can impact a region's climate. Tree removal changes the moisture content of the atmosphere above the local area. This change can break the cycle of rainfall and transpiration, reducing rainfall and drying out the local area. Desertification is the process by which fertile land becomes desert, typically caused by deforestation. The 1996 Japanese environmental impact assessment for the Junin proposed mine forecasted "massive deforestation which would progress to dry conditions (desertification) influencing the local climate..."
- **Energy Needs.** Mining is an energy intensive endeavor. Chile, for example, allocates a total of 33 percent of its energy to the mining industry in the country.³⁵ Although Ecuador has no large-scale mining operations, it is no stranger to energy shortages. In 2009, low water levels caused an energy crisis which disrupted cities throughout the country.³⁶ Large-scale mining requires enormous amounts of electricity for moving overburden. Dams dedicated to mines are often developed at the cost of taxpayers, while the mine competes with residential and business consumers for scarce power.

Impacts on Gross Domestic Product (GDP)

A World Bank independent review of extractive industries in 48 countries where mining is greater than 5 percent of all exports found the average GDP growth per capita was negative between the years of 1990 and 1999.²⁶ Furthermore, this study showed that average growth rates were inversely associated with a country's reliance on mineral exports. Table 1 summarizes the study findings.

Table 1: Extractive Industry Impact on GDP ²⁶

Countries with Extractive Industries	Change in average GDP per capita (1990-1999)
>50% of all exports	-2.3% (negative)
15-50% of all exports	-1.1% (negative)
6-15% of all exports	-0.7% (negative)

Impacts on Resiliency

Reliance on extraction exposes nations and mining communities to a number of economic vulnerabilities and risks.³⁷ If a country's economy is not sufficiently diversified, it will more likely be subject to global economic shocks and downturns, particularly associated with mineral prices. With these downturns, the poor are especially vulnerable. For example, Zambia has lost more than 8,500 mining jobs since 2008 as a result of falling commodity prices and the global economic downturn.³⁸ The country relies heavily on copper mining, which comprises 80 percent of its export earnings. Because government income is disproportionately dependent on mining royalties, health, education, transportation, and public safety expenditures fall when mineral prices fall. This exposes the vulnerability of an economy based on mining. In response to declining copper revenues, Zambia is now investing more in energy infrastructure, agriculture, and tourism.

Often economic decisions require making trade-offs. Table 2 provides a summary of the economic arguments for and against mining. The following section provides a summary of the socio-economic impacts of mining.

Table 2: Summary of Economic Arguments For and Against Mining

Economic Arguments (for mining)	Economic Arguments (against mining)
<ul style="list-style-type: none"> ▪ Job creation ▪ Revenue generation ▪ Technology transfer ▪ Infrastructure development ▪ Downstream industry creation 	<ul style="list-style-type: none"> ▪ Surface water pollution ▪ Volatile waste creation ▪ Costs of using police and public security forces ▪ Potential groundwater contamination ▪ Impact on fish, shellfish, and agricultural production ▪ High cost of remediation ▪ Adverse relationship to genuine progress ▪ Dependency on mineral prices ▪ Widespread deforestation ▪ Energy Needs

Social Impacts of Mining

Although mining can bring prosperity in theory, empirical evidence suggests that mining is more likely to lead to greater poverty rates. Countries that have invested most heavily in extractive industries have tended to perform poorly by World Bank development measures.²⁶ Often countries with large extractive industries have wide income gaps between rich and poor, which impacts a large number of socio-economic factors. Two articles that explore this issue

in detail include the 2001 World Bank study, *Mining and Poverty Reduction*, and later, Scott Pegg's 2006 article in the Journal of Cleaner Production, *Mining and Poverty Reduction: Transforming Rhetoric into Reality*.

Key social impacts from mining include:

- **Diseases.** Miners are “often migrant workers, living without their families and within disrupted social contexts. This situation can contribute to a high prevalence of human immunodeficiency virus (HIV) and other communicable diseases in mining communities.”²⁵
- **Inflation.** Local communities near mining projects are often exposed to a rapid influx of mine workers, who bring higher incomes and inadvertently raise the price of key goods such as food, fuel, and housing. This actually reduces the effective real income of local people, thereby contributing to increased poverty. The influx of workers, not all of whom find employment, can also create social tensions and conflict.²⁵
- **Domestic Instability.** Countries dependent on natural resource exports are at greater risk of armed conflict and civil war. At times, the causes of these insurgencies are clearly related to extractive industries where poverty and pollution are rampant.³⁹
- **Relocation.** Resettlement estimates tend to be lower than the actual impact for large-scale projects. For example, the Sardar Sarovar Dam project initially estimated the displacement of approximately 6,000 families, the final outcome was 100,000 families.⁴⁰
- **Corruption.** Countries dependent on mineral and oil extraction tend to be more corrupt and less democratic than other comparable states. An International Monetary Fund (IMF) study found that the level of capital-intensive industries such as mining (but not the level of labor-intensive

industries such as agriculture) is highly correlated with corruption.⁴¹ A study corroborates and extends these results: non-fuel minerals (such as copper) in particular have anti-democratic effects on nations.³⁷

Table 3: Summary of Social Arguments For and Against Mining

Social Arguments (for mining)	Social Arguments (against mining)
<ul style="list-style-type: none"> ▪ Job creation 	<ul style="list-style-type: none"> ▪ Increased poverty ▪ Increased disease ▪ Rising inflation ▪ Relocation ▪ Domestic unrest and corruption

Alternative Development Vision

Over the years, the Intag community has put a great deal of effort into developing economic alternatives in order to move forward collectively in a sustainable manner. Many groups have been established to create forums of democratic, grassroots decision-making based on their vision for the region. In 1996, the county of Cotacachi elected Auki Tituaña as the new mayor. Under Tituaña’s policy, civil society in Intag and the rest of the County of Cotacachi was able to push through the Cotacachi Ecological Ordinance, which declared Cotacachi an “ecological county.”⁴² The following is a preliminary accounting of some of the economic activities currently taking place as well as some potential ideas for future activities. These counteract arguments proposing the economic need for extractive industries. It should be noted that there are environmental costs of these activities as well, and those costs should be considered by the community.

Subsistence Agriculture

Intag is a very steep, mountainous area where half the land has already been converted to small- and medium-sized farms. Approximately 90 percent of the population owns land that is farmed, indicating a heavy reliance on subsistence agriculture. Farm sizes range from 1 to 50 hectares with an average of eight hectares per family. The most rapid route to economic progress for the vast majority of Intag residents would be to raise real incomes by raising existing farm incomes.

A study completed in 2006 estimated the value of various production alternatives on a hectare of land (specifically in the Rio Cristopamba Valley). The study provided an interesting analysis of typical farms. Values obtained were based on the assumption that the crops listed below are primary, with additional products (such as those mentioned in the preceding paragraph) being mixed in and being used by the family.

Values (per year) are as follows:

- Beans and corn (depends on the varieties used): \$350 per ha – \$970 per ha
- Cabuya: \$900 per ha
- Tree tomato: \$1,160 per ha
- Sugar cane: \$1,920 per ha
- Coffee: \$4,930 per ha
- Mixed fruits (primarily citrus): \$9,570 per ha

The value of livestock use of the land was also evaluated. Values ranged from \$133 per ha for beef cattle, \$230 per ha for milk production, and \$585 per ha for female pigs.⁴³

Other estimates for sugar cane (obtained through personal communications) range from \$1,500 per hectare per year to \$3,500 per hectare per year for cane that is transformed into panela, or alcohol. Miel de panela is also used and sold.

Livestock is an essential part of the local economy. Pigs, chickens, cows, and some guinea pigs are used

by families and/or sold in markets. Approximately 50 percent of the cattle are used regionally for milk and meat for families. The other 50 percent are sold in domestic markets. The heads of cattle that are sold, are sold in local markets for \$300 to \$400 a head, with an estimated two to three cows sold per year. Many families sell their surplus milk to a local milk cooperative (CORPIL) that processes the milk before it is transported to Quito. Approximately 2,500 liters of milk are gathered by three small trucks each day. Each farm supplies between 5 and 150 liters per day and is paid \$0.24 per liter (depending on the milk price at the time). In one day, \$600 worth of milk is picked up, translating to \$3,000 in one week alone. Milk from the Intag zone is considered to be of higher quality due to the environmental conditions as well as the specific animal genetics.

Coffee Production

Coffee is an important global commodity; it is, in fact, the second most traded outside of oil. In Ecuador, a total of 150,000 families survive on income from coffee production. It is a \$60 million per year economic enterprise and contributes significantly to the GDP.

AACRI (Asociación Agroartesanal de Caficultores Río Intag) was started in 1998 with 18 participants. Currently, 400 families are part of the coffee co-op, cultivating the arabic shade-grown coffee organically. By establishing a co-op, decisions can be made locally and higher prices can be obtained for the coffee. Co-op members are paid \$170 per hundred pounds for high-quality coffee and \$150 per hundred pounds for lower quality coffee. In 2010, approximately 180,000 were processed and roasted in Intag to be sold in markets in the region as well as Otavalo and Quito. Another 40,000 pounds were exported.

Crafts

Mujer y Medio Ambiente has existed for 17 years in the Santa Rosa and Plaza Gutierrez area. Currently,

43 women are part of the group and sell products handmade from locally harvested cabuya (sisal). Women reinvest in the group, decisions are made collectively, and 5 percent of each sale goes back into the group. Gross sales for 2006 were \$22,661 with a total net of \$19,271 (after subtracting 15 percent for materials). Thus, each woman earned on average \$448 a year (depending on the number of items individually produced), with some women earning as much as \$1,500.

Coordinadora de Mujeres de Intag has been in existence since 2002. Approximately 150 women from the entire region are part of the group, which focuses on gender inequality, domestic violence, participates in the Asamblea Cantonal (County Assembly), and develops alternative sustainable economic enterprises for the region. The group sells natural soaps, hats, bags, wallets, belts, and more—all handmade using locally grown cabuya. The products are locally sold in Intag, at a fair trade store in Otavalo and nationally.

Ecotourism

As described earlier, ecotourism is an enterprise that is currently underway in Intag and has the potential for far greater growth and development value. Some of the activities visitors partake in throughout the region include hot baths, birding, rafting, biking, hiking, and generally enjoying natural areas and the local culture. In addition, Intag is increasingly an education center for international students on study abroad programs, which brings foreign exchange into the country. The following table indicates the number of attractions in the region:

Table 4: Current Tourist Attractions

Community	Number of natural attractions	Number of cultural attractions
Apuela	8	3
Cuellaje	6	4
Garcia Moreno	13	5
Peñaherrera	9	6
Plaza Guitierrez	5	3
Vacas Galindo	3	1
Total	44	22

The thermal pools and cabañas at Nangulvi are some of the most popular attractions in the region. Nangulvi has three cabañas with a capacity of 18 people and 5 pools. In 2005, from April to December, 776 people stayed overnight at Nangulvi while in 2006, from January to December, 1,169 people stayed overnight. Approximately, 69 percent of the visitors are Ecuadorian and 31 percent are foreigners. For the pools, 8,968 children and 14,173 adults were users in 2005. In 2006, 7,318 children used the pools, and 12,847 adults.⁴⁴

The ecotourism complex in Junin (3,000 hectares) can receive 24 people in cabañas and has a small restaurant. From August 2003 to January 2007, 486 guests registered, with an average stay of 2.8 days. Visitor numbers have increased on average 34 percent every year.⁴⁴

Some of the reserves offer accommodations. Reserva Los Cedros (6,000 hectares) estimated a total of 300 visitors in 2005 and 700 in 2006—most visitors were on study/research trips.⁴⁴ Reserva La Florida (500 hectares) also hosts groups of people and estimates an annual visitation rate of 150 visitors. Other reserves include Siempre Verde (500 hectares) and Alto Choco (3,000 hectares).

Gualiman is a cultural site housing four burial mounds

and 66 smaller ones. A small museum is located on the site and accommodations for small groups are available. It is unknown how many guests visit the site per year.

Hydropower

El Consorcio Toisan, an umbrella organization composed of several grassroots organizations, started in 2006 with the objective of supporting sustainable productive activities in the Intag region. Currently, the consortium is developing a proposal, HidroIntag, to generate 10 micro-hydro dams in the Intag region. These dams could generate electrical power valued at \$30 million per year and would allow the Intag region to be 100 percent energy self-sufficient, with excess power being sold back to the grid. This project has the potential not only to inject money into cash starved public programs but also to provide indirect payments for local ecosystem services. For this hydro project to have long-term success, it will be crucial to maintain the security of the watershed, to ensure a strong and consistent flow in the rivers. To achieve this end, the surrounding forest must be conserved.

Scientific Research

The Tropical Andes is considered the richest biological hotspot in the world with approximately 15-17 percent of the Earth's plant species and nearly 20 percent of its bird diversity (more than 1,700).⁴⁵ A four-square-mile area of rainforest may contain as many as 1,500 different types of flowering plants and 750 species of trees, all of which have evolved specialized survival mechanisms over the millennia that mankind is just starting to learn about.⁴⁶

Commercial interest in biodiversity is becoming more common, not only in the pharmacology and personal care product field, but also in the emerging field of biomimicry. Daily, plant, animal, and insect species are becoming extinct due to rainforest deforestation. As the species disappear, so do many possible cures for life-threatening diseases and today's most difficult problems.

Pharmaceuticals

In 1983, there were no U.S. pharmaceutical manufacturers involved in research programs to discover new drugs or cures from plants. Today, over 100 pharmaceutical companies and several branches of the U.S. government, including the National Cancer Institute, are engaged in plant research projects for possible drugs and cures for viruses, infections, cancer, and AIDS. Merck & Co. made a \$1 million dollar deal with Costa Rica's National Institute of Biodiversity to screen plants, insects, and micro-organisms for medicinal compounds. G.D. Searle & Co. and Pfizer have similar arrangements with U.S. botanical gardens.⁴⁷

According to the U.S. National Cancer Institute, more than two-thirds of all medicines found to have cancer-fighting properties come from rainforest plants.⁴⁸ Ingredients synthesized from a now-extinct periwinkle plant once found only in Madagascar have increased the chances of survival for children with leukemia from 20 to 80 percent.⁴⁸

Personal Care Products

Many companies are turning to rainforests for help innovating personal care products ranging from soaps to perfumes. The agave plant is now valued for hair care products. New fragrances and scents are being developed from orchid species.

Biomimicry

Biomimicry is the science and art of emulating nature's biological ideas to solve human problems. For example, carbon-sequestering cement mimics corals and energy-efficient wind turbines mimic schooling fish. The rainforest offers scientists and engineers countless opportunities to explore and innovate. Business entrepreneurs are rapidly turning to nature to solve sustainability and health problems. The use of indigenous resources such as plants, animals, and knowledge should be done with respect and informed consent of indigenous people.

Another example of biomimicry is a self-cleaning fabric innovation developed after studying butterflies. Engineers observed that nano-scale surface structures on butterfly wings repel water and most dirt and also cause dirt particles to be carried away by water. Schoeller Technologies AG of Switzerland is now marketing NanoSphere®, a fabric treatment that is self-cleaning, dirt- and water-repellent, and abrasion-resistant. Less washing and abrasion reduce use of natural resources and harmful chemical cleaners.⁴⁹

Choosing Between Development Alternatives

Ecosystems are increasingly more valuable. Just as the value of metals increase as they become scarcer, so do ecosystems and their services and products. In the face of climate change and the declining number of intact healthy ecosystems, the remaining ecosystems, such as Intag, will increasingly be more valuable.

Cost/Benefit Analysis

A cost/benefit analysis is an economic decision-making process that adds up the benefits of a public policy and compares those benefits to the costs.⁵⁰ But how do we assess value for something that is priceless, such as breathable air? Consider the value of one ecosystem service, photosynthesis, and the ecosystem benefit it produces, atmospheric oxygen. This indicates that the value of photosynthesis and atmospheric oxygen to people exceeds the value of the gross world product—and oxygen production is only a single ecosystem service and good. Having breathable air means we stay alive.

Frank Ackerman and Lisa Heinzerling's book, *Priceless: On Knowing the Price of Everything and the Value of Nothing*, reviews the economic method of cost/benefit analysis. They argue that things that are priceless, such as human life, are given a monetary value to determine whether endangering activities are prudent and/or have the right to occur. Unfortunately,

the costs and benefits of an action (or inaction) are often calculated using methodologies which can be manipulated to justify decisions based on the analyst's preference.

An example of this can be found in the United States' Office of Management and Budget's 2002 estimate that the value of protecting 60 million acres of forest land was a mere \$219,000 per year. However, by only calculating the cost saved from not building or maintaining roads in the area, environmental benefits of the forest ecosystem and the value they provide to the local, national, and global economy in the form of ecosystem services were completely ignored. In terms of cost, the study asserted that preserving the land prevented society from realizing \$184 million in economic activity the forest could provide if developed.⁵¹ This study also disregarded the future values society might derive from the forest's existence, such as clean water, recreation, flood protection, and local climate stability. Given such manipulated estimates, government protection of the land was argued ineffective from a cost/benefit standpoint and regulations that were created to ensure long-term sustainability were discounted and debated as inefficient protectionism by free-market advocates.

Consider applying historical injustices in the current-

day free market: In the absence of regulation and laws restricting certain activities, we would allow slavery, child labor, and toxic pollution. Seemingly, "anything profitable that is not prohibited by law is likely to occur" in a free market scenario.⁵¹

What is the Value of Life?

A literature review concluded that \$5 million–6 million is a range for the value of a human life (1999 dollar values) used by the US Federal Government.⁵¹ Using a Quality Adjusted Life Years (QALY) model common to health economics, this value is discounted for the poor, disabled, and elderly. This methodology raises a key question: Do disabled or elderly people value their lives less than healthier or younger people? This approach to valuing life would be morally reprehensible to many, yet this kind of justification is precisely what is used in cost/benefit calculations that include social impacts and human health.

The Intergovernmental Panel on Climate Change (IPCC) released an infamous life-evaluation report in 1995 that provided values for economists to use when calculating individual lives affected by climate change. To arrive at these values, the report used the economic value produced by the countries in which people lived as the determining factor. Thus, a person's life in a rich country was worth \$1.5 million,

Figure 2: Illustration of the difference between price and value.



Source: Nina Paley, Mimi and Eunice

while a person's life in a poor country was \$100,000. Due to the outrage that ensued when this report was released, IPCC revised its figures to \$1 million per person, regardless of where they lived in 2001.⁵¹ Although the IPCC's figures were revised, this case is illustrative of the methods economists often employ to assign value to things (in this case people) that are priceless.

Ecological Economic Analysis

It is commonly accepted that natural resource depletion is on an unsustainable trajectory. Around the globe there are critical shortages of natural resources, yet the destruction of ecosystems continues, impacting biodiversity and amplifying the effects of climate change.⁵² Despite decades of widespread scientific documentation and concern about natural resource depletion, the trends continue to worsen.⁵³ Why are we unable to respond to this critical information?

One major reason is that our dominant economic systems value and promote unlimited growth in a finite world, and are blind to critical boundaries and shortages of nature's goods and services (natural capital). Current economic doctrine places natural systems as a subset of the economy. That subset is valued only as a source of raw materials for man-made goods and services and is used as an infinite sink for pollution and used products.

Common sense tells us that the whole economy is absolutely dependent on nature's goods and services (imagine life without fresh water, oxygen, and topsoil), yet often no economic value (beyond extractive value) is placed on nature under common economic analysis. Consequently, conventional economic decision-making is blind to costs occurring when natural systems are damaged, and cannot justify spending money to protect, improve, or repair natural capital until after ecological collapse generates economic catastrophe.

Fortunately, there has been progress. The recent United Nations TEEB report (The Economics of

Ecosystems and Biodiversity) highlighted the value of natural assets, and the World Bank has announced a partnership to develop methods and guidelines for integrating the value that ecosystems provide with national accounts.^{54 55}

Ecological economics is generating new measures and analyses to address the increasing scarcity of natural capital and rising population demands. Appendix A provides background on ecological economics to help elucidate the increasing importance and applications of science-based economic analysis to human well-being, sustainability, and economic progress. The ecological economic framework looks at ecological structure and processes that make up the functions of an ecosystem, and illuminates the role that they play in local, regional, national, and global economies.

