COMMODITIES AND BIODIVERSITY IN THE WATERSHEDS OF THE ANDES

IMPACTS OF COMMODITY DEVELOPMENT ON BIODIVERSITY AND ECOSYSTEM SERVICES IN THE WATERSHEDS OF THE ANDES

MacArthur Foundation

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LIST OF ACRONYMS

ASL	Above Sea Level
BH	Bolivian High
CARs	Regional Autonomous Corporations
CBD	Convention on Biological Diversity
CI	Conservation International
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
EEQ	Empresa Eléctrica Quito (Quito Electric Company)
EIAs	Environmental Impact Assessments
EPMAPS	Empresa Pública Metropolitana de Agua Potable y Saneamiento (Metropolitan Company for Drinking Water and Sanitation)
FDI	Foreign Direct Investment
FONAG	Fondo para la Protección del Agua (Water Protection Fund)
FTAA	Free Trade Area of the Americas
GDP	Gross Domestic Product
HBWAs	High-Biodiversity Wilderness Areas
HDI	Human Development Index
IIRSA	Integration of the Regional Infrastructure of South America
ITCZ	Intertropical Convergence Zone
MA	The Millennium Ecosystem Assessment
MEAs	Multilateral Environmental Agreements
NGO	Non-Governmental Organisation
NTFPs	Non timber forest products
PES	Payments for Ecosystem Services
SPAC	South Pacific Anticyclone
TNC	The Nature Conservancy
UNCCD	United Nations Convention to Combat Desertification
UNFCCC	United Nations Framework Convention on Climate Change
USD	US dollars
WA	Watershed of the Andes
WWF	World Wildlife Fund for Nature

1. Key Points

- The Watershed of the Andes (WA) Region is one of exceptional biodiversity, and of extremely high endemism. It is also of great importance for the ecosystem services provided, both within the study region and far beyond, in particular for water-related services.
- Development has occurred rapidly in the region. Fast population growth, combined with a sharp reduction in poverty levels, has led to an increase in consumption and demand for products and services.
- Political changes have facilitated foreign investment, primarily in the region's natural resources such as hydrocarbons and minerals.
- Previously inaccessible areas are being opened up to exploration, extraction and development as a result of this increasing investment, which stimulates further development.
- The impacts of the development of different commodity types are closely interlinked, highlighting the need for strategic environmental assessments at a regional scale.
- Habitat loss - notably deforestation – is a significant result of most types of commodity development, with little original habitat remaining in the region.
- Commodity-driven land cover change greatly affects water supply, impacting on the livelihoods of millions of people downstream depending on the water from the Andes.
- Protected areas are a key tool for conservation, but protection levels vary throughout the region. Extractive industries are legally permitted to operate in protected areas in some countries, while across the region the prevention of illegal activities is an ongoing struggle.
- Yet, recognition of the importance of watershed level protection, and of the benefits that this provides to users far downstream, is increasing.
- Responses to the core pressures on the environment are increasing but their effectiveness and success varies greatly. Monitoring and enforcement of laws and regulations is weak throughout the region.
- Transboundary cooperation is essential to minimise the impacts of commodity development, due to the inherent transboundary nature of the provision of ecosystem services, as well as of pressures on natural resources such as illegal cross-border trade.
- Despite recent improvements in many countries of the region, historically insecure land tenure rights have played a key role in the failure of many conservation and environmental management initiatives.
- Existing initiatives to address the pressures from commodity developments and strengthen the capacity to respond to adverse impacts need to be expanded to the wider region. Environmental Impact Assessment processes in commodity development projects need to be strengthened. The policies of international donors, investors, operators and other key actors need to be influenced to adopt higher standards regarding environmental and social impacts.

2. Executive Summary

The 'Watersheds of the Andes' region is one of unquestionable importance for its high biodiversity and considerable ecosystem services, benefiting populations both in the region and globally. However, fast-growing economies across the region, based largely on natural resources, pose a great risk to the natural environment unless properly managed. Increasing foreign investment has stimulated exploitation of natural resources, with great costs already evident to biodiversity, ecosystem services and, consequently, human populations. Enforcement of laws and policies in remote and isolated areas is a challenge for countries. It is important that environmental issues are addressed cooperatively, recognising the transboundary nature of both their causes and impacts.

Regional Profile

The 'Watersheds of the Andes Region' (WA Region) is comprised of large portions of Colombia, Ecuador, Peru and Bolivia, as well as smaller areas of Venezuela, Panama and Brazil. Spanning a huge diversity of ecosystems, from the high-altitude grasslands and cloud forests of the Andes to the tropical forests of the Amazon, the region has a unique geological history and important climate variability which is largely responsible for the exceptional biodiversity of the region.

The region, a large part of which overlaps with the 'Tropical Andes' Biodiversity Hotspot , is renowned for hosting some of the most species rich forests and rivers in the world. In addition, it hosts a large number of species found nowhere else: for example, it is estimated that the vascular plant species in the Andes represent 15% of all species known globally, and that 25%-50% of all vascular plants in the Tropical Andes Biodiversity Hotspot are endemic to the region. The region is particularly renowned for the high diversity of domesticated crops and their relatives, making it of particular importance in light of global climate change.

The region not only supports high biodiversity, but also a very large number of people within the region and further afield, with estimates of 100 million people benefiting from services provided by the high Andean wetlands. Among these populations are a high diversity of ethnicities, with a strong Amerindian influence and some of the last uncontacted people living in voluntary isolation in the world. Water from the Andes is the major domestic, agricultural and industrial water source for not only the highlands but also extensive parts of the adjacent lowlands and the arid coastal plains of North Peru beyond the extent of the study region.

Populations in all WA countries have been growing quickly over recent years, alongside steady declines in poverty levels, which has resulted in a rapid increase in consumption and changing demand for goods and services. The region has seen growth in international investment, and resulting growth in national economies, which consequently suffered from the recessions of the 1980s and the 2000s.