Applying the Best Science and Economics

Methodologies for valuing ecosystem services have advanced rapidly. Section 4 of this report can be used to bolster traditional cost/benefit analysis or to inform a multi-criteria analysis for projects and policies in the Intag region. Many countries and regional governments are exploring ways to incorporate the value of ecosystem services into land use and planning decisions. In 2010, the Peruvian congress passed a law requiring environmental impact statements (EIS) for all development projects to include ecosystem service valuation. This bold step helps ensure the sustainable growth of the Peruvian economy in a world of diminishing natural resources. Indeed, those countries that balance investments in built, natural, human, and social capital will be in the best position to have thriving economies and healthy populations in the 21st century.

Example of an open pit copper mine. Bingham Canyon Kennecott copper mine in Utah is one of the largest open pit mines in the world and can be seen from orbit.



Part II

Copper Extraction and Revenue

Section Summary: *According to the exploration carried out by Bishi Metals in the 1990s, there could be as much as 318 million metric tons of copper ore in the area of Junin, equivalent to 2.26 million tons of pure copper. The uncertain aspect of the deposit is due to the fact that not enough exploration was carried out to confirm the deposit. This section describes copper markets, production and pricing and explores projected costs and income from copper mining in Intag. A discussion of regulatory framework and remediation is provided with case study examples.*

Copper

“Copper is one of the metals that has been in use longest. It has been an important material in the development of civilization because of its high ductility, malleability, thermal and electrical conductivity, and resistance to corrosion. Copper has become a major industrial metal, ranking third in quantity after steel and aluminum.”⁵⁶

Common uses of copper include building construction (wire, cable, plumbing and gas tubing, roofing, and climate control systems), aircraft parts (undercarriage components, display unit components, and helicopter motor spindles), automotive parts (wire, starter motor, bearings, gears, and valve guides), industrial applications and machinery (tools, gears, bearings, and turbine blades), furniture, coins, crafts, clothing, jewelry, artwork, musical instruments, cookware, and more.

Once extracted, copper goes through industrial processes before being utilized in consumer products. Copper is contained in ores that must be extracted mechanically, most often in an open pit. This capital-intensive process implies the removal of huge volumes of soil that have to be crushed and concentrated. To extract the copper from the ore, an energy intensive

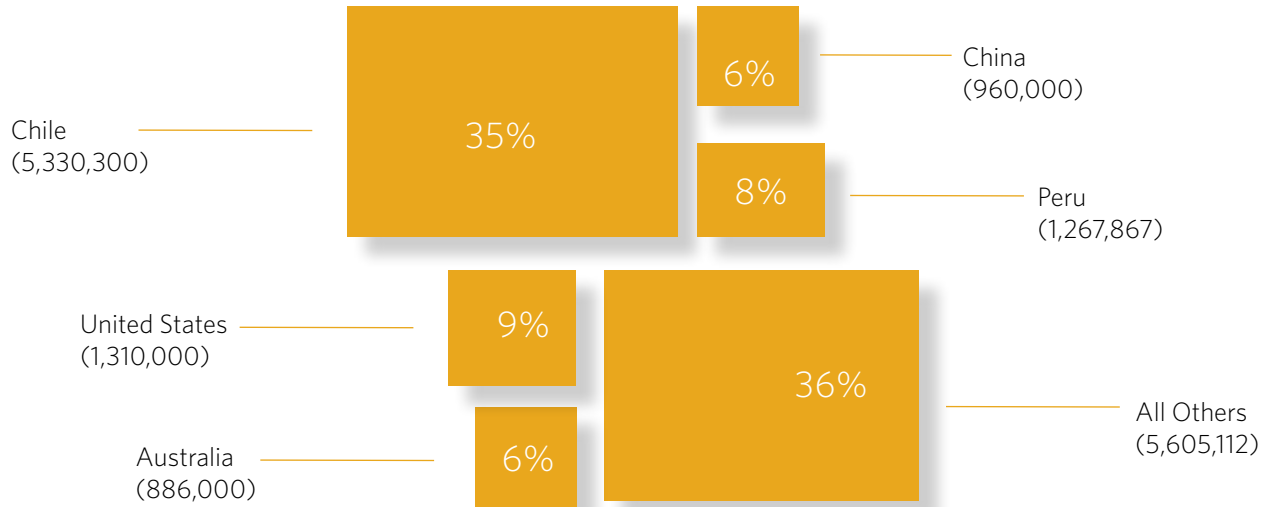
process is needed. Copper smelting is mostly done with pyrometallurgical techniques that can produce significant air emissions of sulphur oxides, arsenic, or other pollutants.

World Copper Production

Among copper producers, Chile has a dominant market position, at approximately one-third of world copper mine production. The next largest producers, the United States and Peru, trail substantially, at nine percent and eight percent respectively.⁵⁷ It is worth noting that according to a Japanese study in 1998, there is an estimated possible reserve of 318 million metric tons of copper ore in Intag at a .71 percent copper grade, equivalent to 2.26 million tons of the pure metal.^{ii,9} In 2010, the world consumed approximately 19 million tons of copper.⁵⁸ A typical deposit of this size could take anywhere from 10 to 20 years to fully exploit depending on the rate of extraction and processing of the ore.

ii The Japanese company, Bishi Metals (now Mitsubishi Materials Corporation) discovered copper deposits in the Intag region in the 1990s. A team, organized by the Japan International Cooperation Agency (JICA) and the Metal Mining Agency of Japan, completed the environmental impact statement in 1996, with an updated version released in 1998.

Figure 3: Worldwide Copper Production in 2008 (metric tons) ⁵⁷



Summary of Externalized Costs
Surface water pollution
Volatile waste creation
Costs of using police and public security forces
Potential groundwater contamination
Impact on fish, shellfish, and agricultural production
High cost of remediation
Adverse relationship to genuine progress
Dependency on mineral prices
Widespread deforestation
Energy Needs

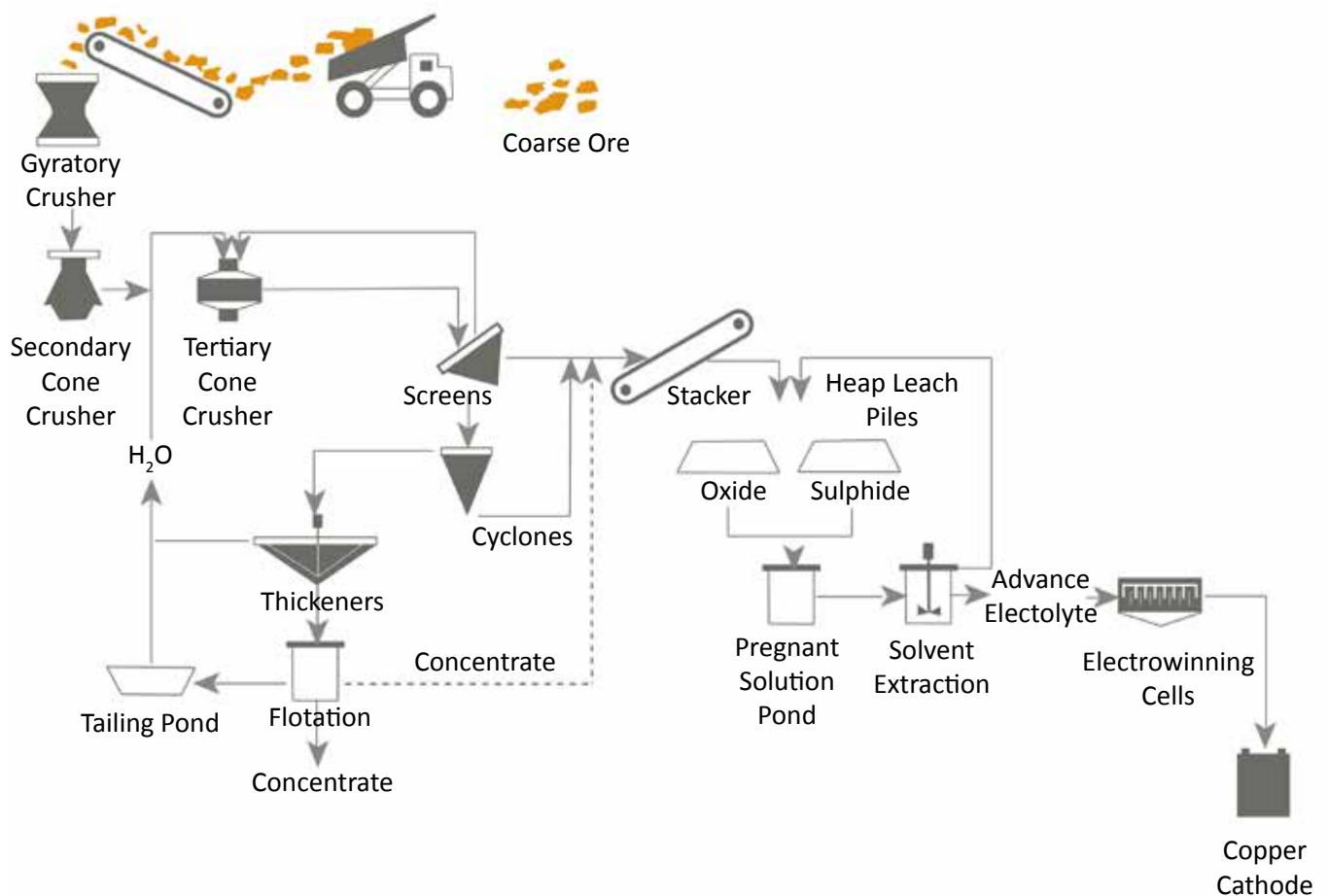
Summary of Internal Costs
Opening of the mine
Extraction
Transport
Treatment
Copper production costs, net of by-product credits per lb of copper
Off-property costs for transport, treatment (smelting and refining), and sales per lb of copper
Total cash costs of production per lb of copper

Copper Extraction

Open pit copper mining is an extremely capital and time intensive investment. Describing the detail and complexity of the copper industry is beyond the scope of this report, but the basic phases of mining are as follows: (1) Prospecting; (2) Exploration; (3) Exploitation; and (4) Reclamation. Figure 4 provides a detailed snapshot of the copper mining process.

Note that there are only 124 copper smelters in the world, ten of which are in South America, and none in Ecuador.⁵⁹ Returns on copper mining investments are significantly lower when off-property costs are calculated.

Figure 4. Copper Processing ⁶⁰



Copper Production Costs

Copper production costs vary in each mine location. For example, operating statistics from the Gibraltar copper mine in British Columbia, Canada, for the years 2010 and 2008 show that the cost of production and off-property costs (transport, treatment, and sales) came out to be \$1.78 per pound of copper in 2010 and \$2.30 per pound of copper in 2008.⁶¹ These cash costs of production figures are a non-GAAP measure that do not take externalities into account.ⁱⁱⁱ

Copper Price Volatility

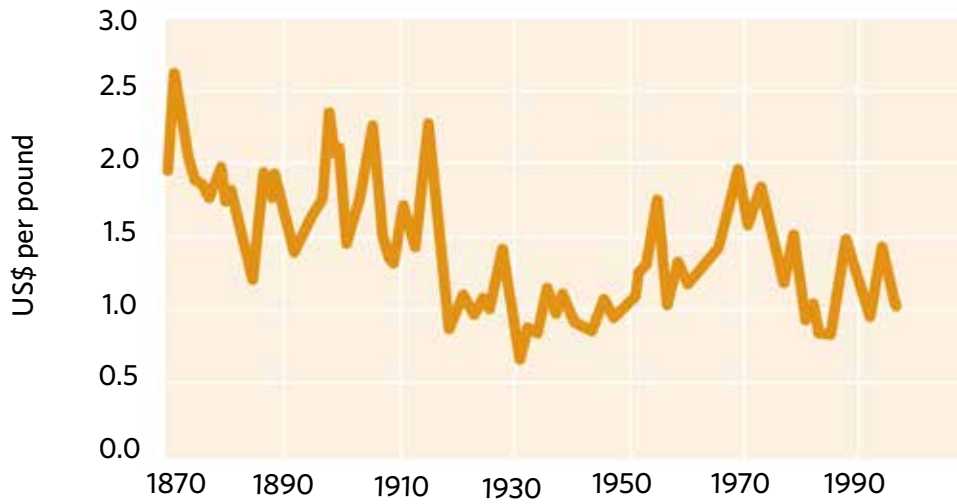
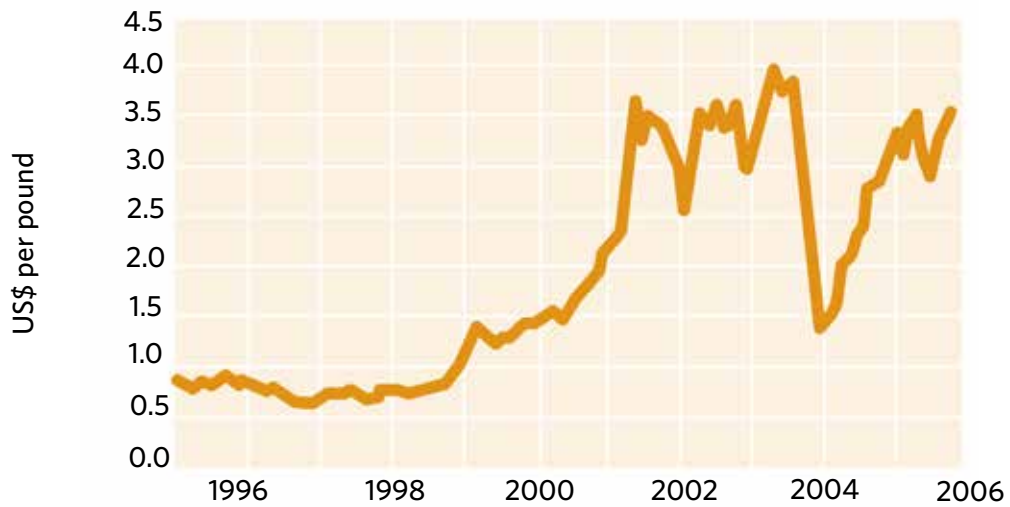
Copper prices are renowned for boom and bust cycles dependent on global economic growth, which drives demand, and global production output, which drives supply. When prices are high, many proposed mines are developed independently with the expectation of high prices. Yet as new mines come online the increased supply drives prices down, sometimes precipitously, and some new mines quickly go bankrupt. This partially accounts for the frequent and often severe dips in copper prices since 2001.

The London Metal Exchange (LME) is the world's premier market for non-ferrous metals. It offers a range of futures and options contracts, which allow traders to try to secure costs for materials months and years in advance. "The prices 'discovered' at the LME are recognized and relied upon by industries throughout the world."⁶² Figure 5 shows real copper prices since 1870. Figure 6 shows global prices of copper since 1995. Starting in 1999, the price of copper increased significantly due, in large part, to the increased demand in Asia.



Native Copper

iii GAAP is defined as Generally Accepted Accounting Principles.

Figure 5: Real Prices for Copper, 1870–1997 ⁶³**Figure 6: Copper Prices since 1995** ⁶²

Selling Copper

The best way to explain what it takes to produce copper is to look to those who do it. QuadraFNX is a Canadian mining company involved in producing copper around the world. They explain how the copper they produce in the Robinson open-pit mine in the U.S. state of Nevada is sold.

Running a successful mine requires significant working capital. Figure 7 illustrates the time period between mine concentrate production and final settlement payments.

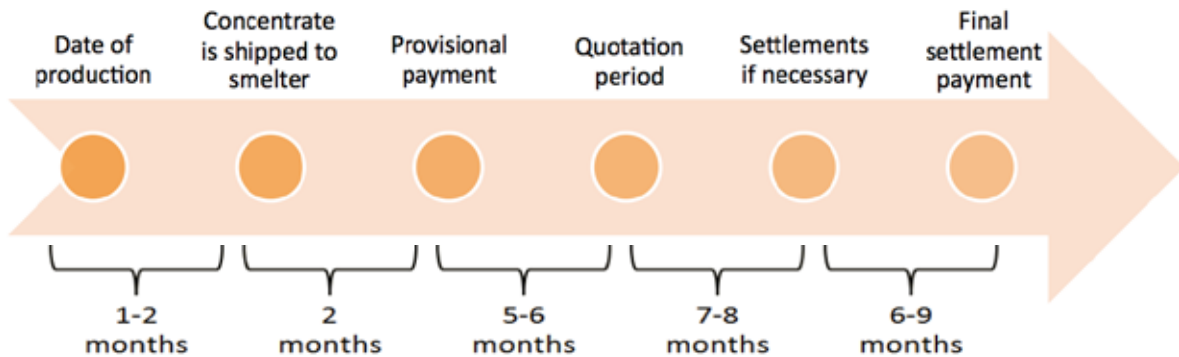


Copper is sold by mining companies in two ways, concentrate sales (impure copper powder) and cathode metal sales (pure copper) depending on the type of ore deposit processed. Concentrate producers sell a concentrate powder containing 24–40 percent copper metal content to a smelter and refiner. The concentrate is sold using a formula that is unique to each smelter but general terms are as follows:

The smelter pays the producer about 96 percent of the metal value based on metal content contained in the concentrate and based on a future average price known as the quotational price less the treatment charges (“Tcs”) and refining charges (“Rcs”). Historically the smelters and refiners have participated in price upside via an arrangement known as “price participation” in which the smelters and refiners share in 10 percent of the value of the copper above a certain threshold, historically approximately 90 cents per pound of payable copper metal. Currently, price participation terms are not included in most smelter sales contracts. Tcs are charged on a \$ per tonne of concentrate treated and Rcs on a \$ per pound of metal refined. The charges fluctuate with the market but are often fixed on an annual basis. By-product metals such as gold and silver have separate refining charges. In addition, the smelters and refiners require concentrate specifications that limit the amount of impurities allowable in the concentrate (an example would be the amount of allowable arsenic) and these limits vary from smelter to smelter. If the concentrate producer does not meet these specifications financial penalties are levied. Normally third party assayers take samples of the concentrate during the shipping of concentrate to a smelter and determine the level of payable metal, moisture and impurities in the concentrate. If there are disagreements between the concentrate producer and the smelter as to the assay results they are usually settled by a third party umpire.

The Robinson Mine produces a copper concentrate that contains approximately 25 percent copper, as well as gold. The concentrate is shipped to smelters in Asia where the material is processed to recover the nearly pure metallic copper and gold.

Figure 7: The Timing of the Quotation Pricing Between the Concentrate Producer and the Smelter and Refiner. ⁶⁴



Quadra transports the concentrate material (via truck and train) to the port in Vancouver, Washington where it is loaded onto ships that deliver the product to smelters in Asia. The customer takes legal title to the concentrate when it is loaded on a ship, and Quadra recognizes revenue at this time. However, it takes several months from this point before final saleable copper can be produced by the smelter and final settlement of the price is made.

Smelters generally act as a ‘toll’ business and do not want to risk their profit margin on a changing copper price. As a result, the concentrate market has evolved so that the concentrate producers (the mines) assume this price risk. In Quadra’s case, the final price of the copper concentrates is not determined until approximately 3–4 months after the product has been delivered to the customer at the port.

For accounting purposes, the revenue is recognized at the time of delivery based on the LME quoted copper prices at that time (the “provisional price”). At each quarter-end, this provisionally priced copper is revalued based on the quarter-end forward copper price for the expected date of final settlement and this accounting revaluation creates “provisional price adjustments”.

In terms of cashflow, Quadra receives an initial payment at the time the product is loaded onto a ship at the port. This initial “provisional payment” is calculated based on 90 percent of the estimated contained metal in the concentrate, using the LME quoted copper price at the time of delivery. After the final pricing has been established (3–4 months after initial delivery) a final invoice is issued and the initial provisional payment is adjusted for the final copper price. In the case of a significant price decline, Quadra would have to refund the customer a portion of the initial provisional payment. ⁶⁴

The following table shows cash flows and revenues from the sale of copper on a shipment in September 2008 from the Port of Vancouver, Canada to a port in China.

Table 5: Cash Flows and Revenues from the Sale of Copper on a Shipment⁶⁴

Date	Activity	Revenues	Cash flow
Sept. 2008	Concentrate material is produced at Robinson and shipped by truck/rail to the Port of Vancouver, Washington.	-	-
Oct. 22, 2008	Ship leaves Port of Vancouver, Washington, with 10,000 dry tons of copper concentrate (containing 26.8% copper, assuming no gold by-product). Customer takes legal title and makes initial payment based on current copper price of \$2.40/lb.	+ \$12.4 M	+ \$11.1 M
Nov. 15, 2008	Ship arrives at customer's port in China.	-	-
Dec. 31, 2008	Receivables are revalued for accounting purposes based on quarter-end copper price of \$1.32/lb.	- \$5.6 M	-
March 2009	Final invoice is prepared based on average metal copper price during Feb. 2009 (3 months after month of arrival) of \$1.50/lb copper among with final weights and assays. Final invoice was calculated at \$12 million.	+ \$0.9 M	- \$3.4 M
	TOTALS =	\$7.7M	\$7.7M

Economic Estimates of Junin's Mineral Deposit

The royalties will be based as a percentage of sales of primary and secondary materials and will be paid twice a year. Article 93 of the Ecuadorian Mining Law states that mining concessionaries will have to pay royalties of no less than five percent of sales revenue. In addition to this payment, mining concessionaries are subject to four national taxes: 25 percent for income tax, 12 percent tax on profits, 12 percent for value added tax, and 70 percent tax for windfall gains.⁶⁵ However, at the time of writing, the government has not yet made clear the taxation formula it will use, and it could make considerable changes to the taxation regime described above.

Without a written contract between the mining company and the Ecuadorian government, final profit calculations generated from the copper mine in Intag are not possible. The National Mining Plan of Ecuador estimates that the Junin mine in Intag could generate \$85 billion. However, the mining plan provides no specifics of how this estimate was calculated.

Resources estimate the mineral concentration in the ground. Reserves tell us how much ore may be economically and legally recoverable. How much ore is ultimately recovered as mining takes place is dependent upon the actual geology, slope stability, hydrology, weather, quality of engineering, overburden ratio, global economic growth, metal prices, content of associated minerals, the regulatory regime, level of corruption in both private and public institutions, social acceptability in the community, remediation, accident frequency and size, and other aspects.

In the past, over-reporting of mineral reserve estimates was a problem in the mining sector during the exploration phase of some mines. For example,

the Bre-X Minerals Ltd. scandal, fraudulently over-estimated gold reserves in Indonesia and became one of Canada's greatest stock collapses. As a result, Canada and other countries instituted new rules such as NI 43-101 relating to mineral resources and reporting thereof that standardized and legally codified the process.

Resources

National Instrument 43-101 (or NI 43-101) is a Canadian codified set of rules and guidelines for reporting information related to mineral properties. It requires that companies traded on the Canadian stock exchange provide technical report information from an independent source on mineral resources. A NI 43-101 compliant inferred resource was verified in 2003 by Micon International of 1.36 billion tonnes at .73 percent Cu, 0.03 percent Mo, 1.6g/t Ag and .01g/t Au or 0.98 percent copper equivalent at 0.2 percent copper cut-off.^{iv}

Mineral resources and reserves are different. The US Geological Survey defines mineral resources as "a concentration of naturally occurring solid, liquid, or gaseous materials in or on the Earth's crust in such form that economic extraction of a commodity is regarded as feasible, either currently or at some future time." Also resource estimates calculate both concentration and tonnes (quality and quantity). Mineral reserves are defined as "that portion of an identified resource from which a usable mineral commodity can be economically and legally extracted."

There are three definitions based on different levels of uncertainty given to potential economically viable identified mineral resources: inferred, indicated and measured.

Inferred: Materials in identified but unexplored deposits whose quality and quantity have been

^{iv} See Appendix E for additional information of the inferred resources presented by Micon International and the concerns of validity.

estimated from geologic projections.

Indicated: Materials whose quality and quantity have been estimated partly from analyses and measurements and partly from reasonable geologic inferences.

Measured: Materials whose quality and quantity have been determined, within a margin of error of less than 20 percent, by quantitative data, including appropriate analyses, from closely spaced and geologically well-known sample sites.

The concession now belongs to Enami EP (the Ecuadorian state mining company). In 2009, Enami EP signed a four-year agreement with CODELCO, a Chilean mining company, which allows CODELCO to explore mining concessions in Ecuador.⁶⁷

Table 6: Junin Preliminary Revenue Estimates

Summary Scoping Level Economic Estimate (+/- 30%)	
Estimated CAPEX	\$1,573,552,691.83
Estimated OPEX	\$6.96 USD per tonne of ore
Pre Tax NPV @ 8% Discount rate	\$21,735,218,408.39
<i>Assuming 5% Royalties</i>	<i>\$1,086,760,920.42</i>
<i>Assuming 30% Net Tax</i>	<i>\$6,520,565,522.52</i>
Economic Estimate for Ecuadorian Government	\$7,607,326,442.94

CAPEX: Capital Expenditures
OPEX: Operational Expenditures
NPV: Net Present Value

Open-Pit Mine Remediation and Compliance

In Intag, an open-pit copper mine is proposed. To mine the ore, it will be necessary to excavate, and relocate large quantities of topsoil, waste rock, and ore. For every ton of rock and soil, a typical copper mine produces 3–4 pounds of copper, five ounces of zinc, three ounces of lead, and two ounces of arsenic.³⁰ In addition, the overburden, or rock, sand and soil, expands in volume significantly, thus there is a far larger volume of material to dispose of than mine pit space. This changes the topography and flow of both surface and ground water (virtually all open pit mines extend into groundwater resources). Since the main objective in any commercial mining operation is to maximize profits by the removal of the mineral deposit at the lowest possible cost, the selection of physical design parameters and the scheduling of the ore and waste extraction require complex geologic engineering, as well as logistical, environmental, and economic planning.

In Ecuador, mining concessionaries have to pay an annual reclamation fee to conserve their mining concessions. For the initial exploration phase, the annual fee is set at 2.5 percent of the legal monthly minimum wage per hectare (equivalent to \$6.50 as of this writing). The fee doubles for the advanced exploration phase, and doubles again for the exploitation phase.⁶⁸

Site restoration, also known as reclamation, is critical to alleviate or mitigate potential long-term impacts of mining, including those described in Part 1 of this report: surface and ground water pollution; management of toxic runoff and waste, including acid mine drainage; impact on fish and shellfish; and, most importantly, avoidance of ecological disaster.

Remediation costs vary dramatically. They are far lower in an arid desert such as the Atacama of Chile, than in steeply sloped, high rainfall tropical cloud forests. If there is no provision in the mining law to

require the mining company to pay for the cleanup, there is the risk for the taxpayers to carry the burden of remediation costs.

The cost of environmental protection, for both producers and government, can be significantly decreased by proactively incorporating it into initial planning and design, rather than performing remedial measures to compensate for design deficiencies. When issues are addressed on an ad hoc basis as problems develop or enforcement actions occur, costs rise sharply. There are numerous examples of the costs associated with environmental damage once a site is closed and, in many cases, the producer exhausts the remediation funds or even files for bankruptcy to avoid further costs to the parent company. When this happens, local governments must shoulder the costs of dealing with the wasteland and local people suffer the health and environmental impacts. This becomes a liability for the national economy. In Peru, an estimated \$77.5 million is needed to deal with mining's environmental legacies and remediation costs from the preliminary list of the most critical sites. Many specialists and government officials have even said this figure is unrealistically low.⁶⁹

Table 7: Examples of Remediation Costs

Location	Primary Mine Type	Clean-up Costs
Papua New Guinea	Open-pit copper	Settlement agreement of approximately \$350 million dollars for the OK TEDI mine. ⁷⁰
Montana	Open-pit copper	Estimated \$400 to \$500 million for one mine site. ⁷¹
Utah	Open-pit copper	Paid the state \$9 million to replace sources of contaminated water in the primary aquifer. State costs were \$28 million for building a water treatment plant (operational costs not included). ⁷¹
Arizona	Open-pit copper	Potential unfunded environmental liability between \$73 and \$292 million. ⁷²



Buff-tailed Coronet (*Boissonneaua flavescens*) is a species of hummingbird found in Intag's cloud forests.

Part III

Ecosystem Services in Intag

Section Summary: *Ecosystem services can be divided into four categories: Regulating, Habitat, Provisioning, and Information Services. This section reviews local perspectives on ecosystem services and provides specific examples of ecosystem services in Intag.*

Categories of Ecosystem Services

The Millennium Ecosystem Assessment classifies ecosystem services into four broad categories, which describe their ecological role. Under this framework, both goods and services are referred to as “Ecosystem Services.”

- **Provisioning Services** are basic goods including food, water, and materials. In Intag, the forest trees can be used for lumber and paper, wild and cultivated crops provide food, plants can be used for medicinal purposes, and rivers provide fresh water for human consumption as well as fish and agricultural production.
- **Regulating Services** are benefits obtained from the natural control of ecosystem processes. Ecosystems, with minimum human impact, in Intag provide regulation of climate, water, soil, flood and storms, and keep disease organisms in check.
- **Habitat Services** are refuge and reproduction habitat for wild plants, animals, and humans. These services contribute to the conservation of biological and genetic diversity as well as evolutionary processes.
- **Information Services** are the services that provide humans with meaningful interaction with nature. These services include spiritually significant species and natural areas, enjoyable natural places for recreation, and scientific and educational opportunities.

Local Perspectives

In May 2010, a skillshare workshop in Nangulví (located near the Intag River) was held to discuss the trends of ecosystem services with the local stakeholders and to gather local knowledge and perspectives of ecosystem services in Intag. In order to gain further knowledge and a new perspective of the direct status of the benefits provided by natural systems, local people identified valuable ecosystem services and rated their condition. A basic numeric ranking system was used to prioritize ecosystem service importance—water supply was ranked the highest.

Ecosystem Service Descriptions and Examples

Working with the local community of Intag between 2008 and 2010, we identified 23 ecosystem services that contribute significantly to the economy, culture, and quality of life for regional residents.

Specific ecosystem services exist within each category. These services are identified in Table 8.

Table 8: List of 23 Ecosystem Services⁷³

	Good/Service	Examples
Provisioning	Water Supply	Provision of water for consumptive use, includes both quality and quantity
	Food	Hunting, gathering of fish, game, fruits, etc.; small-scale subsistence farming and aquaculture
	Raw Materials	Building and manufacturing; fuel and energy; fodder and fertilizer
	Genetic Resources	Improve crop resistance to pathogens and pests
	Medicinal Resources	Drugs, pharmaceuticals, chemical models, tools, test and assay organisms
	Ornamental Resources	Resources for fashion, handicraft, jewelry, pets, worship, decoration and souvenirs
Regulating	Gas Regulation	Provides clean, breathable air; disease prevention; and a habitable planet
	Climate Regulation	Maintenance of a favorable climate promotes human health, crop productivity, recreation and other services
	Disturbance Prevention	Prevents and mitigates natural hazards and natural events, generally associated with storms and other severe weather
	Soil Retention	Maintains arable land, prevents damage from erosion and promotes agricultural productivity
	Water Regulation	Provides natural irrigation, drainage, channel flow regulation and navigable transportation
	Biological Control	Provides pest and disease control, reduces crop damage
	Waste Treatment	Pollution control/ detoxification; filtering of dust particles through canopy services
	Soil Formation	Promotes agricultural productivity and the integrity of natural ecosystems
	Pollination	Pollination of wild plant species and harvested crops
	Nutrient Regulation	Promotes health and productive soils, and gas, climate and water regulations
Habitat	Habitat and Biodiversity	Maintenance of biological and genetic diversity (and thus the basis for most other functions)
	Nursery	Maintenance of commercially harvested species
Information	Aesthetic Information	Enjoyment of scenery
	Recreation	Travel to natural ecosystems for eco-tourism, outdoor sports, etc.
	Science and education	Use of natural systems for school excursions, etc. Use of nature for scientific research
	Spiritual and historic information	Use of nature for religious or historic purposes (i.e., heritage value of natural ecosystems and features)
	Cultural and Artistic Information	Use of nature as motive in books, film, painting, folklore, national symbols, architecture, advertising, etc

Gas and Climate Regulation

Gas and climate regulation refers to the roles that ecosystems play in regulating the gaseous phase of compounds, organic and inorganic, which affect atmospheric composition, air quality, and climate regulation. The oxygen that people breathe is a product of photosynthesis from marine plankton and terrestrial plants. Removal of pollutants is another important aspect of gas and climate regulation. Low air quality can cause health care costs to spike as respiratory diseases develop. The regulation of climate is dependent on the composition of the atmosphere. Greenhouse gases, such as CO₂ are transparent to light but trap heat, warming our planet like a greenhouse. Carbon dioxide is removed through carbon sequestration as plants absorb CO₂ to produce roots, shoots, stems, and leaves.

Maintaining a climate within a stable range is increasingly a priority for local, federal, and international jurisdictions. The role of forests and other ecosystems in controlling greenhouse gases (GHGs) that contribute to global warming is essential to maintaining a stable climate and prosperous economy. However, carbon sequestration is not the only value provided by gas and climate regulation. Agricultural soils can also sequester more carbon when certain techniques are used, including crop rotations, livestock waste disposal and conservation tillage, especially no-till.^{74 75} Because these types of practices could provide significant global value, there is increased interest in including agricultural lands in carbon trading markets, with farmers receiving payments for their sequestration.



Intag Example:

Carbon offsetting by means of reforestation has become a major priority in Ecuadorian policy. The Ecuadorian Ministry of Environment implemented Programa Socio Bosque (meaning Forest Partner, in English) in 2008 where landowners are paid up to \$30 per hectare to maintain their native forests. Funding provided by UN-REDD Programme.

PROFAFOR (Programa FACE de Forestación) provides carbon dioxide emissions trading in Ecuador, which in 2005, traded at rates of up to \$77 to \$135 per hectare of land that is reforested.^v Local programs have been implemented by schools in Intag to work with carbon offsetting organizations to help reduce CO₂ emissions created by air travel.⁷⁶



v Adjusted for inflation. Original rates from PROFAFOR were \$68 to \$119 per hectare.

Disturbance Prevention

One of the most significant factors in an ecosystem's ability to prevent flooding is the absorption capacity of the land. This is a factor of land cover type (forest vs. pavement, for example), soil structure and quality, as well as other hydrological and geological dynamics within the watershed. The U.S. Geological Survey estimates that urban development leads to increases in peak flood discharge flows of 100–600 percent for 2-year storm events, 20–300 percent for 10-year events, and 10–250 percent for 100-year events.⁷⁷

Retention of forest cover and restoration of floodplains and wetlands provide tangible and valuable ecosystem services. For example, upland forests absorb rainwater, which significantly reduces its downhill and peak flows into major stream and river systems. In undeveloped areas of a watershed, typically less than 15 percent of precipitation reaches streams or rivers as surface runoff, compared with 55–70 percent in a developed watershed. In Ecuador, record flooding occurred in 2008, which affected many communities downstream from the Andes over the flat Ecuadorian Coast.⁷⁸

One of the most critical ecosystem services is flood risk reduction. The loss of wetlands, forests, and natural systems that reduce peak flows and promote infiltration and conveyance also increase flood risk. No current flood planning in Ecuador fully accounts for the protection provided by both natural and built infrastructure.

Preventing flooding in Intag and the lower reaches of the Esmeraldas River will require understanding the ecosystem service function of water regulation. Flood risk mitigation is crucial to making good investments, both in natural and built capital.



Intag Example:

The tropical vegetation of the mountain ranges in Intag hold substantial amounts of water throughout the entire year, especially during peak rainy months of December to April.⁷⁹ On average, the annual rainfall in Intag ranges between 1,000 and 3,000 mm, and often exceeds this range during exceptionally wet rainy seasons, for example, an El Niño event. The vegetative system in these mountains is vital to downstream communities. Without the existence of the tropical cloud forests of Intag, a substantial amount of the rainfall would overflow the rivers and flood several regions at the base of the river system.

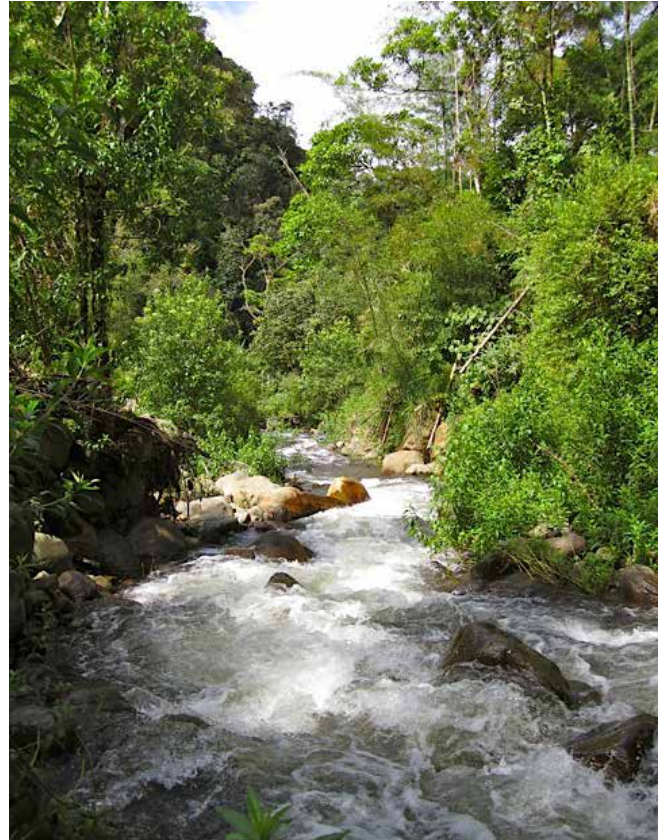
Water Regulation

This category includes regulation of water flows through the ground and along terrestrial surfaces, as well as regulation of temperature, dissolved minerals, and oxygen. Ecosystems absorb water during rains and release it in dry times. They also regulate water temperature and flow for plant and animal species. Forest cover, riparian vegetation and wetlands all contribute to modulating the flow of water from upper portions of the watershed to streams and rivers in the lower watershed.

When forested basins are heavily harvested, the remaining vegetation and litter layer on the forest floor absorbs less water. Because the ground's capacity to absorb water is reduced, more water flows over the land and into streams and rivers. This contributes to higher peak flows, flood events, erosion and landslide issues, as well as lower low flows in summer months, because the water was not retained in natural system.⁸⁰

Intag Example:

Local villagers near the Peñaherra-Cristal micro-watershed usually take 20-minute walks to healthier sections of the forest that provide the materials needed for everyday use.⁸¹ Nearby vegetation providing these items are scarce, mostly due to the clearing of the vegetation in order to develop lands near the villages. According to recent updates, it was estimated that 30-40 percent of land is in urgent need of reforestation.



Soil Retention

Soil serves a vital function in nature. It provides a medium for plant and nutrient growth as well as habitat for millions of micro- and macro-organisms. Healthy soils are able to store water and nutrients, regulate water flow and neutralize pollutants more efficiently than degraded soils.⁸² In this sense, soil retention reinforces a number of other ecosystem services, including disturbance prevention and the provisioning of raw materials.

The soil retention properties of ecosystems determine the rate of erosion, and thus soil retention is closely linked with preventing disturbances such as landslides, which are often caused by excessive erosion and can be attributed to human land use. In many areas, vegetation can prevent landslides and harmful erosion. The susceptibility of a given slope to erosion is determined by grain size, soil cohesion, slope gradient, rainfall frequency and intensity, surface composition and permeability, and type of land cover. A forest's organic layers absorb water during periods of heavy precipitation, acting as a natural sponge and preventing erosion. In areas where active forestry occurs, the upper layers of soil are often removed or degraded.

Intag Example:

As part of the western slopes of Ecuador's northern Andes, the Intag region consists of steep slopes and great canyons.

Soil erosion mainly occurs in elevations below 3,400 meters in Intag.⁸³ This is primarily due to loss of original forest cover and conversion of land to agriculture.



Soil Formation

Soil quality and abundance is critical for human survival, yet human actions can also affect nature's ability to provide high-quality soils. There are generally five elements that influence the type and characteristics of soils: parent material, topography, living organisms, climate, and time characteristics.⁸⁴

Intag Example:

For the most part, parent material is chemically weathered mineral or organic matter that contributes to soil formation. In the Intag zone, the topsoil is rich in organic matter, though in certain regions where the organic matter has not weathered, the soil is formed from silty and sandy deposits. Volcanoes in the region have significantly contributed to the area's relatively rich soils.