Natural resources, and in particular minerals and hydrocarbons, are largely behind this economic growth, comprising the top export commodities in all countries (except for Panama). The USA and China are the most prominent trade partners outside the region. Trade within the region is also important, largely due to specific initiatives such as for example the Initiative for the Integration of the Regional Infrastructure of South America (IIRSA).

Commodity Development and Impacts on Biodiversity and Ecosystem Services

Commodity development is a major driver of habitat loss in the WA region. Conservation International (CI) estimate that only one quarter of the original habitat cover remains in the Tropical Andes Biodiversity Hotspot and forest cover is still declining in all WA countries. Such deforestation has huge impacts on hydrological processes as well as on communities who depend on forests for their livelihoods.

Agriculture is an important activity for the subsistence and livelihoods of rural populations. Its contribution to Gross Domestic Product (GDP) is small, but recent policies emphasising the use of renewable energy sources have led to a huge increase in land cultivated for biofuels. Biofuel crops occupy valuable agricultural space, forcing expansion of other agricultural areas in order to produce enough food to meet the region's growing demands – this expansion is largely upwards at the expense of fragile and vulnerable ecosystems such as cloud forests and the Páramo.

Agricultural expansion is the main driver of **deforestation** in the region. But the forests of the WA Region are highly attractive due to the presence of high-quality hardwood **timber**. Selective logging has significantly depleted populations of trees. In Bolivia, no commercially viable Mahogany trees remain across almost 80% of the species' range, and in Peru, the range has shrunk by 50% (Kometter *et al.* 2004).

Freshwater **fisheries** and **aquaculture** are not highly developed in the region, but aquaculture is growing rapidly, in particular for shrimp and tilapia.

Over recent decades, the emphasis on **hydropower** has grown considerably, seen by governments as a reliable means of meeting growing energy demands whilst diversifying from fossil fuels and providing revenue from exports (Finer and Jenkins 2012). There is important potential for hydropower generation in the region, and many medium and large capacity dams are planned, notably in Ecuador and Peru. Impacts include habitat loss due to flooding, infrastructure creation, sediment trapping, blocking of fish migration paths and social impacts on people who are displaced or whose livelihoods depend on predictable water supply and rich downstream flood plains.

The WA Region holds extensive reserves of **hydrocarbons** as well as economically important **minerals**. Inaccessibility may explain the slow growth in the industry to date, but foreign investment is driving growth in extraction . Impacts of extractive activities are large and varied: habitat destruction occurring during exploration and extraction; water consumption; increased sediment and pollution arising from spillages or from hazardous substances such as cyanide and mercury that are dumped or leaked into water courses; and social impacts due to population displacement and catalysing land-grabbing. In many countries of the region extraction occurs in protected areas, threatening those areas that are designed to protect biodiversity.

These activities rely on **infrastructure development**, resulting in further impacts such as decreased water quality in rivers through erosion. The creation of roads also facilitates access and opens land to invasion by migrant farmers and illegal loggers.

Cultivation of plants for the production of drugs, namely coca, is also a growing activity in the region. Impacts include large-scale habitat destruction, increased soil erosion and intensive water and nutrient use, as well as pollution from the chemicals used in processing (Salisbury and Fagan 2011). Other important commodities include **wildlife trade** and **tourism**, a large and growing industry, although with limited information on specific impacts in the region.

Initiating change and responding to the impacts of commodity development in the WA region

A number of initiatives and measures are being taken in order to minimise or mitigate the impact of commodity development on biodiversity and ecosystem services, with varying degrees of success. Protected areas are increasing, but often with ineffective management. Illegal encroachment and resource extraction is common, and many countries actually permit such activities within the borders of protected areas.

Countries are increasingly turning to Payments for Ecosystem Services (PES) schemes, whereby payment is offered for the conservation and sustainable use of areas providing key services. Most notably this takes the form of watershed protection, recognising that protecting these upstream areas ensures essential water supply for populations far downstream. A number of these schemes have met with considerable success, although their long-term sustainability is often called into question.

While all countries in the WA region are signatories to the major biodiversity-related conventions and have adopted relevant environmental legislation, enforcement remains an issue, often due to the lack of presence of the state in remote and isolated areas. In addition, a lack of capacity and of transboundary cooperation has also limited effective enforcement, which is particularly important given the transboundary nature of many of the watersheds

The countries of the WA region have seen land tenure reforms over past decades, often more than one. Early reforms first opened land up to companies and extractives, before starting to recognise the rights of local populations and allowing communities to obtain land titles. However the titling process is in many cases an extremely slow and onerous process, proving challenging to many. Such issues have been seen to limit the success of conservation initiatives, such as PES schemes.

Existing initiatives to address the pressures from commodity developments and strengthen the capacity to respond to adverse impacts need to be expanded to the wider region. In addition, this review proposes the following actions for the WA region as a whole:

- Support mechanisms for watershed level land use planning and transboundary collaboration on the development of extractives.
- Strengthen the legal status of protected areas and support transboundary protected area management.
- Improve Environmental Impact Assessment processes to better include downstream and longer term impacts and strengthen control mechanisms.
- Influence the policies of international donors, investors, operators and other key actors to adopt higher standards regarding environmental and social impacts.
- Support the implementation of MEAs in particular in relation to the threats from commodity developments.
- Support devolution of rights on land and resources to local communities and strengthen their capacity to manage them sustainably in the face of external pressures, including through PES schemes.
- Generally strengthen national and regional environmental policy and legal frameworks.

3. Introduction

Covering over 200 million hectares along the Northern and Central Andes mountain ranges and spanning six countries, the Watersheds of the Andes (WA) Region is one of exceptional diversity, ranging from lowland tropical forests in the East, to high altitude grasslands and glaciers, to extensive tropical mangrove systems in the coastal regions. The extensive rivers originating high in the Andes are a source of vital water that sustains agriculture, industry, and the people living within and outside the region. However, increasing commodity-driven developments are threatening the region's biodiversity and the ecosystem the services its inhabitants and economies depend on.

This report is the first of a two-part study that supports the targeting of conservation-related investments in the region by the MacArthur Foundation and other donors. The second part of the study is a spatial analysis of the potential impacts of future scenarios for commodity-driven land use change on biodiversity and ecosystem services in the region's watersheds.

The main objective of this report is to provide a synthesis of the impacts of major commodity developments on biodiversity and ecosystem services in the WA region and the current capacity to respond to these pressures.

The study aimed to collect the best available information and provide analysis on the current situation in the region regarding biodiversity and ecosystem services, their importance for economic and social development, impacts on them from major commodity developments, and the current capacity to initiate change to address these impacts. The report brings together a broad range of new and existing information and builds on existing reviews for parts of the region by, among others, the Critical Ecosystem Partnership Fund (CEPF).

The boundaries of the WA Region as defined by the MacArthur Foundation do not wholly coincide with a widely recognized ecologically, geographically or politically delimited region. Where appropriate, this issue has been acknowledged in the text. As the region overlaps with varied sized parts of six different countries, this study has largely focused on the country level, with a greater emphasis on the four main countries of the WA Region (Bolivia, Colombia, Ecuador and Peru).

A detailed literature review and targeted expert consultation were carried out to identify the social, economic and political context of the region and to assess the status and trends in important biodiversity and ecosystem services. Existing datasets were used to analyse commodity development trends in the region. Peer-reviewed and grey literature helped identify impacts on biodiversity, ecosystem services and human well being from these developments.

Finally, the capacity to respond to these threats was investigated through an analysis of the institutional contexts (policy, civil society) in relation to land and resource use in the countries of the region, taking into account the socio-economic context and the evidence from the review of past and current developments and their impacts.

The report outlines data and information gaps, and key messages to help guide investment (by the MacArthur foundation) to reduce negative impacts.

4. The Watersheds of the Andes Region

This chapter describes some of the main geographical, geological, climatic, biophysical characteristics of the study region, including major habitat and ecosystem types and areas considered of great ecological importance. It also gives a broad socio-economic profile of the countries of the Watersheds of the Andes Region.

4.1 GEOGRAPHIC AND POLITICAL BOUNDARIES

The Watersheds of the Andes region as defined by the MacArthur Foundation spans 276,761,640 ha of South America along the Northern and Central Andes mountain range. It includes large portions of Colombia, Ecuador, Peru and Bolivia as well as smaller portions of Venezuela, Panama and Brazil (Figure 1 and Table 1). Sub-national administrative divisions such as 'provinces' or 'departments' that fall fully or partially within the boundaries of the Watersheds of the Andes (WA) region as defined by the MacArthur Foundation are listed in Table 2.

The region comprises numerous rivers that start high in the Andes and mostly drain either West towards the Pacific coast or East into the Amazon basin (Mulligan *et al.* 2010). The region is unusual in its high number of separate basin outlets, rather than the more common single basin outlets draining one main river which is itself fed by numerous rivers and tributaries (Mulligan *et al.* 2010).

Figure 1: the Watersheds of the Andes region as defined by the MacArthur Foundation (MacArthur Foundation 2012)

The WA region includes river basins in Venezuela, Colombia, Ecuador, Peru and Bolivia. A notable feature of the region is the large number of separate basin outlets on the Pacific coast, outside the study region as defined, rather than the more common single outlet basins fed by many rivers and tributaries (Mulligan *et al.* 2010). Complex ecosystems, highly seasonal rainfall, and steep slopes result in high runoff and extreme events such as landslides and floods (Yacoub and Pérez-Foguet 2009).

Andean tributaries of the Amazon River include Caqueta, Madeira, Napo, Marañon, Putumayo, and Ucayali (Finer and Jenkins 2012). Spatial water distribution varies widely throughout the Andean region (Ramírez and Cisneros 2007).

Table 1: Countries covered by the study with proportion included in the WA region as defined by the MacArthur Foundation

Country	MacArthur area (ha)	% of MacArthur area covered by country	Total country area (ha)	% of country area covered
Peru	95,438,210	34.48	129,139,200	73.9 %
Colombia	77,974,840	28.17	113,670,830	68.6 %
Bolivia	70,870,190	25.61	108,279,460	65.5 %
Ecuador	16,709,790	6.04	25,598,700	65.3 %
Venezuela	9,945,060	3.59	91,026,270	10.9 %
Panama	59,500	0.02	7,492,850	0.8 %
Brazil	5,764,120	2.08	847,308,530	0.7 %

Table 2: Administrative divisions covered by the WA region as defined by the MacArthur Foundation

Country	Administrative divisions falling fully or partially within MacArthur region's boundaries
Peru	Amazonas, Cajamarca, San Martin, La Libertad, Loreto, Ucayali, Madre de Dios, Cusco, Apurímac, Ayacucho, Puno, Huancavelica, Junín, Pasco, Huánuco, Ancash, Arequipa (very small portion)
Colombia	La Guajira, Atlántico, Magdalena, Cesar, Sucre, Córdoba, Antioquia, Chocó, Valle del Cauca, Cauca, Mariño, Putumayo, Amazonas, Caquetá, Vaupés, Guaviare, Huila, Tolima, Nariño, Bolívar, Caldas, Quindío, Risaralda, Norte de Santander, Cundinamarca, Bogotá, Boyacá, Meta (very small portion)
Bolivia	Pando, La Paz, Cochabamba, Beni, Chuquisaca, Santa Cruz
Ecuador	Esmeraldas, Carchi, Sucumbíos, Imbabura, Pichincha, Santo Domingo de los Colorados, Napo, Orellana, Pastaza, Morona-Santiago, Zamora-Chinchipe, Loja (small portion), Azuay, Cañar, Chimborazo, Tungurahua, Cotopaxi
Venezuela	Zulia, Mérida, Táchira, Trujillo, Lara, Falcón
Panama	Very small portions of Darién
Brazil	Very small portions of: Amazonas, Acre, Rondônia, Mato grosso

4.2 GEOLOGY

Prior to the uplift of the Andes, the present-day Amazon region was part of a much larger pan-Amazonian region, a river-based landscape with diverse fauna (Hoorn *et al*. 2010).