The climate is the overarching factor for observed altitudinal differences in soil development by affecting the leaching regime and organic matter decomposition. Climate in the Intag region is that of an equatorial high altitude environment (within 50 km of the Equator) where temperatures stay within a smaller range throughout the year. The Intag and Manduriacos regions have a wide altitudinal range from 650 m to 4,000 m, where the mean annual temperature is about 15°C. At much higher elevations, temperatures drop by 0.6°C for every 100 meters. Like much of the Andean Tropics, Intag has an average rainfall of 1,000 mm to 3,000 mm.

Time is absolutely essential to soil formation. In the volcanic complex of Cotacachi, located east of Intag, there has been a long history of volcanic activity involving several different eruption centers. Closest to Intag, ancient volcanic lake Cuicocha has had three phases of activity, which occurred over a period of a few hundred years, ending at around year 3,000 BP.^{vi} Calderas formed by explosive eruptions result in pyroclastic flows, or massive fast-moving currents of hot gas and ash, that spread throughout the area of the volcano and deposit tephra in a thin blanket.



vi Before Present (BP) years is a time scale used in archaeology, geology, and other scientific disciplines to specify when events in the past occurred.

Nutrient Regulation

The transfer of nutrients from one place to another and transformation of critical nutrients from unusable to usable forms is an essential ecosystem service. There are 22 essential elements for the growth and maintenance of living organisms. All living things depend on the nutrient cycles of carbon, oxygen, nitrogen, phosphorous, and sulfur in relatively large quantities. These are also the nutrient cycles that human actions have most affected. Silicon and iron are important elements in oceanic nutrient cycles because they affect phytoplankton community composition and productivity. Natural processes facilitate the movement of nutrients and turn them from biologically unavailable forms, such as rocks or gases in the atmosphere, into forms that can be used by other living things. Nutrient cycling is a fundamental precursor to ecosystem and economic productivity. Without functioning nutrient cycles, life on the planet would cease to exist.

Living organisms mediate nutrient regulation. On land, plants depend on biologically-mediated breakdown of organic matter to make the nutrients they need for growth available. As plants and plant parts die, they contribute to the pool of organic matter that feeds the microbial, fungal, and micro-invertebrate communities in soils. Underground fungal structures can also provide support to living plants—for example, young trees may not receive enough nutrients through sunlight because mature trees block sunlight, but can instead draw nutrients from mycorrhizal structures hundreds of yards away.⁸⁵ Such communities facilitate the transformation of nutrients from one form to another. Larger animals play a crucial role in nutrient cycles by moving nutrients from one place to another in the form of excrement, and the decomposition of their bodies after they die. Animals also play a role in transporting nutrients between terrestrial and aquatic environments.



Intag example:

In montane tropical forests nutrient availability is determined by temperature and precipitation among other factors. However, limiting nutrients control the overall growth of this ecosystem and the thriving of specific species able to adapt to these limitations. The major components of net primary production (NPP) in tropical montane forests are, in order of importance, above-ground litterfall, root production, and, to a much lesser extent, wood increment. Intag, like other montane forests, depends immensely on the amount of litterfall for the nutrients optimal distribution. Reduction in foliar coverage will affect the NPP of the entire ecosystem, creating disastrous rippling effects.⁸⁶

Waste Treatment

Microorganisms in sediments, soils, and wetlands break down human and other animal wastes.⁸⁷ They can also slowly detoxify petroleum products. The physical destruction of habitat, alteration of food webs, or overload of nutrients or waste products disrupts disease regulation and waste processing services. Alteration of ecosystems can also create breeding sites for disease vectors where they were once nonexistent. People can be exposed to disease in areas through direct contact with bacterial or viral agents while swimming or washing in fresh or saltwater, and by ingesting contaminated fish, seafood or water.

Wetlands, estuarine macro algae, and near-shore sedimentary biota play a crucial role in removing nitrogen and phosphorous from water.⁸⁸ The removal of these nutrients maintains offshore water conditions that are conducive to healthy native fish and invertebrate biota.

Intag Example:

Decomposition rates are rapid in tropical forests characterized by high, constant temperatures and high annual rainfall. However seasonal droughts limit decomposition rates in many tropical forests. Water affects decomposition directly through leaching and indirectly through effect on microbial decomposers. Intag's forests and other vegetative biotypes influence the area's climatic system, thereby reducing casual effects such as droughts, as well as providing forest soils with necessary elements to regenerate, and for decomposition, making essential nutrients available to other organisms.⁸⁹



Biological Control

Biological Control is the ability of ecosystems to limit the prevalence of crop and livestock pests and diseases. A wide variety of pest species destroy human agricultural crops, reducing worldwide harvest by an estimated 42 percent, thereby causing a loss of \$244 billion dollars each year.⁹⁰ A number of natural predators for pest species contribute to natural control of damages. These predators also play a role in protecting forests from pests. Birds, for example, are natural predators of many harmful insects.

Intag Examples:

In recent years, humans have increasingly used pesticides to control crop losses. While pesticides can reduce the risk of specific pest attacks, they can also harm natural predator populations and lead to resistance among pests, making them even more difficult to control in the future. Overuse of pesticides is also known to reduce provisioning of some other ecosystem services, particularly water quality. As agriculture makes up the majority of economic activity in Intag, pesticides have traditionally been used heavily, notably tomatoes, Tree Tomatoes (*Cyphomandra betacea*) and Naranjilla (*Solanum sp.*), which has taken a heavy toll on biodiversity and accessible drinking water.⁹¹

While there may be a role for pesticide control in agricultural practice, there are also ways to manage crops to enhance biological control services. Local grassroots organizations have stepped in and gathered funding in order to educate the regional farmers and help the community purchase and protect local watersheds. Several workshops have been held to educate the public on the impacts of pesticides and sustainable farming in Intag.⁹² These workshops discuss techniques that include crop diversification and genetic diversity, crop rotation, and promoting an abundance of smaller patches of fields.⁹³



Pollination

Pollination is essential to agricultural crops, trees, and flowers, little is known about the status of many pollinator species specific to the Intag region. It is the role that insects, birds, mammals and, in some cases, the wind, play in transporting pollen grains to fertilize plants. People depend on pollination directly for food and fiber, and indirectly as part of ecosystem productivity. Many plant species would go extinct without animal- and insect-mediated pollination. Pollination services by wild animals are also crucial for crop productivity for many types of cultivated foods, enhancing the basic productivity and economic value of agriculture.⁹⁴

The importance of wild pollinators to food crops means that wild habitats near croplands are necessary in order to provide sufficient habitat to keep populations of pollinators intact. Recent research on coffee agrosystems in Costa Rica have shown that the pollination services provided by pollinators nesting in forest patches adjacent to coffee plantations may contribute to substantially greater yields of coffee.⁹⁵ Dr. Taylor Ricketts and a group of scientists from Stanford University and the World Wildlife Fund found that coffee fields near tropical forest fragments had higher productivity yields than coffee fields more distant from the forest. In their case study, they found that coffee farmers beyond 1 km from forest suffered 20 percent lower yields due to inadequate pollination services.⁹⁶

Intag Example:

Coffee is an important agricultural product for many families in the Imbabura Province. Coffee production relies on the diversity of animal and insect pollination. Each farmer protects a small forest on his cultivable land, which allows for habitat of wildlife, including pollinators, and also protects the farmland from erosion. All members of the coffee co-op (AACRI) are required to grow crops under shade trees.





Habitat Refugium and Nursery

Habitat is the biophysical space and process in which wild species meet their needs—a healthy ecosystem provides physical structure, adequate food availability, appropriate chemical and temperature regimes, and protection from predators. Habitat may provide refugium and nursery functions; a refugium refers to general living space for organisms, while nursery habitat is specifically where all the requirements for successful reproduction occur.⁷³ Biodiversity provides the structure and complexity of ecosystems lending resiliency and producing provisioning, regulating, cultural and supporting ecosystem services. In addition to the physical structure provided to species, food/web relationships are important components of habitats that support all species.

Intag Example:

Ecuador is ranked as one of the 17 most biodiverse countries in the world.⁹⁷ The Intag region is located within the Tropical Andes biological hotspot and Tumbes-Chocó-Magdalena biological hotspot.⁹⁸ The Tropical Andes hotspot has been identified as the richest and most diverse region on Earth.⁴⁵ This region contains about a sixth of all plant life in less than one percent of the world's land area, and is home to several endangered and threatened species including the Yellow-eared parrot (*Ognorhynchus icterotis*), Yellow-tailed woolly monkey (*Oreonax flavicauda*), and Spectacled bear (*Tremarctos ornatus*).⁴⁵ The Tumbes-Chocó-Magdalena hotspot is home to the bare-necked umbrella bird and the endangered white-winged guan of southern Ecuador. Many species in the area are threatened or are declining due to urbanization, hunting, and deforestation.⁴⁵

Food

Providing food is one of the most important ecosystem functions. Agricultural lands are our primary source of food; farms are considered modified ecosystems, and food is considered an ecosystem good with labor and built capital inputs. Agricultural value is measured by the total market value of crops produced; however, market value is only a small portion of the total value agricultural lands provide through pollination, carbon sequestration, aesthetic value, and other services.

Intag Examples:

Fifty percent of Intag has been converted to small and medium farms. Even in the steep and mountainous area, approximately 90 percent of the population owns land that is farmed. Farm sizes range from 1 to 50 hectares, where a variety of crops are grown, including fruits such as citrus, papayas, pineapples, blackberries, plantains; and vegetables such as broad beans, peas, yuca (*Manihot esculenta*), camote (*Ipomoea sp.*), carrots, potatoes, avocados, tree tomatoes, beans, and corn.^{vii} Although most of the crops are used locally, growing portions are sold in regional markets such as Otavalo. Other cultivated products include sugar cane, coffee and cabuya (*Furcraea sp.*).



Yuca (*Manihot esculenta*)



vii This is a partial list of the diverse crops grown on a typical farm.

Water Supply

Watersheds produce water, including surface water and groundwater for rural and metropolitan areas. The hydrological cycle is affected by structural elements of a watershed, such as forests, wetlands, and geology, as well as processes, such as evapotranspiration and climate. According to the UNEP; over 60 percent of the world's population gets their drinking water from forested watersheds. The total rainfall per person in Ecuador is 43,000 cubic meters, which is three times the world average rainfall.⁹⁹ Yet only 36.8 percent of the country's population has access to potable water and, on average, 41.8 percent has access to sewage services.¹⁰⁰ The rainfall figure is misleading because water resources are not distributed evenly over the year, geographically, or throughout the population. Increasing loss of forest cover around the world has decreased water supply due to lower groundwater recharge and to lower flow reliability.¹⁰¹

Ecuador has been a pioneer in water economics. Below are three case studies of successful national water projects that have proven users' interest in protecting local watersheds.

Case # 1 FONAG, the Water Fund for Quito. Ninety percent of Quito's drinking water comes from the Condor biosphere reserve. A group of private, public, and international organizations developed a fund with the purpose of creating a permanent financial source for watershed conservation at the Condor Bioreserve.^{viii} The fund was created in 2000 by voluntary contributions from water users and increased up to US \$1.65 million from 2001–2005. During this time period, it provided for watershed services, forest protection, and compensation to 27,000 reserve residents.¹⁰⁰

viii Fundación Antisana (a local NGO), USAID, The Nature Conservancy and Ecodecision (a local environmental organization)

Case # 2 Pimampiro Payment for Ecological Services.

In 2000, the municipality of Pimampiro launched a payment program for the protection of the upper watershed that delivers their community drinking water. The municipality pays 27 households living on the banks of the Palaurco River for water quality and quantity protection, as well as forest and páramo protection and regeneration. The payment is financed with a 20 percent consumption fee paid by water users in Pimampiro and the interests generated by a fund with an initial capital of US \$15,000.¹⁰²

Case # 3 Pedro Moncayo and Otavalo Micro-Watershed Reforestation Fund.

Pedro Moncayo and Otavalo Micro-Watershed Reforestation Fund was created to protect Lake Mojanda. Deforestation of the slopes around the lake has led to a drop in the lake's water level (5 meters in last 10 years) and there are concerns about future water availability. The Municipal Company for Drinking Water and Waste Treatment and irrigation users began compensating people in the micro-valleys within the slopes of Mojanda for improving management such as agroforestry practices and commercial plantations reforesting using native species.¹⁰³

Intag Example:

Cloud forests are unique in their ability to store water. As tropic weather heads east from the Pacific Ocean, more water is pushed inland and moisture is forced up the Andes mountain ranges. Cloud forests in tropical areas store water ranging from 3,000 to 50,000 liters per hectare.¹⁰⁴ Recent studies show how clearing rain forests impacts local climates as far as 50 km away.¹⁰⁵ As winds move across cleared lowlands, clouds are lifted higher over the mountains. Fewer clouds form over the forests, leading to less rainfall and a cycle of dying forests, changing vegetation growth and wind patterns.

Raw Materials

Raw materials include biological materials used for medicines, fuel, art, and building, as well as geological materials used for construction or other purposes. Crude oil, natural gas, and other fossil fuels are not considered in this category because they are not renewable.

Intag Example:

The agave plant, locally known as Cabuya, is an extremely useful plant. The plant is primarily used for fibers from the leaf (sisal). Useful goods are produced with the sisal, such as baskets, purses, belts, hats, and even iPad covers. Vegetable ivory (*Phytelephas sp.*), known as Tagua in Ecuador, is used in a wide variety of products such as handicrafts and jewelry. The Tagua has become an important substitute for elephant ivory. The women's group, Mujer y Ambiente, has been producing hand made handicrafts since 1993. They meet once a month to share techniques and to talk about events happening in the area.

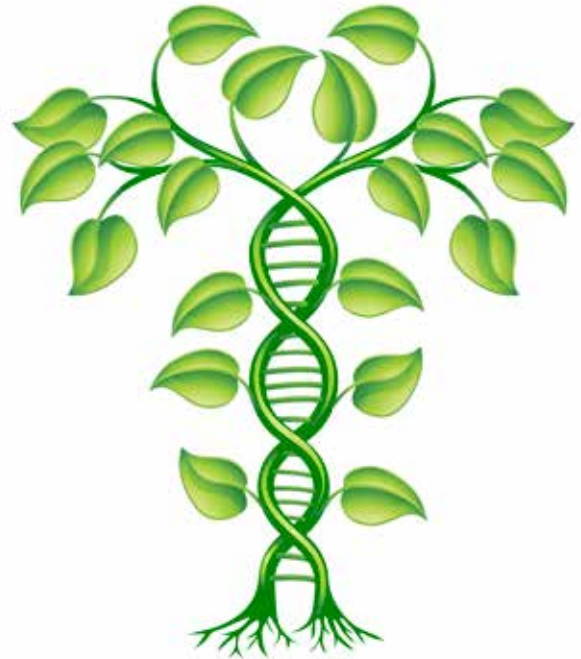


Genetic Resources

Genetic resources represent an ecosystem service in itself because novel, valuable products have been derived from genetic and chemical properties of species. Genetic resources provide a secure food base (multiple sources of food with different seasonal availability). Recent developments in plant biology have allowed scientists to study the patterns of evolution, which allow flora to adapt and coexist with newly introduced pests, pesticides, fertilizers, and climates. Genetic material has yet to be fully understood and thus potential applications of endangered plant species provide a significant enough reason to preserve them.

Intag Example:

The Tropical Andes biological hotspot supports 664 distinct species of amphibians, the largest variety in the world, with almost 450 amphibian species listed as threatened on the 2004 IUCN Red List.⁴⁵



Aesthetic and Recreational

Aesthetic value, as an ecosystem service, refers to the appreciation of natural land and seascapes. The existence of national parks and designated scenic areas attests to the social importance of this service. There is also substantial evidence demonstrating the economic value of environmental aesthetics through analysis of data on tourism, housing markets, wages, and relocation decisions. Degraded landscapes are frequently associated with economic decline and stagnation.¹⁰⁶

Intag Examples:

Intag's unique environment is becoming increasingly popular as a tourist destination. Notably, according to the Intag Cloud Forest Reserve, there are 219 bird species, with more added every year.

According to a U.S. AID Report, tourism in Ecuador is the third largest source of foreign exchange and provides employment for nearly three percent of the economically active population, accounting for nearly 400,000 jobs.⁹⁷ The Ecotourism Network of Intag (REI) is made up of 13 organizations based in Intag's parishes. REI hopes local, national, and international tourists will begin to recognize Intag. At the moment, tourism in Intag is underdeveloped compared with the Galapagos and the Amazon. Efforts are underway to map trails in the Intag region to market Intag to tourists who visit Otavalo.

From the Galapagos Islands to the Pacific coast, Pacific slope, paramo, eastern slope, and tropical forests, Ecuador has a tremendous diversity of spectacular tourist opportunities. This represents a substantial opportunity for economic development and foreign cash infusion in many areas of the country.



Scientific and Educational

The number of educational and research institutions devoted to studying marine and terrestrial environments shows the scientific and educational importance of ecosystems. Government, academic, and private resources are all devoted to formally studying ecosystems in the Intag region. Such pursuits benefit people through direct knowledge gained for subsistence.

Intag Example:

Several social, scientific, and educational institutions devoted to terrestrial environments collaborate and aid local communities that rely on the Intag Forest Region. They also provide locally significant employment. DECOIN, Xarxa, Rainforest Concern, GEO schützt den Regenwald e.V., the Sloth Club are just some of a long list of organizations involved in supporting Intag's communities. University study abroad organizations, such as Global Learning, are also becoming an important source of support for the emerging nature-based and solidarity tourism initiatives.

Camera trapping methods have recently been used in several regions of the Andes Mountains to estimate the density of specific and possibly endangered species of animal. In one study, 15 Andean Bears were identified from camera trap photos feeding on wild avocados.¹⁰⁷

Various universities conducted field studies in or around Intag, including the University of Sussex, which looked at conservation efforts for the brown-headed spider monkey (*Ateles fusciceps*).¹⁰⁸



Medicinal Resource

Medicinal resources are rarely valued in ecosystem service literature or in traditional economic analyses. Maintaining ecological diversity is crucial to ensuring the availability of genetic and biological resources for future medical discoveries. About 25 percent of mainstream drugs used by Western medicine come from the rainforest. The U.S. National Cancer Institute has reported that more than two-thirds of all medicines with cancer-fighting properties have come from rainforest plants.¹⁰⁹ Additionally, at least ten billion dollars per year in research are spent in Western countries.¹¹⁰ Scientists are looking to nature to find the cure to cancer. These efforts include studying bears and their habits of hibernation for treatment for kidney failure, and studying fungi, *Cordyceps*, as a potential alternative to treating Chagas, a disease common in Central in South America. Despite this, less than one percent of tropical rainforest plant species have been investigated for their potential use as therapeutic agents.



Cinchona tree (*Cinchona rubra*)

Intag Examples:

Quinine is an organic chemical derived from the bark of the cinchona tree (*Cinchona rubra*), which is native to the Andean regions in South America. For nearly 400 years after its effectiveness was first documented, Quinine was valuable for treating malaria for hundreds of millions of people and in some parts of the world it is still an important anti-malarial drug.

The Sangre de Drago is a latex-like sap that comes from the Croton species of tree found in Intag. This medicinal sap was used for centuries by the indigenous peoples of the Amazon to treat various ailments, including diarrhea; ulcers in the mouth, throat, stomach, and intestines; upper respiratory viruses; cancer; and wounds.¹¹¹

Ornamental resources

Ornamental resources are animal or plant products used for fashion, decoration, and jewelry that meet human needs through “aesthetic beauty and intellectual stimulation that lift the human spirit”.¹¹²

Intag Example:

Ecuador has the largest variety of orchids in the world (declared in the International Orchid Expo in Hannover, 2000).¹¹³ There are at least 4,215 different orchid species in the country. Besides being an important tourist attraction, orchids are an increasingly attractive export product for Ecuador, with an estimated 60,000 orchids exported a year.¹¹⁴ Data from the Central Bank of Ecuador indicates that 31 percent of orchid exports went to Germany, 29 percent went to Singapore, 25 percent went to the United States, and four percent went to Japan.¹¹⁵ The biggest orchid exporter in Ecuador is Ecuagenera, which exports around 40,000 plants each year, at prices varying from \$8 to \$50 per plant. This exporter alone provides between \$320,000 to \$2 million to the Ecuadorian economy.¹¹⁶ The orchids grown in Intag are mainly for personal use. It is also one of the largest attractions for tourists who make the trek to Intag.