Uplift in the Central and Northern Andes resulted from tectonic readjustments around 65-34Ma, and intensified following plate breakup in the pacific at around 23Ma (Hoorn *et al*. 2010). This uplift had a huge impact on climate for the entire region, and consequently on the evolution of landscape for the northern half of the continent, including the Amazon region (Hoorn *et al*. 2010). The combination of increased uplift and the climatic processes brought about by surpassing a critical elevation of around 2000m above sea level (ASL) led to increased erosion and water and sediment supply to the lowlands (Hoorn *et al*. 2010).

Stretching for 1800km along the central Andes, and reaching a width of 350-400km, the Altiplano-Puna Plateau was formed in the absence of tectonic collision, possibly due to a combination of magmatic processes and crustal shortening (Allmendinger *et al*. 1997).

The most intense period of mountain-building in the Andes took place around 12Ma, which brought with it changing lowland environments, and the development of a wetland system, promoting radiation of endemic species and diversified flora and fauna (Hoorn *et al*. 2010). A diverse forest was already present at this time, and remained on the margins of the wetlands (Hoorn *et al*. 2010).

Around 10 Ma the increased uplift and sedimentation, combined with sea level drop and climatic cooling permitted Andean sediments to reach the Atlantic Coast through the Amazon drainage system (Hoorn *et al*. 2010). It is at this point that the western Amazonian region began to resemble the present-day system, and the Amazon River became fully established around 7Ma (Hoorn *et al*. 2010).

As the plates reorganized, the Panama Isthmus was closed at around 3.5Ma, resulting in the Great American Biotic Interchange, which led to a decline in the number of endemic South American mammal families, although overall diversity remained stable (Hoorn *et al*. 2010).

4.3 CLIMATE AND HYDROLOGY

As mentioned above, the Andes mountain range is the most influential feature on climate across the whole of northern South America, and leads to climatic phenomena on scales ranging from a few kilometres to over a thousand kilometres (Garreaud 2009).

The Andes also result in a sharp contrast in conditions to their east and west (Garreaud 2009). The most extreme east-west precipitation differences are seen between 18 and 23 degrees south, with the Atacama desert on the west of the Andes and the Chaco wetlands on the east. This divide in precipitation runs along a diagonal from south-east to north-west (Garreaud 2009).

In the Northern Andes, seasons are defined by precipitation as the temperature stays relatively stable year round (Parsons 1982). Temperature is determined by elevation and air humidity, which in turn produce an ecological elevational zonation with significant differences between the eastern and western slopes of the Andes (Martinez *et al.* 2011). Precipitation is influenced by both the Atlantic and Pacific Oceans, and the Amazon Basin and is highly variable (Martinez *et al.* 2011). The Intertropical Convergence Zone (ITCZ), where trade winds from both hemispheres converge, is an important reason for the seasonal variability in the region. During the year, the ITCZ migrates first south to north and then back north to south, passing through the Central and Northern Andes twice annually and bringing with it heavy rains (Martinez *et al.* 2011).

In the Southern Andes, rainfall is mostly determined by the availability and transport of water vapour from the Amazon basin, the Pacific Ocean and the presence of Lake Titicaca (Martinez *et al.* 2011). This region sees one prolonged wet season from October to April, and one dry season per year, influenced by the South Pacific Anticyclone (SPAC), and the Bolivian High (BH; Martinez *et al.* 2011). The SPAC is associated with stability and dryness, while the BH is associated with precipitation (Martinez *et al.* 2011). The Altiplano remains extremely dry for most of the year, yet still shows a strong climatic gradient with average annual precipitation ranging from below 200mm per year in the South West to over 800mm in the North East (Garreaud 2009; Vuille *et al.* 2000). Most of this rain falls during the austral summer months (Vuille *et al.* 2000).

4.4 HABITATS AND ECOSYSTEMS

Considered the longest mountain range in the world, the Andes form a continuous chain of highlands along the western coast of South America and are home to many types of climates, landscapes, plants and animals. Due to its complex geography and varied weather conditions, the WA region contains a very large diversity of ecosystems (Josse *et al.* 2009). These different factors have also isolated populations, favouring speciation (Herzog *et al.* 2011).

Across the lower altitudes of the WA region, the Amazon **rainforest** is the dominant ecosystem, and can be found up to 1,000m elevation. **Tropical wet** and **moist forests** are found between 500 and 1500 m, while **pre-montane** and **montane cloud forests** extend from 800 to 3,500m and cover over 50,000,000 ha in Peru and Bolivia alone (Ramirez and Cisneros 2007). Precipitation here can range from very low up to 6000mm per year (Killeen 2007). These montane forests are among the most biologically diverse habitats in the Andes, with landscapes characterized by valleys, canyons, slopes of varying steepness, cliff faces, and ridge tops (Killeen 2007). Cloud forests are found at the upper limit of the montane forests and are effectively geographically isolated with unique environmental conditions (Killeen 2007). The 'ceja andina' (literally 'Andean Eyebrow') is a zonal type of cloud forest that was originally found between the tall upper montane cloud forest belt and the páramo, between 3,500 and 4,000m ASL (Hofstede *et al.* 2010). This vegetation type once extended from north to south of the tropical Andean Cordillera (Hofstede *et al.* 2010).

Above the forests, a vast high-altitude plain, the **Altiplano-Puna Plateau**, extends across much of southern Peru and western Bolivia at elevations above 3500m (Josse *et al.* 2011). Between 3,000 and 5,000m ASL, **grassland** and **scrubland** of the **páramo** and the **puna** extend to the snowline.

The **páramo** is a dense neotropical vegetation comprised mainly of shrubs and grasses, found in the northern tropical Andes between Venezuela and northern Peru (Buytaert *et al.* 2006). The páramo has unique soils characterized by their high infiltration properties that supply much of the Andean highlands as well as huge areas of lowlands with water, and regulate the headwaters of some of the largest tributaries of the Amazon basin (Buytaert *et al.* 2006, 2007). Found between 3,500 and 5,000m ASL, these fragile and unique ecosystems comprise a mosaic of lakes, peat bogs, wet grasslands, shrublands and forest patches (Buytaert *et al.* 2006; Vuille 2013). The southernmost páramos are found in southern Ecuador and northern Peru. These páramos are often locally known as '**jalca**' and are composed of slightly different vegetation, and sometimes seen as a transition between the páramo and the puna (Buyteart *et al.* 2006; Tovar *et al.* 2013a).

The **puna** is drier than the páramo, and is made up largely of alpine bunchgrass species, herbs, grasses, sedges, lichens, mosses, and ferns (Schuler *et al.* 2011). The World Wildlife Fund (WWF) recognizes three distinct puna sub-ecoregions: Central Andean dry puna, found in Argentina, Chile and Bolivia; Central Andean puna, found in Peru, Argentina and Bolivia, and Central Andean wet puna, found in Peru and Bolivia (WWF 2014b) **Opuntia scrublands** are also important systems, found in the Andean area and Mesoamerica. These scrublands require a certain amount of management in order to maintain them (Rodriguez *et al.* 2006).

There are also patches of **dry forests, woodlands, cactus stands, thornscrub, and matorral** in the region (Schuler *et al.* 2011). The characteristics of the major ecosystem groupings and their altitudinal ranges in the northern and central Andes are described in more detail in Table 3.

The WA region also extends into coastal areas in Ecuador and Colombia. For the most part, the Pacific coast of Ecuador and Colombia has relatively low population density, with extensive humid tropical mangrove ecosystems (Alvarez-León R.and Garcia-Hansen 2003). The Colombian Caribbean coastline is more developed, but still holds extensive dry tropical mangrove forests. Many of these forests are highly degraded (Alvarez-León R. and Garcia-Hansen 2003).

Table 3: Characteristics of major ecosystem groupings in the northern and central Andes (Anderson *et al.* 2011) * some differences in definition of the altitudinal range of the puna ecosystems exist, and it is largely considered to occur at altitudes above 3000m ASL (Halloy *et al.* 2008) or, commonly, 3500m ASL (e.g. WWF, no date).

Ecosystem	Altitudinal Range	General characteristics of terrestrial components and distribution	Important species
Páramo	>3000m	High elevation humid shrublands occurring from Venezuela to northern Peru in relatively thin strips along the top of the northern Andes, fragmenting into small patches in the south to Argentina and harbouring high levels of endemism.	Espeletta spp. Chusquea, Jamesonia, Azorella biloba, Gynoxis, Ericaceae, Loricaria, Werneria, many mosses, lichens and ferns
Humid Puna	2000-6000m*	Dominated by grasses, shrubs, and cacti, replacing páramo to the south where precipitation is lower, extending from northern Peru to Bolivia and Argentina	Festuca, Calamagrostis, Stipa, Poa spp. Liolaemus, llamas, alpacas, flamingos
Dry Puna	2000-6000m*	Almost desert-like vegetation in southern Peru through Bolivia to northern Argentina with low spiny shrubs	Festuca, Stipa, Deyeuxiay, Parastrephia spp., llamas
High Andean/ Superparamo	>4500m	The very highest places on mountaintops or just below snow fields or glaciers with permanent vegetation, usually consisting of very small stature plants, lichens and mosses. Occur throughout the tropical and temperate Andes	Azorella spp. Nototriche, Axchersoniodoxa, Menonvillea Attagis gayii, Vicuna, high levels of endemism
Cloud Forest	1000-3500m - to 600m in southern Peru and Bolivia	Very humid forests receiving a significant amount of precipitation in the form of cloud-borne mist that is intercepted by trees and have a highly endemic, closed canopy forest with high epiphyte loads. Occur throughout the tropical Andes	Ceroxylon, Dyctocaryum, Podocarpus, Calatola, Gustavia, Chusia spp.
Seasonal Andean Forest	800-3100m	Areas that experience 3-5month dry seasons and reduced precipitation, with medium stature forests made up in part by deciduous trees. Occur throughout the tropical Andes, but more extensive in Peru and Bolivia.	Roupala, pseudocordata, Psidium caudatum, Tipuana tipu, Calycophyllum multiflorum
Dry Andean Forest	800-4100m	Forests that typically have low stature trees with thick stems and leaves for water storage and abundant spines and chemical defences. Occur primarily in Inter-Andean valleys in Ecuador, Peru and Bolivia	Schinopsis haenkeana, Prosopis alba, Bursera spp., Plumeria spp., Jacaranda spp.
Inter-Andean Valleys	1900-3500m	Landscapes that have been heavily altered by humans for many millennia and are characterised by shrublands with seasonal herbs with adaptations to dry periods. Occur throughout the tropical Andes.	Acacia feddeana, Caracidium andicola, Jatropha spp., Croton spp., Salvia spp., Tecoma arequipensis, numerous Cactaceae species
Aquatic Habitats	>800m	Lakes, wetlands, cushion bogs, streams, rivers, occur throughout the tropical Andes	Orestias spp., Astroblepus spp., Chaetostoma spp., Phoenicoparrus spp., Theristicus spp., Telmatobius Isoetes, Ephemeroptera

4.5 BIODIVERSITY HOTSPOTS

The WA region overlaps with parts of one of the world's 5 High-Biodiversity Wilderness Areas (HBWAs) as defined by Conservation International (CI): **Amazonia** and with two of the world's 35 Biodiversity Hotspots as defined by CI: the **Tumbes-Chocó-Magdalena** and the **Tropical Andes** Hotspots (Figure 2). Biodiversity Hotspots are identified by CI based on both exceptional levels of endemism and serious levels of habitat loss (Conservation International 2014a) while HBWAs are highly biodiverse areas where over 70% of the original habitat still remains (Mittermeier *et al*. 2003).

The WA region overlaps with the Tumbes-Chocó-Magdalena Hotspot only in Panama, but the Hotspot extends for 1,500 km from the Panama Canal to North-West Peru, comprising 27,459,700 ha along the western coast and slopes of the Andes. From wet forests in Panama, Colombia and Ecuador to the dry forests of north-western Peru, the hotspot is bounded by the Pacific coast on the east and the 1000m elevation contour of the western slopes of the Andes, where the Tropical Andes Hotspot begins (Figure 2).