Cultural and Spiritual

Many natural areas have special value to native people from a spiritual perspective, as evidenced by indigenous traditions, stories, and art depicting wildlife and natural systems. Non-native people also tend to feel an emotional or spiritual connection to the landscape in which they live. Spiritual and religious values are impossible to assess monetarily, as there is no real way to measure their quantity or importance across individuals.

The use of “willingness to pay” surveys for natural goods and services, such as protection for whales or tropical species, reveals that many people rank the protection of nature above additional material gains. That is to say, they would choose protection over a monetary reward. Some respondents to such survey instruments give “protest bids,” which indicate that they are not willing to put a finite price on saving wildlife or wild places.

Intag Example:

The wealth of cultural history has barely been studied in Intag. Before the Incas broadened their reign into northern Ecuador, the Yumbo people inhabited a region in the Imbabura and Pichincha provinces, just north of Quito, from 800 to 1600 A.D.¹¹⁷ The Yumbo Interpretation Centre attracts many visitors with its burial mounds providing insight into the history of the region.



“As long as we are forced to make choices,
we are going through the process of valuation.”

-Robert Costanza



Part IV

Valuation Analysis of the Intag Region

Section Summary: *The economic value of ecosystem services generated in the Intag Region was estimated using the benefit transfer methodology. The results of this methodology indicate that ecosystem goods and services within Intag generate a large amount of monetary value to the economy.*

Valuation Methodology

The benefit transfer methodology was used to conduct an economic valuation on Intag. This analysis is a widely accepted economic methodology that estimates the economic value of an ecological good or service as determined by examining previous valuation studies of similar goods or services in other comparable locations. The study used on Intag uses values from Ecuador, as well as values from similar ecosystems elsewhere in the world.

Earth Economics manages a database of published, peer-reviewed ecosystem service valuation studies. Originally developed in partnership with the Gund Institute for Ecological Economics at the University of Vermont, the database provides value transfer estimates based on land cover types and is regularly updated.

The value of the ecosystem services is additive. A hectare of forestland provides water regulation and filtration services, as well as aesthetic, flood protection and refugium benefits. One study may establish the value per hectare of a watershed in water filtration for a drinking water supply. Another study may examine the value per acre of refugium for wildlife. To determine the full per-acre value provided by a vegetation type, ecosystem service values are summed up and multiplied by the acreage.

The valuation techniques utilized to derive the values in the database were developed primarily within environmental and natural resource economics, and include direct use value and indirect use value. Direct use value involves interaction with the ecosystem itself rather than via the services it provides. It may be a consumptive use, such as the harvesting of trees or fish, or it may be non-consumptive use, such as hiking, bird watching, or educational activities. This value is often determined by market exchange values of goods produced or costs associated with enjoying the resource.

Indirect use value is derived from services provided by the ecosystem when direct values are not available. This may include the removal of nutrients, providing cleaner water down stream (water filtration), or the prevention of downstream flooding. Studies may derive values from associated market prices such as property values or travel costs. Values can also be derived from substitute costs like the cost of building a water filtration plant when natural ecosystem filtration services are disturbed and fail. Contingent valuation is an additional method that entails asking individuals or groups what they are willing to pay for a good or service. Table 9 describes the primary valuation methods used in this report.

Table 9: Methods for Primary Research in Ecosystem Service Valuation.

Direct Use Values	
Market Price	Prices set in the marketplace appropriately reflect the value to the “marginal buyer.” The price of a good tells us how much society would gain (or lose) if a little more (or less) of the good were made available. <i>Example: Rainforest products such as coffee and cacao.</i>
Indirect Use Values	
Avoided Cost	Value of costs avoided by ecosystem services that would have been incurred in the absence of those services. <i>Example: Hurricane protection provided by barrier islands avoids property damages along the coast.</i>
Replacement Cost	Cost of replacing ecosystem services with man-made systems. <i>Example: Natural water filtration replaced with costly man-made filtration plant.</i>
Factor Income	The enhancement of income by ecosystem service provision. <i>Example: Water quality improvements increase commercial fisheries catch and incomes of fishermen.</i>
Travel Cost	Cost of travel required to consume or enjoy ecosystem services. Travel costs can reflect the implied value of the service. <i>Example: Recreation areas attract tourists whose value placed on that area must be at least what they were willing to pay to travel to it.</i>
Hedonic Pricing	The reflection of service demand in the prices people will pay for associated goods. <i>Example: Housing prices along the coastline tend to exceed the prices of inland homes.</i>
Contingent Valuation	Value for service demand elicited by posing hypothetical scenarios that involve some valuation of land use alternatives. <i>Example: People would be willing to pay for increased preservation of beaches and shoreline.</i>
Group Valuation	Discourse-based contingent valuation, which is arrived at by bringing together a group of stakeholders to discuss values to depict society’s willingness to pay. <i>Example: Government, citizen’s groups, businesses come together to determine the value of an area and the services it provides.</i>

Intag Land Cover Class

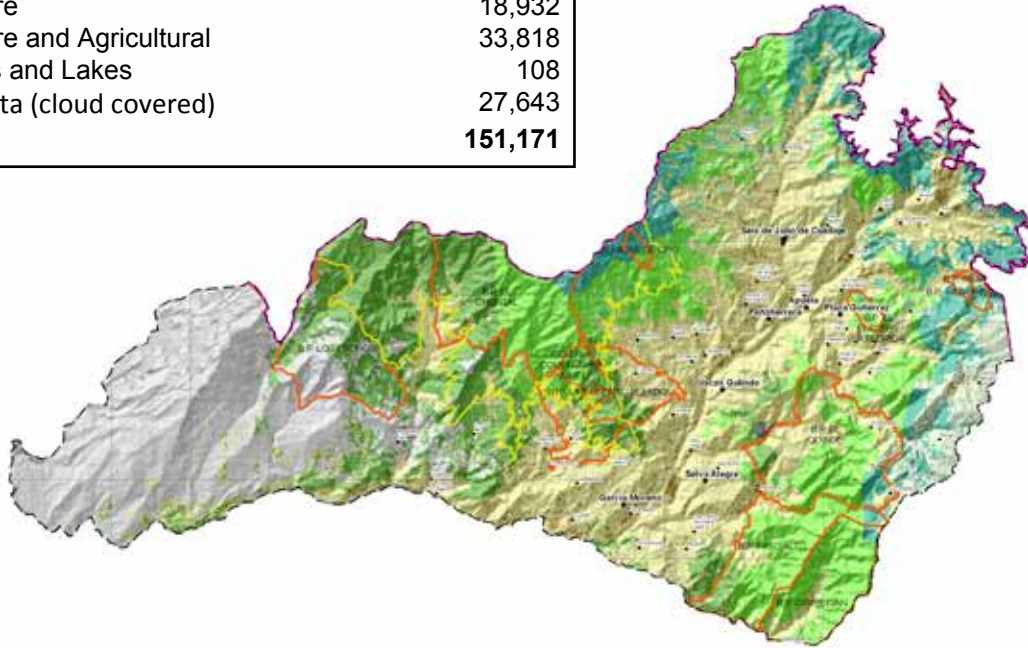
The total area of the Intag region is roughly 150,000 hectares. Geographic Information Systems (GIS) data on land cover (forests, bamboo, rivers, pastures) is provided by satellite surveys. These land cover types provide suites of ecosystem services that we can value. One challenge of gathering GIS data in a region like Intag is that cloud forests tend to limit satellite coverage. Satellite information was not available for 27,643 ha of the Intag area because of cloud cover. This is important to note because it means that the values presented in this study are undervalued. The area valued totaled 123,528 hectares or 82 percent of the total area (18 percent of the land area was

obscured by clouds when satellite photos were taken, those photos were the basis for the GIS analysis).

Land cover data derived from EcoPar, an environmental non-profit organization based in Ecuador, reflects the best available GIS data for the Intag region. The following table shows GIS land cover type and area for each class in the region. The vegetation data was realized in 2008 using Landsat and Aster images in 2002 and 2007, respectively. Cloud forests and agricultural lands mainly cover the Intag region. Figure 8 shows the geographic boundary of the study site.

Figure 8: Map and Acreage of Intag Region by Land Cover Class (2008)


Land Cover Types	Hectares
Agricultural Lands	3,432
Bamboo	1,900
Cloud Forests	60,965
Native Andean Alpine Grasslands	4,373
Pasture	18,932
Pasture and Agricultural	33,818
Rivers and Lakes	108
No Data (cloud covered)	27,643
Total	151,171





Source: EcoPar, Fernando Espinosa

Table 10: Ecosystem Services Identified and Valued in Intag

	Agricultural lands	Grasslands	Lakes/Rivers	Pasture	Pasture/Agricultural	Bamboo	Cloud Forest
Aesthetic and Recreational	X		X		X		X
Biological Control		X			X		X
Cultural and Spiritual							
Disturbance Regulation							
Erosion Control	X	X					X
Gas and Climate Regulation	X	X				X	X
Genetic Resources							X
Habitat Refugium & Nursery		X	X			X	X
Medicinal Resources							
Nutrient Cycling	X						X
Pollination	X	X			X		X
Raw Materials	X					X	X
Soil Formation	X	X		X	X	X	X
Waste Treatment		X	X			X	X
Water Regulation		X	X				X
Water Supply		X	X			X	X
Food Production	X	X	X		X		X

 Ecosystem service produced but **not** valued in this report

 Ecosystem service produced and valued in this report

 Ecosystem service not produced by land cover class

Ecosystem Services Identified and Valued

Of the 23 ecosystem services identified by the local community, we were able to place a dollar value on 18 of them. Some important ecosystem services were not provided a dollar value for one of the following reasons: (1) Primary studies did not exist for the ecosystem service identified; (2) No method exists to place a monetary value on the ecosystem service identified; or (3) It is impossible to place a value on some services, such as cultural and spiritual services. The following table identifies which services were valued in this study by land cover type.

High and Low Value Estimates by Land Cover Class

The following series of tables provide high and low valuation results per hectare by land cover type. All values are adjusted for inflation and are presented in 2009 US dollar per hectare per year units.

Appendices C-D describe the land cover type, ecosystem service, authors of papers used in this study, the lowest and the highest values known for each value utilized in this study. There is also a single value column where low and high values do not exist.

Table 11: High and Low Estimates for Agricultural Lands

	Agricultural Lands (per ha per yr)	
	Min	Max
Aesthetic and Recreational	\$72.03	\$72.03
Biological Control		
Erosion Control	\$14.16	\$14.16
Gas and Climate Regulation	\$27.70	\$774.00
Genetic Resources		
Habitat Refugium and Nursery		
Nutrient Cycling	\$54.27	\$54.27
Pollination	\$6.29	\$419.41
Raw Materials	\$988.65	\$2,525.28
Soil Formation	\$14.16	\$14.16
Waste Treatment		
Water Regulation		
Water Supply		
Food Production	\$384.47	\$10,512.64
Total	\$1,561.73	\$14,385.95

Table 12: High and Low Estimates for Bamboo

	Bamboo (per ha per yr)	
	Min	Max
Aesthetic and Recreational		
Biological Control		
Erosion Control		
Gas and Climate Regulation	\$474.45	\$615.01
Genetic Resources		
Habitat Refugium and Nursery	\$572.85	\$572.85
Nutrient Cycling		
Pollination		
Raw Materials	\$456.86	\$456.86
Soil Formation	\$676.24	\$676.24
Waste Treatment	\$230.19	\$230.19
Water Regulation		
Water Supply	\$562.14	\$562.14
Food Production		
Total	\$2,972.73	\$3,113.29

Table 13: High and Low Estimates for Cloud Forests

	Cloud Forests (per ha per yr)	
	Min	Max
Aesthetic and Recreational	\$3.68	\$766.06
Biological Control	\$5.68	\$23.55
Erosion Control	\$6.82	\$958.89
Gas and Climate Regulation	\$26.12	\$623.02
Genetic Resources	\$1.73	\$253.84
Habitat Refugium and Nursery	\$2.59	\$1,342.82
Nutrient Cycling	\$514.55	\$1,346.65
Pollination	\$3.10	\$654.83
Raw Materials	\$11.21	\$3,423.68
Soil Formation	\$10.01	\$14.26
Waste Treatment	\$86.51	\$259.52
Water Regulation	\$25.17	\$76.65
Water Supply	\$3.10	\$10.58
Food Production	\$8.38	\$2,659.22
Total	\$708.65	\$12,413.57

Table 14: High and Low Estimates for Pasture

	Pasture (per ha per yr)	
	Min	Max
Aesthetic and Recreational		
Biological Control		
Erosion Control		
Gas and Climate Regulation		
Genetic Resources		
Habitat Refugium and Nursery		
Nutrient Cycling		
Pollination		
Raw Materials		
Soil Formation	\$16.29	\$16.29
Waste Treatment		
Water Regulation		
Water Supply		
Food Production		
Total	\$16.29	\$16.29

Table 15: High and Low Estimates for Pasture and Agricultural

	Pasture and Agricultural (per ha per yr)	
	Min	Max
Aesthetic and Recreational	\$63.68	\$63.68
Biological Control	\$33.51	\$33.51
Erosion Control		
Gas and Climate Regulation		
Genetic Resources		
Habitat Refugium and Nursery		
Nutrient Cycling		
Pollination	\$5.56	\$28.02
Raw Materials		
Soil Formation	\$1.41	\$1.41
Waste Treatment		
Water Regulation		
Water Supply		
Food Production	\$86.26	\$86.26
Total	\$190.42	\$212.88

Table 16: High and Low Estimates for Native Andean Alpine Grassland

	Native Andean Alpine Grasslands (per ha per yr)	
	Min	Max
Aesthetic and Recreational		
Biological Control	\$22.61	\$33.16
Erosion Control	\$41.83	\$44.21
Gas and Climate Regulation	\$9.41	\$397.35
Genetic Resources		
Habitat Refugium and Nursery	\$3.10	\$3.10
Nutrient Cycling		
Pollination	\$25.01	\$36.07
Raw Materials		
Soil Formation	\$1.21	\$1.44
Waste Treatment	\$7.48	\$125.49
Water Regulation	\$4.32	\$5.02
Water Supply	\$3.10	\$14.95
Food Production	\$57.03	\$57.03
Total	\$175.11	\$717.81

Table 17: High and Low Estimates for Rivers and Lakes

	Rivers and Lakes (per ha per yr)	
	Min	Max
Aesthetic and Recreational	\$33.87	\$51,597.93
Biological Control		
Erosion Control		
Gas and Climate Regulation		
Genetic Resources		
Habitat Refugium and Nursery	\$42.33	\$42.33
Nutrient Cycling		
Pollination		
Raw Materials		
Soil Formation		
Waste Treatment	\$183.92	\$2,391.04
Water Regulation	\$3,697.88	\$6,466.48
Water Supply	\$79.91	\$14,641.83
Food Production	\$40.99	\$40.99
Total	\$4,078.91	\$75,180.60

Per hectare values were summed for each land cover class across ecosystem services. Table 18 shows the acreage value of each vegetation type within the region, the total \$ per hectare for that vegetation type across the ecosystem services where values exist. Because no valuation studies for sum vegetation type per ecosystem service value combinations exist for some services, these are clearly underestimates.

Table 18: Annual Ecosystem Service Value Flows for the Intag Region

Land Cover Types	Acreage	Low and High Values (per Acre per Year)		Annual Low and High Totals (Values x Acreage)	
	Hectares	Low	High	Low	High
Agricultural Lands	3,432	\$1,561.73	\$14,385.95	\$5,359,864.44	\$49,372,582.60
Bamboo	1,900	\$2,972.73	\$3,113.29	\$5,648,187.00	\$5,915,251.00
Cloud Forests	60,965	\$708.65	\$12,413.57	\$43,203,021.44	\$756,793,127.50
Native Andean Alpine Grasslands	4,373	\$175.11	\$717.81	\$765,743.02	\$3,138,989.33
Pasture	18,932	\$16.29	\$16.29	\$308,443.02	\$308,443.02
Pasture and Agricultural	33,818	\$190.42	\$212.88	\$6,439,603.47	\$7,199,219.29
Rivers and Lakes	108	\$4,078.91	\$75,180.60	\$440,522.14	\$8,119,504.91
No Data	27,643	-	-	-	-
Total	151,171			\$62,165,384.53	\$830,847,117.65

Summary of Results

The annual flow of value shown by the partial valuation of 17 ecosystem services across seven land cover types in the Intag region is roughly between \$62 million and \$831 million. The low and high estimates are both underestimated because several ecosystem services have not been included; these services are appreciating in value and for other reasons noted in Appendix A. This represents significant development and income opportunity for the region and a basis for sustainable economic development.

From this annual flow of value, a capital asset value analogous to an “asset value” can be calculated. This is the difference between the sum of monthly mortgage payments across the year (an annual flow of value for living in the house for one year) and the full sale value of a house (the asset value or present value). To determine the present value of ecosystems to society, we apply a depreciation (or discount) rate of three-percent over 100 years from the present day. Applying a commonly used three-percent discount rate, we find that Intag’s 17 ecosystem services that were examined provide an asset value between \$3 billion and \$28 billion. This shows there that the current natural and agricultural systems of the Intag region are tremendous national assets. Because natural assets appreciate, rather than depreciate, over time the discount rate is likely closer to zero.

Table 19: Present Value over 100 Years with Zero and Three Percent Discount Rates

Discount Rate (100 years)	Low Estimate (US\$ billion)	High Estimate (US\$ billion)
0%	\$6	\$83
3%	\$3	\$28

The discount rate measures how much value current decision-makers give to future value production. A zero-percent discount rate implies that current flows of ecosystem services are just as important to future flows of ecosystem services. A three-percent discount rate implies that people today have a time preference - what remains in the future is less important than what we have today.

Calculations of the present value of the flow of ecosystem services do show that intact natural systems provide enormous value to society in the short- and long-term. The present generation receives a relatively small amount of the total value provided by these systems. For example, the supply of drinking water for this year is critically important and clearly valuable, but is small in comparison to the total amount of water and value provided over a 100-year period. Through time, future generations will cumulatively receive very large economic benefits from functioning natural capital.

Self-interested actions that damage the long-term productivity of these systems for short-term gain could result in vegetative destruction or ecological process changes that would degrade the ecological services provided. This would likely result in a substantial loss of benefits and potentially substantial costs incurred by public and private individuals and firms.

Even on the low side of these estimates, these values clearly support a significantly higher investment in conservation, which will produce higher real benefits for residents. The asset value of ecosystems in the Intag region certainly exceeds billions.



Apuela, a small town in Intag

Part V

Implications and Recommendations

Section Summary: *Economies depend upon ecosystem goods and services, and become weakened when regional ecosystems are degraded. The long-term health of the Intag Region and Ecuador depends upon our ability to make wise choices and investments that increase the productive capacity of the watershed's natural capital. Recommendations on how to understand and positively apply the results of this study are designated in **bold text** below.*

Investing in the Future

Ecuadorian leadership has critical investment decisions to make. The term “investment” describes choices made today to allocate resources to generate returns in the future. An economy is the product of previous decades of investment. Even without a catastrophic industrial accident, the cost of mining production, remediation, and reclamation far outweighs the short-term profits gained by mining in this unique and sensitive region.

The city of Quito has a first-rate public transportation system, which surpasses those of many cities in the United States. It is because leaders over 15 years ago invested in the bus rapid transit. When investing in this infrastructure, the city considered not only the short-term costs and benefits of local transportation, but also the long-term investment in a world approaching peak oil. Ecuadorian leadership should apply this same principle when making mining decisions for the Intag region.

As ecosystems in the Intag region become fragmented and the fragile cloud forests become scarcer, it is imperative to support new and existing conservation and restoration projects for the future regional economy.

Decision-Making Support

The large dollar values of ecosystem services in the Intag region demonstrate the importance of natural systems to the local economy. The appraisal values identified in this study are defensible and applicable to decision-making at every jurisdictional level.

This study provides decision-makers an opportunity to shift from addressing issues and challenges at a single jurisdiction and single issue to taking an integrated approach of developing a sustainable economy in which natural capital is an integral part of wise investments that maintain or rise in value over time.