The Tropical Andes Hotspot covers 154,264,400 ha, extending from western Venezuela to northern Chile and Argentina, and covering large areas of Colombia, Ecuador, Peru, and Bolivia. The region includes the tropical part of the Andes Mountains and several adjoining cordilleras. This hotspot descends to 1000m elevation in the west and 500m in the east (Conservation International 2014a). There is considerable overlap with the Tropical Andes hotspot, which contains over 100 types of ecosystem yet only 25% of primary vegetation is thought to remain (Myers *et al*. 2000).

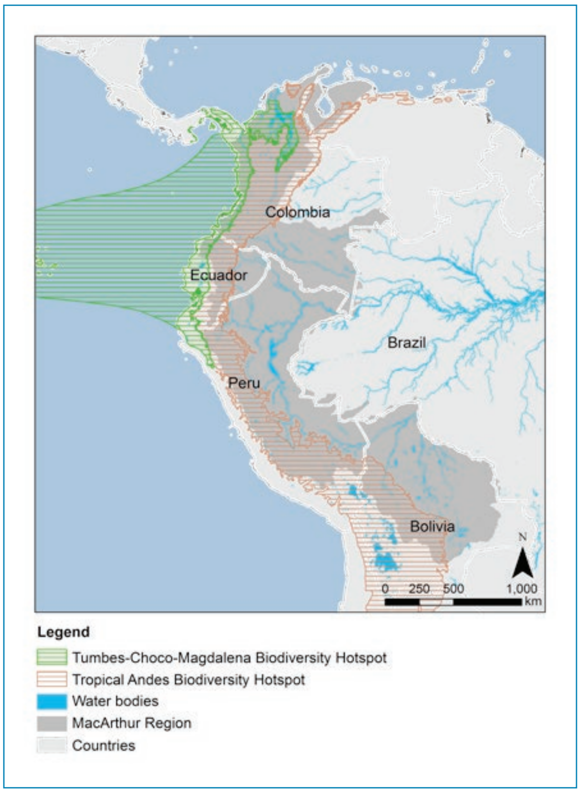


Figure 2: Biodiversity Hotspots and the WA region (adapted from Conservation International 2013)

To the east of the Andes, the WA region descends into lowland forests of the Amazon basin, famous for their high biodiversity, overlapping in part with the Amazonia HBWA, which extends into nine countries and supports over 40,000 species of plants, of which ¾ are endemic to the region (Conservation International 2014b).

4.6 SOCIO-ECONOMIC OVERVIEW

The following section provides an overview of statistics relating to demographics, poverty, human development, economy and trade. It should be noted that national statistics are presented in this section as these were most readily and consistently available, yet these may not be wholly representative for countries such as Brazil, Panama and Venezuela for which only a very small portion of the country is represented in the study region (0.7%, 0.8% and 10.9% respectively), and for which the proportion of the study region covered by the country is also small (2.08%, 0.02% and 3.59% respectively).

Demographic Overview

The WA region is home to a great diversity of ethnicities; among them some of the last groups of uncontacted people living in voluntary isolation (Finer *et al.* 2008).The Amerindian influence is strong, particularly in the countries of the WA region, where significant proportions of the populations still speak indigenous languages (Brea 2003).

Explosive population growth was seen across the whole continent during the twentieth century, fuelled by high birth rates and dropping death rates (Brea 2003). This growth has since slowed but the overall young populations in the countries of the WA Region will continue to increase (Brea 2003).

Herzog *et al.* (2011) noted that in the Tropical Andes Region, the current population stands around 100 million, but this is expected to increase to 135 million by mid-century (Herzog *et al.* 2011). Table 4 gives further information on population dynamics in individual countries.

Table 4: Demographic characteristics per country of the region (World Bank 2014)

	Total population (millions) (2004)	Total population (millions) (2012)	Population growth rate (%) (2004)	Population growth rate (%) (2012)	Urban Population (%) (2004)	Urban Population (%) (2012)	Labour force (millions) (2004)	Labour force (millions) (2012)
Bolivia	9.2	10.5	1.90	1.70	63.7	67.2	4	4.9
Brazil	184	199	1.20	0.90	82.5	84.9	92	104.7
Colombia	42.5	47.7	1.60	1.30	73.3	75.6	19.6	23.1
Ecuador	13.5	15.5	1.90	1.60	62.9	68	6.4	7.3
Panama	3.3	3.8	1.90	1.60	69.8	75.8	1.5	1.8
Peru	27.4	30	1.20	1.30	74.6	77.6	12.7	16.1
Venezuela	26.3	30	1.80	1.50	91.5	93.7	12.7	13.9

Population growth rates are fairly similar between countries of the WA Region, with the exception of Brazil where the growth rate is somewhat lower. Between 2004 and 2012 the growth rate has dropped slightly in each country except Peru. Urban populations are also increasing across the region with Venezuela reaching the highest rate of urbanization. Ecuador and Panama achieved the highest urban population growth rates between 2004 and 2012, at around 8%, while Brazil, Colombia and Venezuela were the lowest, at 3-4%. Increasing urbanization brings with it an increase in and change in consumption (Herzog *et al.* 2011). Urbanization in Latin America is notable in that the proportion of the urban population living in the countries' main cities is considerably higher than the global average (UN 2010).

Poverty

Poverty levels across all countries of the WA region have decreased since at least 2005, and for many countries since before this date.

Figure 3 shows poverty levels, where available, as a percentage of the population and by national standard.

Poverty is more prevalent among rural populations, although all countries appear to be making slightly greater progress in alleviating rural poverty than urban poverty (World Bank 2014).

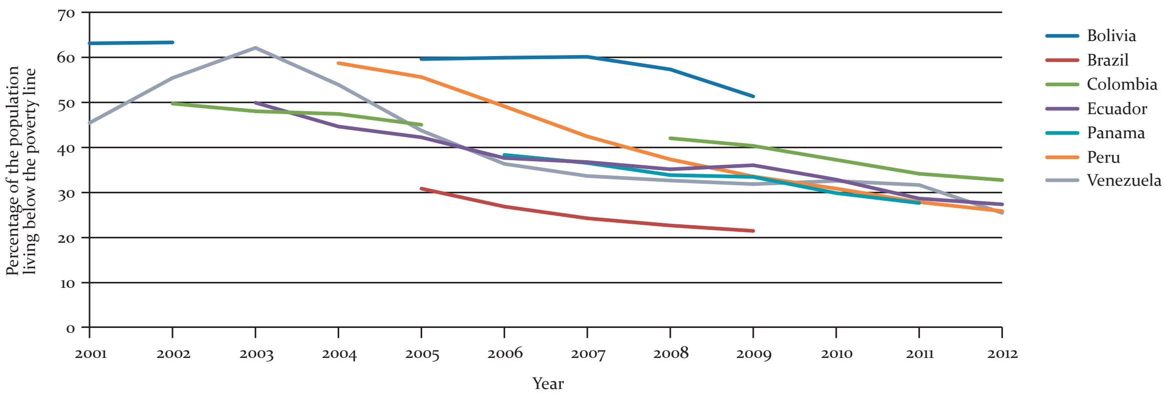


Figure 3: Percentage of the population living under the national poverty line (World Bank 2014)

Human Development Index

Countries across the WA region have seen a steady increase in their Human Development Index (HDI) since the earliest figures in 1980. Figure 4 shows that all countries except Bolivia have exceeded the overall world HDI score, but that Brazil, Ecuador, Colombia and Bolivia remain below the average for the Latin America region.

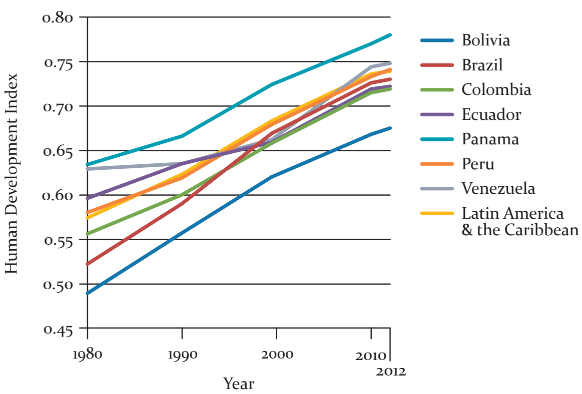


Figure 4: Human Development Index for WA Region countries and Latin America (UNDP 2014)

Political and Economic Context

In the 1930s, after the USA began to replace the UK as the principal investor in most countries, governments in the region increased their control over public services and economic activities such as utilities, infrastructure and natural resources (Bulmer-Thomas 2003). Yet, despite this state control, the inequality in income distribution was not changed and became extremely evident during the 1970s and 1980s (Bulmer-Thomas 2003).

The 1980s saw the effects of the global economic crisis hit Latin America. By the end of the 1980s, the average per capita Gross Domestic product (GDP) across the continent was 8% lower than at the start and inflation was nearly 1000% (Remmer 1991). This crisis was in no small part responsible for the fact that, during this same decade, a wave of democratization passed through Latin America (Yashar 1999). The region gave a new perspective to democracy, as the new regimes were particularly liberal with regards to political rights, but more restrictive with regards to social rights and responsibilities (Yashar 1999). These regimes also weakened corporatist institutions, common during the mid twentieth century, and aimed to replace them with more pluralist forms (Yashar 1999).

In the 1990s, economies in the region continued to grow, albeit erratically (Bittencourt 2011). During this decade, major reforms included the privatization of land markets, notably in Peru and Bolivia, and the liberalization of agricultural prices among others (Yashar 1999). There was also a major reconfiguration of local political power, control and administration as result of decentralization programmes (Yashar 1999). However, the 1990s did not bring political stability as in many countries across the WA region and the continent presidents were removed from power – and in some cases, such as Brazil, more than once (Pérez-Liñán 2007). However, the democracies endured and with relative stability came economic growth as private capital flows that had disappeared during the 1980s, reappeared. The Asian Crisis in the late 1990s meant that this tailed off again in about 1997, leading to the 'lost half decade' (Ocampo 2009).

Growth rates began to increase after 2002 and, although they were not remarkably high, the growth was more evenly spread across the continent. It was largely driven by high commodity prices, increased international trade, exceptional financing conditions and high levels of remittances from overseas (Ocampo 2009). However, the global economic crisis of 2008 hit the continent very hard as a result of a reverse in these same four factors, and it has taken the continent some time to recover (see also Figure 5 and Figure 6).

Despite this growth and expansion, none of the countries of Latin America can be considered developed – economic indicators almost consistently fall mid-way between the poorest countries of sub-Saharan Africa and the high-income countries in western Europe and North America (Bulmer-Thomas 2003). A number of countries in Asia that had much lower living standards during the nineteenth century have now overtaken Latin America (Bulmer-Thomas 2003).

Figure 5 shows the trends in total GDP since 1970, with all countries in the region growing steadily but with Brazil showing the most marked increase. There is difference between Brazil and the other countries however when considering GDP per capita (Figure 6). The aftermath of the global economic crisis is evident in 2009.

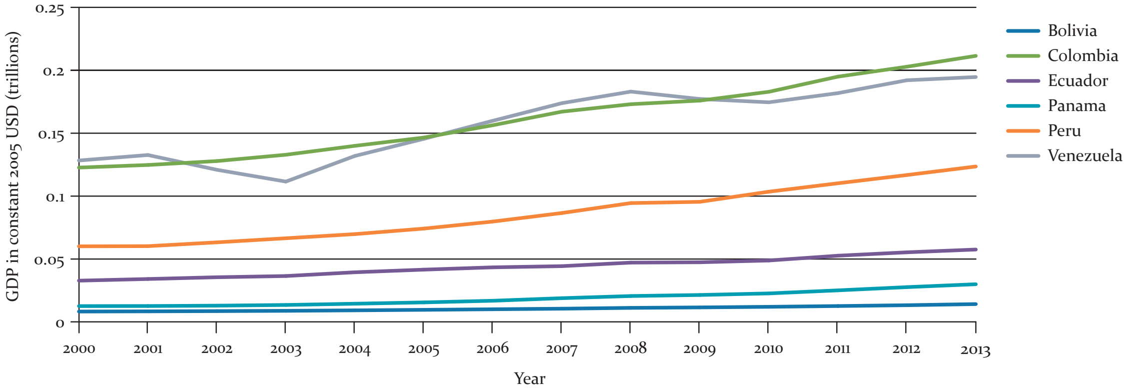


Figure 5: GDP in constant 2005 USD (trillions; World Bank 2014)