Watershed Characterization

Watershed characterizations and other watershed-based analyses should be a priority. Understanding and documenting watershed boundaries and flow is incredibly important to development in the 21st century. In recent years, characterization methodologies have dramatically advanced to recognize that human economy and ecosystem services are crucial to understanding the value and depth of watershed characterization. It is also important that provincial and national agencies adopt this analysis as a normal part of operations. Training for academic institutions, private firms (including consulting companies and nonprofits), and government agencies in ecosystem service analysis

should proceed at a rapid pace.

Economic benefits provided by natural systems are important and need to be valued to properly inform public and private investment. These improvements in economic analysis, which promote better investment, are informed by ecosystem services. The mapping of ecosystem services on the landscape, their provisioning, beneficiaries, and impediments all inform how institutions should be set up and how incentives and funding mechanisms should be created. Government funding mechanisms could be greatly improved by setting up mechanisms on the global scale, where beneficiaries in Europe, North America and Asia can compensate for the benefits of biodiversity, climate stability, and other global benefits provided by areas like Intag.

Completing watershed characterization studies should be made a priority, including ecosystem services, which are crucial to solving many of the biological and economic sustainability issues in Intag.

Cost/Benefit Analysis

A cost/benefit analysis is used to make investment decisions in areas such as health care, levee construction, education, road building, economic development, and tax breaks. If a cost/benefit analysis is flawed, investments will be flawed. For example, a fish-processing plant counts as an asset in cost/benefit analysis. However, United States' federal rules do not recognize natural systems as assets. Therefore it is not recognized or valued in the cost/benefit analysis.

In the United States, the federal cost/benefit analysis rules (Principles and Guidelines) are currently being rewritten to include the value of natural systems and ecosystem services. This will affect all federal agencies from the National Health Institute to the Army Corps of Engineers. The process is expected to take two years. It is Earth Economics' experience that

when local and regional jurisdictions factor natural capital into cost/benefit analysis, better-informed decisions result. When working with federal agencies on projects, local jurisdictions have an opportunity to take a leadership role.

Local jurisdictions in Ecuador should encourage this during project planning phases to develop a full range of alternatives including no-project options, to gain a full understanding of the potential risks and benefits of any project.

Project Prioritization

Criteria for selection and prioritization of capital infrastructure projects need to reflect the goals of the communities and the policies of local jurisdictions. Although not a comprehensive list of criteria, some questions driven by ecosystem services-related policies include:

1. **Does the project enhance or maintain natural processes?**
2. **Do the project impacts enhance or degrade associated ecosystem services (such as habitat or water quality) at the site-specific or regional scales?**
3. **Are the costs and benefits (safety, health, economic, and ecological) of this project distributed equitably over time and space?**

Environmental Impact Statements

Environmental impact statements (EISs) can affect project design and investment by identifying actions that reduce the negative environmental impacts or enhance restoration. One of the fundamental challenges of EISs is the lack of an economic interface. In other words, environmental damages can be quantified in scientific terms, but this has no common language with project financing, which is denominated in dollars. Ecosystem service identification and valuation often strengthen the weakest area of environmental planning and analysis: providing an understanding of the economic benefits

and costs of conservation or restoration projects.

In 2010, the Peruvian congress passed a law requiring EISs for all development projects to include ecosystem service valuation. The Peruvian Ministry of Environment then requested Earth Economics' assistance in developing a robust valuation program, which utilizes web-based tools that can be run by planning officials or local consultants. Earth Economics is currently developing a web-based tool called SERVES (Simple Effective Resource for Valuing Ecosystem Services) to do scenario valuation and will have an internal version of that tool in late 2011. Earth Economics is working with the Peruvian government to fundraise to make this tool and the required training available to be used for all development projects in two pilot provinces in 2012.

Providing this valuation in EISs allows for a stronger understanding of the economic benefits the project provides. Identifying the dollar value of ecosystem services enhanced by the project and provided to the public also strengthens the capacity for funding proposals. **Private and public institutions should include an ecosystem service analysis to strengthen environmental impact assessments. Policy makers should lead the nation in requiring ecosystem service analysis in all applicable EISs.**

Environmental Bonds

Large-scale mining may cause health and environmental impacts. History shows that without including the potential costs of restoration, long-term health, and environmental damage, taxpayers or local communities may pay vast costs beyond the life of the mine. The US EPA and other national institutions have created environmental bonds so that the risk of catastrophic or long-term damage can be included up front in the costs of a risky project. The environmental bond does three things. First, it provides an incentive for companies to invest in technology and actions that reduce the risk of damaging others and the environment because as the risk of damage is

reduced, the size of the bond required is reduced. Second, it ensures that if there is severe damage, then sufficient funds have been set aside to repair and restore damaged areas and compensate people damaged by that action. Finally, environmental bonding shifts mining and other risky investments to areas where they have less risk of damaging people and sensitive environmental areas. For example, one aspect of the environmental bond for a mine in the Atacama Desert would be less than a bond in Intag, because there is less rainfall and potential risk for a flood event to wash mine waste into downstream communities. **If mining does proceed, the size of the environmental bond should be capable of covering potential damages.**

Development of Funding Sources

The values included in this report are not spatially explicit but they do provide reference values for some of the ecosystem services that are produced by comparable ecosystems to those in the Intag region. A riparian restoration group, for example, might like to apply for grant funding that would restore 100 acres of riparian forest. Using the values found in Appendix C as a reference, they can perform a simple calculation to show the increase in public economic value generated by that land, thus showing an economic return on investment to the region in addition to the ecological Return on Investment (ROI). **Ecosystem service valuation can provide conservation and restoration organizations, local and national agencies, and private owners with the tools to show a rate of return on investment for natural resource investments. This is a new tool and it enables restoration projects to show monetary as well as ecological benefits of projects implemented.**

Jobs Analysis

Ecosystem services and jobs are closely connected. Examinations of jobs created by projects that improve natural systems have economic importance. Establishing an increase in permanent gainful

employment is far more important than providing temporary jobs. **Jobs analysis (i.e. number of jobs created) should be effectively linked to economic advancement and sustainability.**

Towards a Sustainable and Desirable Future

Infrastructure can be further integrated to satisfy multiple goals (e.g. sustainability, economic development, and flood protection) to provide a better return on investment over time. Understanding where and how to invest in a watershed is essential to improving human wellbeing. Intag leaders can use the concepts, values, and recommendations presented in this study to begin incorporating ecosystem services into agency goals, metrics, indicators, assessments, and general operations. Examples include: developing budgets and program planning, writing grant applications to secure outside funding, examining policies and accounting practices, designing and reporting health indicators, and developing and reviewing progressive permit processes in rural areas.

Yasuní Model

The Yasuní-ITT initiative is a proposal to protect Yasuní National Park in the Ecuadorian Amazon rainforest by leaving oil reserves underground and untouched in return for the international community's compensation for the forgone oil revenue.¹¹⁸ The Ecuadorian government recognizes the need for a post-petroleum economy and the Yasuní initiative is a monumental step towards a more sustainable development path. If successful, the model could be replicated in the Intag region.

Next Steps

Earth Economics has been working with the visionary community of Intag for two years to identify and value the region's ecosystem services. This is the first step in ecosystem service analysis. With further investments in mapping, detailed scenario analysis, accounting improvements, and policy research, further innovations can be made to ensure Intag's

natural assets and the surrounding regions are managed for generations to come. To this end, we suggest the following next steps:

1. Develop further modeling and mapping capacity. General, basin-wide investigation including hydrological studies should be coupled with further development of ecosystem service and scenario tools. Leading-edge tools are available for identifying, mapping, and valuing carbon sequestration, biodiversity, flood protection, etc. Maps of ecosystem services can include:
 - Provisioning maps to show where ecosystem services and goods are produced;
 - Beneficiary maps to show who is benefiting from existing ecosystem services;
 - Flood source maps to show how flooding is created, and where provisioning of flood protection and other ecosystem services is being impaired, such as a bridge that might restrict the floodway, causing increased flooding upstream, or a steep and unstable slope that could slide to block river flows;
 - Critical path maps to show how the ecosystem services are transferred to beneficiaries and to identify critical areas for service provisioning.
2. Develop scenario analyses. Create scenario analyses with modeling to help judge project and investment proposals against established criteria.
3. Develop project prioritization and reporting methodology. Investigate robust reporting options to keep stakeholders and the community informed of project and investment status, location, and performance.
4. Develop funding mechanisms. Examine improved cross-disciplinary funding mechanisms for storm protection and other ecosystem services to ensure the sustainability of ecosystem project investments and outcomes.
5. Develop innovative funding sources. Create

complementary funding sources. Conservation in Intag has generally been funded by the government through local taxes and fees or from grant funding from abroad. There are other funding mechanisms, such as a watershed investment district, agroforestry, and payment for ecosystem service schemes, which could provide complementary funding mechanisms to supplement these traditional approaches.

6. Seek cross-jurisdictional partnerships. Develop funding mechanisms with a wide combination of complementary international, national, provincial, and local funding mechanisms.
7. Improve Comprehensive Planning. Continue to advance land use planning, such as watershed characterization, and examine ecosystem services within the watershed, in light of economic development planning. This analysis supports a triple-bottom-line approach.
8. Invest in Local Research. The range of 18 identified categories of ecological goods and services provided by Intag should be more closely examined. This can be done in a collaborative arrangement with government agencies, organizations, and universities to conduct a set of ecosystem service studies. For example, if each protected area jurisdiction conducted one ecosystem service study with a full research agenda in its jurisdiction, the compilation of those studied would contribute greatly to better defining and narrowing the range of value produced by Ecuador's ecosystems. This approach would reduce the cost of the studies and all jurisdictions would benefit.

Progressive Mine Remediation

With Chinese investment in Ecuador copper extraction, the Junin mine is currently under consideration for development. If large open-pit mining does proceed in the Intag region, here are a few recommendations:

1. Incorporate the knowledge gained in this information transfer by employing ecosystem services valuations to identify the true impacts to natural systems in order to make a fully informed decision about the project. This will allow for better understanding not only of the direct impacts of the project, but how the health of these systems will be impacted by indirect, long-term influences, and who will reap benefits and who will pay costs.
2. Provide space for the adoption of precautionary steps as a guiding precept to recognize potential negative impacts and development of a crisis response.
3. Have transparency in every step of the process and establish accountability mechanisms to ensure compliance with project agreements.

It is through the past 12 years of experience in applying ecosystem service concepts that Earth Economics understands that the impact Intag community groups can have should not be underestimated. The public should continue to be actively involved and informed of Intag's ecosystem services and their value. Stakeholders should partner with other national and international organizations and governmental agencies to increase their understanding of Intag's natural capital and its value to local and global communities, and apply sustainability concepts for a prosperous 21st century Ecuadorian economy.

Conclusion

This study shows that the economy and quality of life of the people of Intag and all citizens of Ecuador depend upon healthy “natural capital.” This report is the most comprehensive valuation of Intag’s natural systems to date. An initial analysis in a growing field, this study should not be taken as the final word on ecosystem service valuation for Intag, nor a full ecological economic analysis. It is a first step towards understanding the significant economic and social risks of investment in mining operations in Intag, while accounting for the significant economic contributions that ecosystems make to the regional and national economies.

These natural assets are not indestructible. They can be lost and, in fact, are being lost. The best way to prevent this loss is to invest in economic activities that provide long-term economic and environmental sustainability. The cost to promote conservation is minimal compared to the income generated by extractive activities and it is also minimal compared to the associated risks.

The ecosystem services examined in this report include climate stability, flood protection, drinking water purification and supply, wildlife habitat, pollination, soil erosion control, soil formation, biological control, nutrient cycling, raw materials, waste treatment, food production, aesthetic, and recreational value. The seven land cover types are: cloud forests, agricultural lands, pastures, mix of agricultural and pastures, rivers and lakes, native Andean alpine grasslands (páramo in Spanish), pre-montane forest, and native bamboo.

In our research, we found that 17 of 23 ecosystem services across the land cover types in Intag provide the regional and national community an average of \$447 million in yearly benefits. These figures are based on cutting-edge economic analysis tools that were developed, in part, with a United States National

Science Foundation grant.

One way of determining economic value is to estimate the asset value of the natural capital providing this annual flow of value. This is like comparing house payments (flow of value) to the market value of the house (asset value). The value of an asset can be estimated from the flow of benefits it provides. If the natural capital of the Intag region were treated like an economic asset, the asset value of the natural systems would be an average of \$45 billion at a 0-percent discount rate, which recognizes the renewable nature of ecosystem services and that there will be people in the future benefiting from them.

It is becoming increasingly clear that economic sustainability relies on environmental sustainability. The loss of nature’s bounty has real regional and global economic costs. The analysis of economic benefits of natural systems has advanced very rapidly with the realization that natural systems are vital to the health and development of economies. Economics is re-tooling for the 21st century with three essential goals: sustainability, justice, and economic progress. Sustainability requires living at a scale that does not destroy the basic natural systems, which maintain the economy. Justice and rights are core democratic values. Rights frame and help define economic value. Economic progress provides a global approach to sustainable economic growth, alleviates poverty, and achieves social progress.

The value of the economic benefits the Intag region provides is enormous; indeed, it is priceless. The benefits provided are local, national and global. The economic value of the watershed is larger than its built economic assets or the underground minerals. This conclusion may be surprising given the price of copper in today’s market, however, as this report illuminates, the social and environmental costs of copper extraction are much higher than the value of copper itself.

In Intag and elsewhere, economic progress depends on healthy communities, healthy people, and sustainable ecosystems. Development progress must be resilient to price fluctuations in single commodities and extend beyond the life of traditional extractive industries. Strategic investment in conservation and market development for the rich diversity of ecosystem goods and services is key to the long-term viability of this special region of Ecuador.

Ecuadorian leadership has critical investment decisions to make. The term “investment” describes the choices we make today to place resources for returns in the future. An economy is the product of previous decades of investment. Future generations will benefit or suffer from the choices made today. This report provides several recommendations for stabilizing and promoting the social and economic conditions in Intag, which include the following:

- Include ecosystem service valuations (ESV) to environmental impact assessments (EIA).
- Initiate mapping and modeling of ecosystem services in the region.
- Use ESV data to fund further region specific service value transfer studies through local universities and implement broad changes in asset accounting practices.
- Perform an initial analysis of restoration and conservation funding mechanism and work with local and regional stakeholders to further refine the sustainable plan to ensure ongoing funding and policy support for basin-scale restoration and conservation efforts.

The overall conclusion of the report is that economic development within the Intag region is best achieved by tapping the vast value that ecosystem goods and services provide and that this approach is aligned

with the development vision of Intag communities. Copper development will carry great costs. It is a risky venture dependent upon global economic trends and pricing, and competition from well established and planned mines that could undercut expected profits and tax revenues. In addition, mining is inherently unsustainable. One day a large pile of mine tailings will be left and the mine closed. World Bank studies confirm that most often the benefits of mining accrue to few while the costs are borne by many, and that, overall, extractive industry dependence is associated with economic decline.

The Intag region is blessed with a flow of benefits on the order of \$447 million per year. This is sufficient to build a robust economy given advancement in agroecology, markets, and the development of local to international funding mechanisms. Well managed, the resources of the Intag region can provide for sustainable, equitable and prosperous development in the region and nation.



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Appendix A: Study Limitations

The results of this first attempt to assign monetary value to the ecosystem services rendered by the Intag region have important and significant implications for the restoration and management of natural capital in the watershed. Valuation exercises have limitations that must be noted, although these limitations should not detract from the core finding that ecosystems produce significant economic value for society. Benefit transfer analysis estimates the economic value of a given ecosystem (e.g., wetlands) from prior studies of that ecosystem type. Like any economic analysis, this methodology has strengths and weaknesses. Some arguments against benefit transfer include:

1. Every ecosystem is unique; per-hectare values derived from another location may be irrelevant to the ecosystems being studied.
2. Even within a single ecosystem, the value per hectare depends on the size of the ecosystem; in most cases, as the size decreases, the per-hectare value is expected to increase and vice versa. (In technical terms, the marginal cost per hectare is generally expected to increase as the quantity supplied decreases; a single average value is not the same as a range of marginal values).
3. Gathering all the information required to estimate the specific value for every ecosystem within the study area is not feasible. Therefore, the “true” value of all of the wetlands, forests, pastureland, etc. in a large geographic area cannot be ascertained. In technical terms, we have far too few data points to construct a realistic demand curve or estimate a demand function.
4. To value all, or a large proportion, of the ecosystems in a large geographic area is questionable in terms of the standard definition of exchange value; we cannot conceive of a transaction in which all or most of a large area’s ecosystems would be bought and sold. This emphasizes the point that the value estimates for large areas (as opposed to the unit values per hectare) are more comparable to national income accounts aggregates and not exchange values.¹²⁹ These aggregates (i.e. GDP) routinely impute values to public goods for which no conceivable market transaction is possible. The value of ecosystem services of large geographic areas is comparable to these kinds of aggregates (see below).

Proponents of the above arguments recommend an alternative valuation methodology that amounts to limiting valuation to a single ecosystem in a single location and only using data developed expressly for the unique ecosystem being studied, with no attempt to extrapolate from other ecosystems in other locations. An area with the size and landscape complexity of the Intag region will make this approach to valuation extremely difficult and costly. Responses to the above critiques can be summarized as follows:

1. While each wetland, forest or other ecosystem is unique in some way, ecosystems of a given type, by their definition, have many things in common. The use of average values in ecosystem valuation is no more and no less justified than their use in other “macroeconomic” contexts, for instance, developing economic statistics such as Gross Domestic or Gross State Product. This study’s estimate of the aggregate value of Intag’s ecosystem services is a valid and extremely useful (albeit imperfect, as are all aggregated economic measures) basis for assessing and comparing these services with conventional economic goods and services.
2. As employed here, the prior studies we analyzed encompass a wide variety of time periods, geographic areas, investigators and analytic methods. Many of them provide a range of estimated values rather than single point estimates. The present study preserves this variance; no studies were removed from

the database because their estimated values were deemed to be too high or too low. Limited sensitivity analyses were performed. The approach is similar to determining an asking price for a piece of land based on the prices for comparable parcels. Even though the property being sold is unique, realtors and lenders feel justified in following this procedure to the extent of publicizing a single asking price rather than a price range.

3. The objection to the absence of even an imaginary exchange transaction was made in response to the study by Costanza et al. (1997) of the value of all of the world's ecosystems. Leaving that debate aside, one can conceive of an exchange transaction in which, for example, all or a large portion of a watershed was sold for development so that the basic technical requirement, that economic values reflect exchange values, could in principle be satisfied. Even this is not necessary if one recognizes the different purpose of valuation at this scale—a purpose more analogous to national income accounting than to estimating exchange values.¹²⁹

In this report, we displayed our study results in a way that allows one to appreciate the range of values and their distribution. It is clear from inspection of the tables that the final estimates are not extremely precise. However, they are much better estimates than the alternatives of assuming that ecosystem services have zero value, or, instead, of assuming they have infinite value. Pragmatically, in estimating the value of ecosystem services, it seems better to be approximately right than precisely wrong.

The estimated value of the world's ecosystems presented in Costanza et al. (1997), for example, has been criticized as both (1) a serious underestimate of infinity and (2) impossibly exceeding the entire Gross World Product. These objections seem to be difficult to reconcile, but that may not be so. Just as a human life is "priceless" so are ecosystems, yet people are paid for the work they do.

General Limitations

- **Static Analysis.** This analysis is a static, partial equilibrium framework that ignores interdependencies and dynamics, though new dynamic models are being developed. The effect of this omission on valuations is difficult to assess.
- **Increase in Scarcity.** The valuations probably underestimate shifts in the relevant demand curves as the sources of ecosystem services become more limited. The values of many ecological services rapidly increase as they become increasingly scarce.¹³⁰ If Intag's ecosystem services are scarcer than assumed here, their value has been underestimated in this study. Such reductions in supply appear likely as land conversion and development proceeds. Climate change may also adversely affect the ecosystems, although the precise impacts are more difficult to predict.
- **Existence Value.** The approach does not fully include the infrastructure or existence value of ecosystems. It is well known that people value the existence of certain ecosystems, even if they never plan to use or benefit from them in any direct way. Estimates of existence value are rare; including this service will obviously increase the total values.
- **Other non-Economic Values.** Economic and existence values are not the sole decision-making criteria. Techniques called multi-criteria decision analyses are available to formally incorporate economic values with other social and policy concerns. Having economic information on ecosystem services usually helps this process because traditionally, only opportunity costs of foregoing development or exploitation are counted against non-quantified environmental concerns.

GIS Limitations

- **GIS Data.** Since this valuation approach involves using benefit transfer methods to assign values to land cover types based, in some cases, on their contextual surroundings, one of the most important issues with GIS quality assurance is the reliability, both in terms of categorical precision and accuracy, of the land cover maps used in the benefits transfer. The source GIS layers are assumed to be accurate but may contain some

minor inaccuracies due to changes in land use since the data was sourced, inaccurate satellite readings and other factors.

- **Ecosystem Health.** There is the potential that ecosystems identified in the GIS analysis are fully functioning to the point where they are delivering higher values than those assumed in the original primary studies, which would result in an underestimate of current value. On the other hand, if ecosystems are less healthy than those in primary studies, this valuation will overestimate current value.
- **Spatial Effects.** This ecosystem service valuation assumes spatial homogeneity of services within ecosystems, i.e. that every hectare of forest produces the same ecosystem services. This is clearly not the case. Whether this would increase or decrease valuations depends on the spatial patterns and services involved. Solving this requires spatial dynamic analysis. More elaborate systems dynamics studies of ecosystem services have shown that including interdependencies and dynamics leads to significantly higher values, as changes in ecosystem service levels ripple throughout the economy.¹³⁰ Earth Economics has tools to do spatial and temporal analysis but this kind of work was not included in this study due to funding limitations.

Benefit Transfer/Database Limitations

- **Incomplete coverage.** That not all ecosystems have been valued or studied well is perhaps the most serious issue since it results in a significant underestimate of the value of ecosystem services. More complete coverage would almost certainly increase the values shown in this report, since no known valuation studies have reported estimated values of zero or less. Table 10 illustrates which ecosystem services were identified in Intag for each land cover type, and which of those were valued.
- **Selection Bias.** Bias can be introduced in choosing the valuation studies, as in any appraisal methodology. The use of a range partially mitigates this problem.
- **Consumer Surplus.** Because the benefit transfer method is based on average rather than marginal cost, it cannot provide estimates of consumer surplus. However, this means that valuations based on averages are more likely to underestimate total value.

Primary Study Limitations

- **Willingness-to-pay Limitations.** Most estimates are based on current willingness-to-pay or proxies, which are limited by people's perceptions and knowledge base. Improving people's knowledge base about the contributions of ecosystem services to their welfare would almost certainly increase the values based on willingness-to-pay, as people would realize that ecosystems provide more services than they had previously known.
- **Price Distortions.** Distortions in current prices used to estimate ecosystem service values are carried through the analysis. These prices do not reflect environmental externalities and are therefore again likely to be underestimates of true values.
- **Non-linear/Threshold Effects.** The valuations assume smooth responses to changes in ecosystem quantity with no thresholds or discontinuities. Assuming (as seems likely) that such gaps or jumps in the demand curve would move demand to higher levels than a smooth curve, the presence of thresholds or discontinuities would likely produce higher values for affected services.¹³¹
- **Sustainable Use Levels.** The value estimates are not necessarily based on sustainable use levels. Limiting use to sustainable levels would imply higher values for ecosystem services as the effective supply of such services is reduced.

If the above problems and limitations were addressed, the result would most likely be a narrower range of values and significantly higher values overall. At this point, however, it is impractical to determine precisely how much higher the low and high values would be.

Appendix B: Key Ecological Economics Concepts

Human well-being and advancement has always been tied to a healthy supply of nature's goods and services, but early economics models were created in a time of abundant natural resources. In that context, only built, financial and human capital (labor) were identified as constraining factors in the production process. Today's context is very different: Our planet has become "full" of built capital, and natural capital is now the scarce, limiting factor in production. Ecological economics extends basic economics concepts and reflects today's economy more accurately. The "ecosystem services" framework is an operational way of including natural capital in economics analysis and is important to understanding and embracing an integrated approach to managing a watershed economy.

What's an Economy for, Anyway?

Economies have existed since humans began to make and distribute goods and services; they have been instrumental in raising our standard of living and comfort. In the late 18th century, Adam Smith, David Ricardo and other economists articulated many of the basic market concepts that guide economic policy today. When Smith and Ricardo lived, the population of the Earth was less than one billion people, the Industrial Revolution was just beginning, the science of ecology did not exist, and natural goods and services were plentiful relative to manufactured and built capital.¹¹⁹ Thus, the economy focused on improving quality of life through built capital, allocating plentiful natural resources to build and distribute these built goods.

Early Economics and the Three Economic Questions

Economics is the study of the allocation of limited, or scarce, resources among alternative desirable ends. This definition can be stated as three questions, in the following order:

- What ends do we desire?
- What scarce resources do we need to attain these desirable ends?
- What desirable ends receive priority, and to what extent do we allocate resources to them?

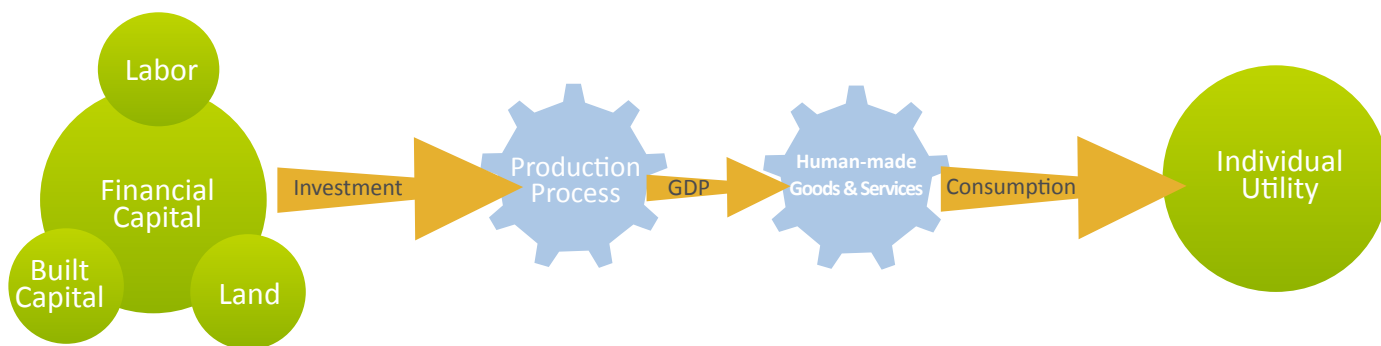
Economists have traditionally answered "utility" or "human welfare" to the first question. Human welfare was thought to depend on what people wanted, revealed through market transactions, i.e. goods and services they bought and sold on a market. Classical economics assumed that most scarce resources were market goods, giving the highest attention to one mechanism for allocating alternative resources to alternative ends: the market. This classic thought was also focused on equal allocation of final goods and services (i.e. distribution), and not at all on the problem of an economy's size relative to the natural systems in which it existed (i.e. scale).

Macroeconomic activity is tracked using national economic measures such as the Gross Domestic Product (GDP). GDP adds together both final goods and services (coffee, bus transportation, etc.) and "bads" (e.g. oil spill cleanup costs) to arrive at an indication of the economy's total throughput. Today, GDP is often mistakenly used to measure economic progress on the assumption that the market is thought to supply most of our desired ends (or more specifically, preferences that we reveal for market goods and services). The GDP is a measurement of market transactions; the rate of GDP growth measures the increase in these transactions. The GDP does not measure quality of life or "economic welfare"—in other words, people's quality of life—and was not intended to do so.

Many of today’s economic models and norms were developed when natural capital (such as forests and fish) was abundant, and built capital (such as roads and factories) was scarce. Because economic logic tells us that we should maximize the productivity of the scarcest, most constraining factors, as well as to try to increase their supply, our economy, facilitated by the instrument of finance, has focused on the production of built capital. This focus on built capital has yielded a highly productive market system for manufactured goods. Capital (such as machinery), land and labor have traditionally been considered the primary “factors of production,” and the most constraining to economic development. Natural, social (such as culture) and human capital (such as education), on the other hand, has infrequently been included in economic analysis.

Figure A provides a sketch of the “Partial Economy” model, which includes the traditional “factors of production” and the GDP measure.

Figure A - The Partial Economy Model



A Shift in Scarcity

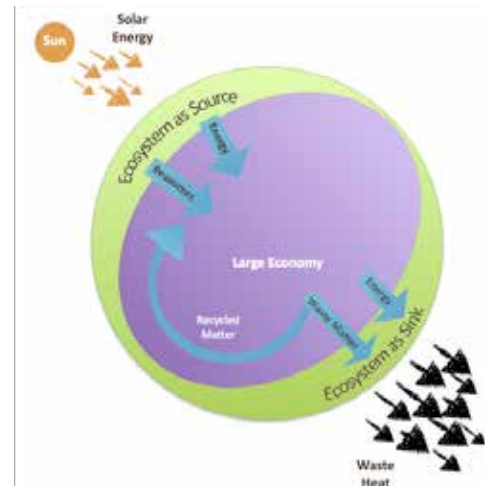
Over the past 50 years, humans have changed ecosystems more rapidly and extensively than in any comparable period in human history, and there is ample evidence that scarcity has shifted from built capital to natural capital.¹²⁰ For example, the ability to produce logging machinery, for instance, now far outweighs the world’s forest’s ability to grow trees, and timber harvest must be limited by laws and agreements.

Equally, in contrast to several generations prior, timber harvest is now limited by land availability and tree growth, rather than available logging equipment. On a global scale, many experts can now show that humans may be depleting the Earth’s flow of natural goods and services faster than the flow can be regenerated, and in many areas we are depleting the natural capital that produces this flow. For example, it has been estimated that humans now directly or indirectly appropriate up to 40 percent of the Earth’s annual net primary productivity, dramatically reducing the amount available for other species, including those that support humans (for example, via fisheries).^{121 122} Net Primary Productivity is the total biomass that is produced by ecosystems through photosynthesis, and is the foundation for life on Earth. Other measures present a similar picture: The World Wildlife Fund (WWF) recently calculated the “Ecological Footprint” of humanity, or the land and sea area that would be needed to sustainably regenerate the resources (and absorb the waste) that humans consume annually. It was found that our current rate of resource consumption and waste disposal requires 1.3 planet Earths—and this “footprint” is rising.

Figure B - Previous Empty World Situation



Figure C - Today's Full World Situation



Independent of the measure, it appears that our economy today occupies a significant portion of the biosphere. An important reason for this shift in scarcity is that in the past century alone, the per-capita economic production of market goods and services has increased nine-fold.¹²³ Figures B and C illustrate the human economy's move from the "Empty World" situation of the past to the "Full World" situation that we live in today.

Why has the "Shift in Scarcity" been Overlooked?

The success of the industrial revolution has greatly reduced the scarcity of market goods for much of the world's population. However, this has entailed a tradeoff: Today, natural goods and services have become scarce. The shift in scarcity, from built capital to natural capital, holds major implications for the way our economy is structured and understood. Recognizing why this shift, on a global scale, has not been noticed can be instructive as we attempt to rebalance natural and built capital, and in addition, human, social and financial capital. Two major reasons are offered as to why the shift in scarcity has been overlooked, though other reasons certainly exist:

- **Exponential Growth of Human Population.** With a constant rate of population growth, the Earth would be expected to grow from half-full to completely full in one doubling period—the same period it required to grow from 1–2 percent full. With improvements in technology and general living standards, the human population has in reality grown exponentially, and doubling periods have shortened. For example, the United Nations states that it took about 123 years (1804–1927) for the Earth's population to grow from 1 to 2 billion, and just 47 years (1927–1975) to then grow from 2 to 4 billion. Not only have human populations grown exponentially, but so has each individual's absolute use of resources. The shift from an "empty world" to a "full world", and a concomitant shift in scarcity, has occurred more quickly than early economic models have been able to adapt.
- **Complementarity versus Substitutability.** If two goods or services are thought of as substitutes in an economic model, then a shortage of one does not limit the productivity of another. By default, the Partial Economy Model tends to view built capital and natural capital as perfect substitutes, in this way avoiding the problem of scarcity. The false assumption that built capital and natural capital are perfect substitutes can be largely attributed to the failure of the Partial Economy Model to include natural capital explicitly as one of the factors of production (likely because the model was devised while the Earth was still "empty").

If natural capital is thought of as a complement to built capital in the creation of goods and services, as it always must be to varying degrees, then its scarcity constrains the other capitals by definition. For example, dams and levees can provide flood protection services, but only after the majority of floodwater mitigation has occurred in headwater forests, wetlands and floodplains. Some natural goods and services, such as oxygen production and carbon sequestration, can be thought of as complements to all types of built capital, because there is no practical built substitute (i.e. all built capital production would cease in the absence of oxygen). In the economy, natural capital is thus, in many respects, an essential complement to built capital.

Ecological Economics: The Whole Economy

The primary goal of ecological economics is to ground economic thinking in the physical reality of today's "full world," a necessary advancement of economic thought. Ecological economics accepts much of the traditional economic theory regarding efficient allocation, but differs in fundamental respects, for example by addressing the problem of scale (i.e. sustainability) directly. Specifically examining the relationship between ecosystems, the economy, and human well-being, ecological economics recognizes that as a subset of nature, our economy is best understood in the context of natural systems and processes.⁵³

Ecological economics is recognized worldwide as a tool used to improve decision-making processes at all levels of government. The ecological economic model of the economy, or "Whole Economy" model, illustrated in Figure D, demonstrates that production of goods and services is tied to five capitals: natural, built, human, social and financial. Ecosystem goods and services contribute to human well-being, both directly and by providing natural capital for the production process; the negative feedback loops from pollution and degradation are also included. In addition, Figure D introduces the four guiding principles for a healthy economy: good governance, sustainability, efficiency and justice, which are displayed in blue.

The Value of Natural Capital

In 2001, an international coalition of scientists from the United Nations Environmental Program initiated an assessment of the effects of ecosystem change on human well-being. The product of this collaboration was called the Millennium Ecosystem Assessment, which classifies ecosystem services (discussed below) into four broad categories describing their ecological role.

Ecological Economics and the Three Economic Questions

Earlier in this Appendix three core questions of economics were posed, namely:

- What ends do we desire?
- What scarce resources do we need to attain these desirable ends?
- What desirable ends receive priority, and to what extent do we allocate resources to them?

In light of the whole economy model, ecological economics approaches the three economic questions with logic: It reflects deeply on the first two questions before attempting to answer the third question. The solutions that ecological economics has developed are outlined below.

Desired Ends: Human Well-Being

- In the context of ecological economics and the Whole Economy Model, human well-being and a high quality of life for the current and future generations represent our desired ends. Human well-being is not a rigidly defined state, but a combination of physical and abstract human ends and needs that differ between individuals and places. Many of these ends can be met on the market, but many cannot. For example, some basic shared needs may include a dependable supply of food and clean drinking water, physical and financial

Figure D - The Whole Economy Model



security, health and friendship, and social bonds. Meeting the suite of human needs, now and into the future, largely depends on understanding the extent of our scarce resources and how they are allocated to different ends.

Scarce Resources: The Five Capitals

The five capitals represent our scarce resources—the resources that ultimately go towards human needs and human well-being. The Whole Economy model recognizes that five capitals are essential to economic progress and a high quality of life: Healthy natural capital underlies all built, human, social and financial capital, which in turn create the conditions for a healthy and sustainable economy:

- **Natural Capital.** The stock of minerals, energy, plants, animals, and ecosystems found on earth that yields a flow of natural goods and services. When taken as one whole system, natural capital provides the total biophysical context for the human economy.
- **Human Capital.** The self-esteem, knowledge acquired through education, technical skills, and interpersonal skills, such as communication, listening, cooperation, and individual motivation to be productive and socially responsible.
- **Social Capital.** The inventory of organizations, institutions, laws, informal social networks, and relationships of trust that make up or provide for the productive organization of the economy.
- **Built Capital.** The infrastructure of technologies, machines, tools, and transport that humans design, build, and use for productive purposes. Coupled with our learned skills and capabilities, our built techno-

infrastructure is what directly allows raw materials (i.e. natural capital) to be converted into a flow of economic goods and services, the products that we typically find in markets.

- Financial Capital. Shares, bonds, banknotes, and other financial assets play an important role in our economy, enabling the other combinations of capital (e.g. healthcare, education) to be owned, traded, and allocated. Financial capital is based on trust and represents a promise that it will eventually be honored with one of the other types of “real” capital.

Attaining Desired Ends: The Four Guiding Principles

The third question of economics is the least straightforward, namely: What ends get priority, and to what extent do we allocate resources to them? While the question cannot be answered directly, ecological economics provides four guiding principles that address the long-term attainment of human well-being.

- Sustainability. Living within a physical scale that does not destroy the basic natural systems that maintain the economy. Natural systems are part of our “commonwealth,” which can be managed sustainably to produce economic benefit to current and future generations.
- Justice. Fair distribution of public and private gains from natural, built, human, social, and financial goods and services ensures maximum benefit for lowest public investment. Intergenerational distribution is equally important; our children, grandchildren, and future generations should be given fair access to the Earth’s stock of mineral and ecological resources.
- Efficiency. Careful decision-making regarding how and where resources are moved or invested to produce different suites of goods and services. Consideration of the most efficient balance of built, natural, human, social and financial capital for the types of goods and services we wish to enjoy, and whether or not a particular balance is detrimental to the goal of long-term sustainability.
- Good Governance. This principle consists of two elements:
 - Creation and maintenance of both private and public institutions and groups, policy instruments, systems, and markets that ensure sustainability, justice, and efficiency are achieved.
 - Employing measurements that give an accurate indication of the Whole Economy’s health, measuring what our scarce resources are and whether alternative desired ends are being met.

Addressing Inherent Complexity

Importantly, ecological economics is equipped to deal with complexity, which is a physical reality in our economy. Ecological economics recognizes that each of the five capitals—natural, built, human, social and financial—are comprised of complex systems that are closely intertwined. Complex systems are characterized by strong (usually non-linear) interactions between the parts, complex feedback loops that make it difficult to distinguish cause from effect, and significant time and space lags, discontinuities, thresholds, and limits.¹²⁴

The concept of economic or ecological resilience is important. Resilience implies the potential of a system to, after disturbance, return to a previous state. A system is assumed to be fragile when resilience is low. Fragile systems tend to be replaced when disturbed; for example, wetlands that are converted to open water produce reduced amounts of ecosystem services and provide less economic value.¹²⁵ An entire economic system can also collapse without resilience and revert to a less productive one (Somalia, or in many countries’ agricultural areas subject to desertification); ecological economics therefore strives to build resilience into economic understanding.

Introduction to Ecosystem Goods and Services

One advantage of the Whole Economy Model is that it can account for the full range of economically valuable

benefits that natural capital provides beyond resource extraction, such as carbon sequestration and water filtration. Ecological economics, guided by the Whole Economy Model, has developed an operational framework through which to accurately internalize the value of nature in economic decision-making, the “ecosystem service” framework. Ecosystem services were recently given higher prominence in the Millennium Ecosystem Assessment, a project called for in 2000 by then-United Nations Secretary-General Kofi Annan, which was completed in 2005.

The Millennium Ecosystem Assessment set out to examine the worldwide changes in ecosystems that have been occurring, the impacts of these changes on human well-being, and options for enhancing the conservation of ecosystems and their contribution to human well-being. The project, involving over 1,360 experts worldwide and a multi-stakeholder board representing governments, businesses, NGOs, indigenous peoples and international institutions, utilized the concept of “ecosystem services” to best understand the linkages between ecosystems and human well-being. In 2000, The Fund for the Protection of Water (FONAG) was established by the Ecuadorian municipal government, together with local NGOs, to act as a trust fund which uses proceeds contributed by major cities, like Quito, to finance critical ecosystem services. Through the fund, nearly 65,000 hectares of watersheds are now under improved management, by which upstream farmers receive support for watershed protection programs.¹²⁶

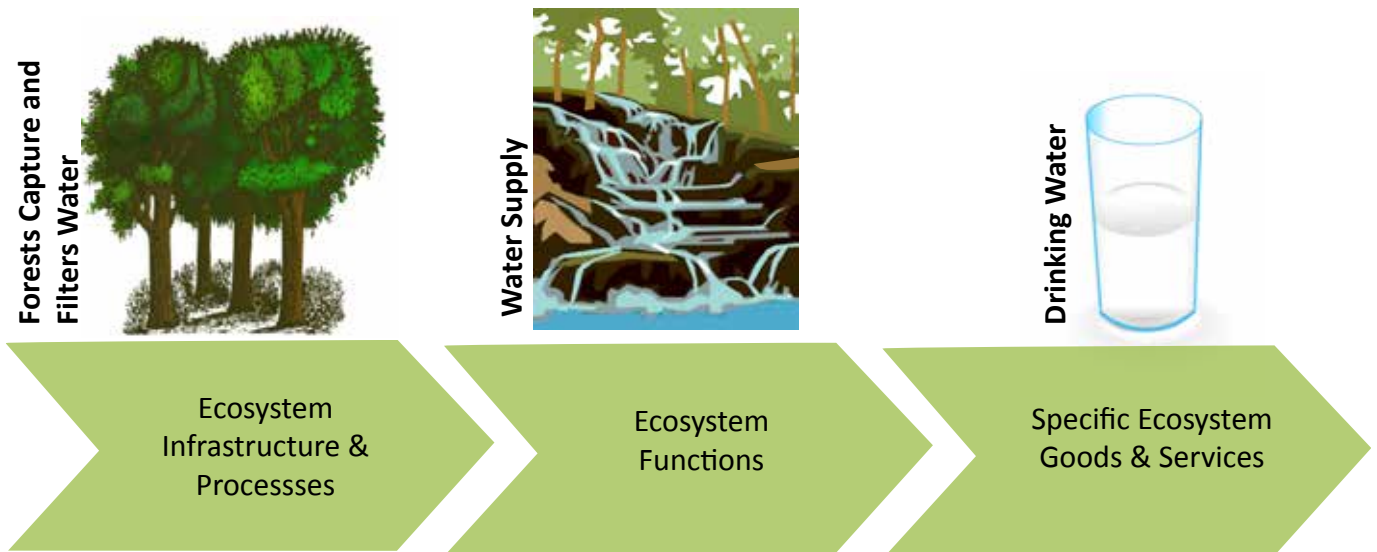
Our natural environment provides many of the things we need to survive: breathable air, drinkable water, food for nourishment, and stable atmospheric conditions, to name a few. These are what we refer to as “ecosystem goods and services.” Ecosystem goods and services are those derived from natural systems that provide benefit to humans. Ecosystems perform many functions, but only functions that provide human benefits are considered ecosystem goods or services. Every ecosystem produces a “suite” of ecosystem services.

Healthy, resilient, natural infrastructure, referred to as “natural capital”, is critical to the production of ecosystem goods and services. The natural capital of an ecosystem consists of its individual structural components (trees, forests, soil, hill slopes, etc.) that produce dynamic processes (water flows, nutrient cycling, animal life cycles, etc.), which, in turn, create functions (water catchment, soil accumulation, habitat creation, etc.) that generate ecological goods and services (coffee, timber, flood protection, recreation, etc.). This relationship is summarized in Figure E, and might be likened to the production of cars in a factory: To build a car (a “built” good) requires high quality built capital (e.g. the factory, machines, and connection to a power plant), natural capital (e.g. the extracted metal, rubber, food for the workers), human capital (the workers), financial capital (equity to buy the raw materials) and social capital (labor laws and agreements, etc.).

Ecosystem goods and services are different from the economic benefits provided by labor and capital that we typically value in the economy. Although we might include the dollar value of a levee as an economic asset, as measured by the costs of the workers’ time, fuel, and earthmoving equipment, if we do not include the value of flood protection provided by forests, wetlands, and lakes, then the economic analysis is deeply flawed. These “natural” assets sometimes provide more flood protection than built structures and can often be implemented with little or no capital cost (the cost of building a levee or building), and low maintenance costs (the cost of upkeep).

Ecosystem services clearly provide economic value to our measured economy. When the values of ecosystem services are not counted, their loss is often felt economically. Ecological economics provides the framework to include the real value of these goods and services in economic accounting and decision-making. When we alter environmental conditions, critical ecosystem services are damaged or lost, and must then be replaced by more costly built alternatives that are often funded by taxpayers. If ecosystems are valued as assets, however, the most valuable and cost-effective services will not be lost. Otherwise, once lost, many ecosystem goods and services may not be recoverable.

Figure E - The Link between Natural Infrastructure and Ecosystem Goods and Services



Ecosystem Goods

Ecosystem goods are typically tangible, quantifiable items or flows, such as drinking water, trees for forestry, fish, and food. Most goods are excludable, which means that if one individual owns or uses a particular good, that individual can exclude others from owning or using the same good. For example, if one person eats a banana, another person cannot eat that same banana. Excludable goods can be traded and valued in markets. The quantity of water produced per second or the amount of timber cut in a 40-year rotation can be measured by the physical quantity an ecosystem produces over time. The current production of goods can be valued relatively easily by multiplying the quantity produced by the current market price.

Ecosystem Services

Ecosystem services are defined as “the conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfill human life.”¹²⁷ Unlike ecosystem goods, ecosystem services are generally not tangible items that one can see or hold. Flood protection, recreational value, aesthetic value, and storm prevention are a few of the services that ecosystems may provide. Though often more difficult to value because market values rarely exist, ecosystems services have tremendous economic value and are critical both for our quality of life and for economic production.^{127 128} There are now economic techniques for valuing many ecosystem services.

One reason these services have not been monetized is that many ecosystem services are non-excludable. For example, when one person enjoys a view of a sunset, or Cuicocha Lake, another person is not prevented from enjoying the same view. Similarly, many non-paying downstream residents may benefit from the flood protection provided by forested land upstream. Because of the challenge associated with valuing and measuring ecosystem services, they have often been ignored. However, in many cases, the value of a service flow may significantly exceed the value of the flow of goods.

For example, a standing forest may be cut down once every few decades to provide an ecosystem good—timber—with revenue generated from the harvest and sales of the wood. However, the same forest, if left standing, might purify the drinking water for a nearby city for centuries, saving the cost of constructing a filtration plant and the additional costs of maintaining the plant each year as it begins to degrade.

The City of Quito offers an example of the benefits received from protecting watersheds that act as the source of economic demand for water. For the 1.5 million inhabitants of Quito and its surrounding areas, the availability of water depends on the conservation of protected areas upstream, where more than 60 percent of the water supply originates from the Cayambe-Coca Reserve.³

Appendix C: Value Transfer Studies Used by Land Cover Class

Land Cover	Ecosystem Service General	Author(s)	Minimum	Maximum
Agricultural Lands	Aesthetic & Recreational	Bergstrom, J., Dillman, B. L. and Stoll, J. R. 1985	\$72.03	\$72.03
	Erosion Control	Canadian Urban Institute.	\$14.16	\$14.16
	Gas & Climate Regulation	Smith, W.N. et al.	\$68.43	\$68.43
		Wilson, Sara J.	\$27.70	\$774.00
	Nutrient Cycling	Canadian Urban Institute.	\$54.27	\$54.27
	Pollination	Robinson, W. S., Nowogrodzki, R. and Morse, R. A. 1989	\$31.69	\$31.69
		Southwick, E. E. and Southwick, L. 1992	\$6.29	\$6.29
		Ricketts, T.H., Daily, G.C., Ehrlich, P.R., and Michener, C.D.	\$419.41	\$419.41
	Raw Materials	Martinet, A.	\$988.65	\$988.65
		Valverde, M. and Gaybor, A.	\$2,525.28	\$2,525.28
	Soil Formation	Canadian Urban Institute.	\$14.16	\$14.16
		Sandhu, H.S., Wratten, S.D., Cullen, R., and Case, B.	\$14.16	\$14.16
Food Production	Martinet, A.	\$384.47	\$10,512.64	
	Valverde, M. and Gaybor, A.	\$4,681.29	\$4,681.29	
Pasture	Soil Formation	Pimentel, D. 1998	\$16.29	\$16.29
Bamboo	Gas & Climate Regulation	Tianhong, L. et al.	\$474.45	\$615.01
	Habitat Refugium & Nursery	Tianhong, L. et al.	\$572.85	\$572.85
	Raw Materials	Tianhong, L. et al.	\$456.86	\$456.86
	Soil Formation	Tianhong, L. et al.	\$676.24	\$676.24
	Waste Treatment	Tianhong, L. et al.	\$230.19	\$230.19
Pasture and Agricultural	Water Supply	Tianhong, L. et al.	\$562.14	\$562.14
	Aesthetic & Recreational	New Jersey Type A Studies 2006	\$63.68	\$63.68
	Biological Control	Costanza et al. 1997	\$33.51	\$33.51
	Pollination	New Jersey Type A Studies 2006	\$5.56	\$28.02
	Soil Formation	Costanza et al. 1997	\$1.41	\$1.41
	Food Production	Costanza et al. 1997	\$86.26	\$86.26

Native Andean Alpine Grasslands	Biological Control	Pimentel et al. 1995	\$22.61	\$22.61
		Pimentel et al. 1997	\$33.16	\$33.16
	Erosion Control	Barrow (1991) (Calculated 1992)	\$44.21	\$44.21
		Costanza et al. 1997	\$41.83	\$41.83
	Gas & Climate Regulation	Costanza et al. 1997	\$9.51	\$9.51
		Fankhauser and Pearce (1994)	\$9.41	\$9.41
		Wilson, Sara J.	\$25.82	\$397.35
		Wunder, S., et al.	\$148.47	\$296.94
	Habitat Refugium & Nursery	Asquith et al.	\$3.10	\$3.10
	Pollination	Pimentel et al. 1995	\$25.01	\$25.01
		Pimentel et al. 1997	\$36.07	\$36.07
	Soil Formation	Costanza et al. 1997	\$1.44	\$1.44
		Sala and Paruelo (1997) (Calculated 1994)	\$1.21	\$1.21
	Waste Treatment	Pimentel et al. 1997	\$125.49	\$125.49
		Wunder et al.	\$7.48	\$14.95
	Water Regulation	Costanza et al. 1997	\$4.32	\$4.32
		Jones et al. (1985) (Calculated 1992)	\$5.02	\$5.02
Water Supply	Asquith et al.	\$3.10	\$3.10	
	Wunder, S. et al.	\$7.48	\$14.95	
Food Production	US Dept of Comm (1995) (Calculated 1992)	\$57.03	\$57.03	
Rivers and Lakes	Aesthetic & Recreational	Burt, O. R. and Brewer, D.	\$1,209.65	\$1,209.65
		Cordell, H. K. and Bergstrom, J. C.	\$354.58	\$3,718.51
		Kealy, M. J. and Bishop, R. C.	\$33.87	\$33.87
		Kreutzwiser, R.	\$474.75	\$474.75
		Piper, S.	\$629.16	\$629.16
		Ward, F. A., Roach, B. A. and Henderson, J. E.	\$53.64	\$5,025.45
		Young, C. E. and Shortle, J. S.	\$214.39	\$214.39
		Loomis J.B. 2002	\$29,155.62	\$51,597.93
	Postel & Carpenter 1997	\$230.01	\$230.01	
	Habitat Refugium & Nursery	Loomis 1996	\$42.33	\$42.33
	Waste Treatment	Gibbons (1986) (Calculated 1980)	\$183.92	\$2,391.04
	Water Regulation	Gibbons (1986) (Calculated 1980)	\$3,697.88	\$6,466.48
	Water Supply	Bouwes, N. W. and Scheider, R.	\$1,617.32	\$1,617.32
		Croke, K., Fabian, R. and Brenniman, G.	\$1,482.30	\$1,482.30
		Gibbons (1986) (Calculated 1980)	\$163.68	\$1,257.87
		Henry, R., Ley, R. and Welle, P.	\$1,124.47	\$1,124.47
		Howe & Easter (1971) (Calculated 1971)	\$361.42	\$14,641.83
		Piper, S.	\$79.91	\$79.91
		Ribaudo, M. and Epp, D. J.	\$2,209.24	\$2,209.24
	Food Production	Postel & Carpenter 1997	\$40.99	\$40.99

Cloud Forests	Aesthetic & Recreational	Prince, R. and Ahmed, E.	\$3.68	\$4.70
		Gössling, S.	\$9.55	\$766.06
	Biological Control	Costanza et al. 1997	\$5.68	\$5.68
		Krieger, D.J.	\$23.55	\$23.55
	Erosion Control	Chopra 1993	\$6.82	\$958.89
		Costanza et al. 1997	\$136.82	\$136.82
		Chomitz, K.M., and Kumari, K.	\$76.02	\$824.93
		Magrath, W.B., and Arens, P.	\$9.07	\$9.07
	Gas & Climate Regulation	Pimentel, D. 1998	\$32.94	\$32.94
		Adger et al. 1995	\$34.60	\$173.01
		Mates. W., Reyes, J. 2004	\$44.90	\$623.02
		New Jersey Type A Studies 2006	\$26.12	\$32.94
		Kumari, K.	\$500.97	\$500.97
	Genetic Resources	Grieg-Gran, M. et al.	\$77.23	\$135.15
		Adger et al. 1995	\$1.73	\$155.71
		Pearce, D., and Moran, D.	\$34.47	\$34.47
	Habitat Refugium & Nursery	Godoy, R. et al.	\$55.05	\$253.84
		Amigues, J. P., et. al.	\$158.25	\$604.54
		Amigues, J. P., et. al. 2002	\$185.72	\$709.56
		Garber et al. 1992	\$706.82	\$1,185.42
		Haener, M. K. and Adamowicz, W. L.	\$3.76	\$25.75
		Kenyon, W. and Nevin, C.	\$1,310.29	\$1,310.29
		Shafer, E. L. et. al.	\$7.36	\$7.36
		New Jersey Type A Studies 2006	\$2.59	\$1,342.82
	Nutrient Cycling	Asquith et al.	\$3.10	\$3.10
		Chopra 1993	\$1,346.65	\$1,346.65
	Pollination	Costanza et al. 1997	\$514.55	\$514.55
		Wilson, Sara J.	\$487.17	\$487.17
		New Jersey Type A-C studies 2006	\$145.79	\$654.83
	Raw Materials	Asquith et al.	\$3.10	\$3.10
		Costanza et al. 1997	\$35.63	\$35.63
		Shone and Caviglia-Harris 2006	\$20.59	\$42.40
		Grimes, A. et al.	\$3,423.68	\$3,423.68
Soil Formation	Gram, S.	\$11.21	\$21.18	
	Costanza et al. 1997	\$14.26	\$14.26	
	Pimentel et al. 1997	\$10.01	\$10.01	
Waste Treatment	Pimentel et al. 1997	\$87.01	\$87.01	
	Adger et al. 1995	\$86.51	\$259.52	
Water Regulation	Loomis, J.B. 1988	\$25.17	\$25.17	
	Olewiler, N.	\$76.65	\$76.65	
Water Supply	Asquith et al.	\$3.10	\$3.10	
	Kumari	\$10.58	\$10.58	
Food Production	Costanza et al. 1997	\$71.27	\$71.27	
	Adger et al. 1995	\$2,659.22	\$2,659.22	
	Godoy et. al. 1993	\$8.38	\$110.13	

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Appendix E: Ascendant Copper-Results of Check Assaying Program on Junin Property

Ascendant Copper-Results of Check Assaying Program on Junin Property (Ecuador) - TSX (TSXTSX...

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DENVER, COLORADO—(CNMatthews - June 11, 2007) - Ascendant Copper Corporation (the "Company" or "Ascendant") (TSX:ACX)(TSX:ACX.WT)(BERLIN:A0HMLE)(FRANKFURT:ASC) (WKN:A0HMLE) announces the results from a check assay program on its Junin project, a copper/molybdenum, gold/silver porphyry property located in northern Ecuador. During the period from 1991 to 1997, prior to the acquisition of the property by Ascendant, a third-party consortium carried out an exploration program (the "1990s Program") on the Junin project, which included the drilling of 30 drill holes.

In late 2006, based on recommendations contained in the Junin Report(1), Ascendant initiated a check assaying program of selected intervals of historic drill core from four holes (Holes 27, 28, 29 and 30) drilled under the 1990s Program. The assay results that Ascendant received from this check assay program were substantially different from the results of the 1990s Program. Given the discrepancy in results, as set out in the table below, Ascendant retained Micon International Co. Limited ("Micon") to review Ascendant's check assay results. Micon recommended that core from an additional four holes (Holes 4, 10, 17 and 22) from the 1990s Program be re-sampled and assayed. Ascendant completed this re-assay work in March 2007, with a total of 702 check samples taken from the selected eight holes of historic core drilled during the 1990s Program.

A summary of check assaying results from the eight holes re-assayed (the "2007 Check Assay Program") as compared to the original assay data prepared and reported by the 1990s Program is as follows:

Hole	Total Depth (meters)	Interval Sampled		1990s Program		2007 Check Assay Program	
		From (meters)	To (meters)	% Cu	% Mo	% Cu	% Mo
4	149	26	96	1.66	0.217	2.08	0.201
10	301	12	59	0.36	0.003	0.47	0.002
17	150	12	139	0.34	0.007	0.41	0.023
22	304	96	206	0.28	0.009	0.22	0.007
27	603	6	602	0.57	0.008	0.33	0.018
28	603	6	596	0.46	0.008	0.28	0.016
29	602	250	508	1.25	0.135	0.50	0.034
30	603	242	506	1.77	0.077	0.88	0.016

The 2007 Check Assay Program involved Ascendant obtaining access to the boxes of historical core, which are the property of the Ecuadorian government and stored in a government warehouse, diamond sawing the remaining core in the boxes, and re-assaying one-half of the core. In order to maintain the core in good condition, a substantial portion of the core had been previously transferred from deteriorating core boxes into new core boxes. From visual examination, it appeared that much of the fine fraction of material was lost in the transfer process. In many cases, as noted in the table above, the 2007 Check Assay Program results were significantly different from the historically reported assays from the 1990s Program, with check assays showing a range of both higher and lower results.

It was expected that the 2007 Check Assay Program results would be in close proximity to the 1990s Program results. Because of the noted discrepancies, Micon has advised Ascendant that the inferred resource estimate contained in the Junin Report of 982 million tonnes grading 0.89% copper, 0.04% molybdenum and 1.9 grams per tonne silver, may not be fully representative of the mineralization at Junin, as the inferred resource estimate was based on historical data, some of which is now considered

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to be unverifiable due to deterioration of the core samples over time, the loss of fine material in the transfer of the historical core samples, and the methods of sampling and assaying employed during the 1990s Program.

Micon has also advised Ascendant, however, that it does not believe that the results obtained in the 2007 Check Assay Program are sufficient to complete a meaningful revision of the inferred resource estimate identified in the Junin Report. As previously outlined in the Junin Report, Micon recommends that Ascendant complete a drilling program of the Junin project, including twinning of certain historic holes, and that all aspects of future drilling, logging, sampling and assaying be closely scrutinized and carried out in accordance with industry standard best-practices. Ascendant intends to follow Micon's recommendation.

"Management remains optimistic about the value-creation potential of the Company's mineral properties," declared Gary E. Davis, President and Chief Executive Officer of Ascendant. "Our Chaucha copper/molybdenum project in southern Ecuador has yielded encouraging drill results, and we will continue to carry out work on our Junin property with the aim of realizing the value that it could offer Ascendant's shareholders."

John R. King, Ascendant's resident exploration and geological expert as well as a Qualified Person as defined by National Instrument 43-101, Standards of Disclosure for Mineral Projects, has reviewed the above statements and check assay results of the 2007 Check Assay Program. Mr. King confirms that Ascendant followed quality controls and correct assay procedures in the 2007 Check Assay Program and that the geologic observations of the samples are correct.

Ascendant Copper Corporation is a mineral exploration and development company responsibly advancing the Chaucha copper-molybdenum project, the Company's lead project, and the Junin copper-molybdenum project, both in Ecuador, toward a verifiable economic base metal discovery. Ascendant has a solid mineral asset base, a diversified portfolio, proven management, and is committed to becoming a mid-tier copper producer through its agreement in respect of the Chaucha project with Antofagasta PLC (LSE:ANTO) and its strategic exploration alliance in Ecuador with Rio Tinto (LSE:RTZ).

(1) Technical report dated April 7, 2005, and amended August 5, 2005 and October 12, 2005, entitled Technical Report Review of the Quartz Porphyry-Hosted Copper-Molybdenum Mineralisation at Junin, Otavalo, Ecuador (the "Junin Report"), prepared by Qualified Person, Paul D. Gribble, C. Eng., Senior Mineral Resources Geologist, of Micon.

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