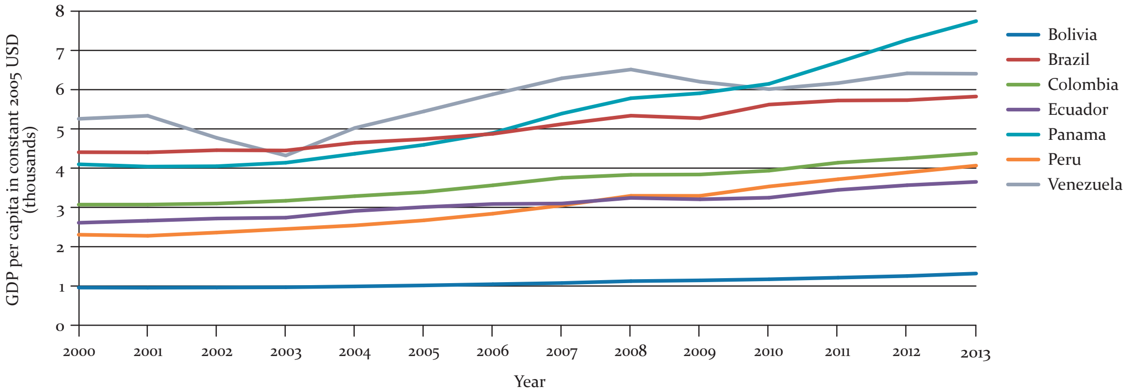


Figure 6: GDP per capita in constant 2005 USD (World Bank 2014)

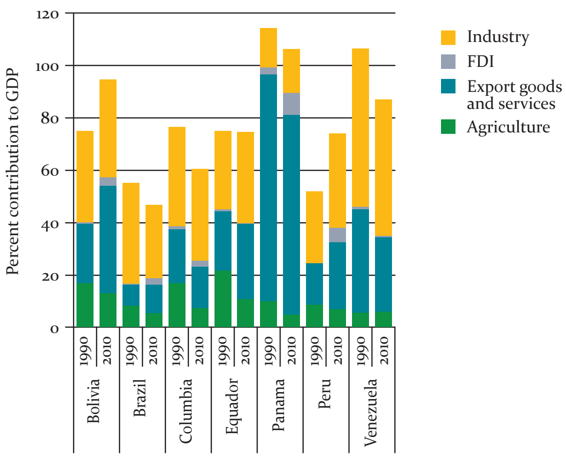


Figure 7: Contribution of Industry, Foreign Direct Investment, Exported Goods and Services and Agriculture to GDP (World Bank 2014) NB: figures above 100% due to overlap between category definitions

Figure 7 shows the contributions of economic activities to GDP in each of the WA countries. The contribution of agriculture, which has always mostly been for subsistence, has diminished over the past two decades, except in Venezuela. For most countries the contribution of Foreign Direct Investment (FDI) was negligible in 1990 but has now grown considerably. This is in a large part due to China's increased involvement in the region. China has shown great interest in Latin America, acquiring shares in particular in the extractive industries and, in the case of Ecuador, offering loans in order to guarantee oil exports to China (US EIA 2014a). As a result of this, China's trade with Latin America increased by 1200% between 2000 and 2009 (Chen and Chen 2013). Nonetheless, the USA is still a more frequent export partner than China for the WA region as a whole (Table 5).

Table 5: Top 10 export commodities and top 3 export partners for WA Region countries (UN Comtrade and UN Service Trade 2013a, b, c, d, e, f, g)

Bolivia	Brazil	Colombia	Ecuador	Panama	Peru	Venezuela
Gaseous hydrocarbons	Iron	Crude petroleum oils	Crude petroleum oils	Antibiotics	Gold	Crude petroleum oils
Precious metals	Crude petroleum oils	Coal and coal products	Bananas	Medicaments	Copper ores and concentrates	Non-crude petroleum oils
Zinc	Soya beans	Non-crude petroleum oils	Crustaceans	Footwear with outer soles and uppers of rubber or plastic	Refined copper and alloys	Iron
Oil-cake	Can/beet sugar	Gold	Fish, caviar	Perfumes	Non-crude petroleum oils	Ferrous products
Waste/scrap precious metals	Poultry	Coffee	Non-crude petroleum oils	Women's/ girls' clothing	Flours, meals and pellets of meat	Unwrought aluminium
Unwrought tin	Coffee	Cut flowers	Cut flowers	Men's/boys' clothing	Lead	Flat-rolled iron/non-alloy steel products
Crude petroleum oils	Oil-cake	Ferro-Alloys	Cocoa beans	Footwear with rubber, plastic or leather soles	Zinc	Ferro-alloys
Soya-bean oil	Chemical wood-pulp, soda or sulphate	Bananas	Palm oil	Wool clothing	Coffee	Artificial corundum
Silver	Non-crude petroleum oils	Coke	Motor vehicles	TV reception apparatus	Gaseous hydrocarbons	Coal and coal products
Lead	Aircraft/ spacecraft	Cane/beet sugar	Gold	Alcohol	Iron	Aluminium wire
Brazil Argentina USA	China USA Argentina	USA China Spain	USA Chile Peru	USA Venezuela Colombia	China USA Switzerland	S America North America Central America

Supporting the figures above, which show agriculture's reducing contribution to GDP, Figure 8 shows employment in agriculture, industry and services. There is a small drop between 2000 and 2008 for every country in the number employed in agriculture, with the exception of Peru. This is largely explained by increasing urbanisation, and by growth in industry and/or services for most countries.

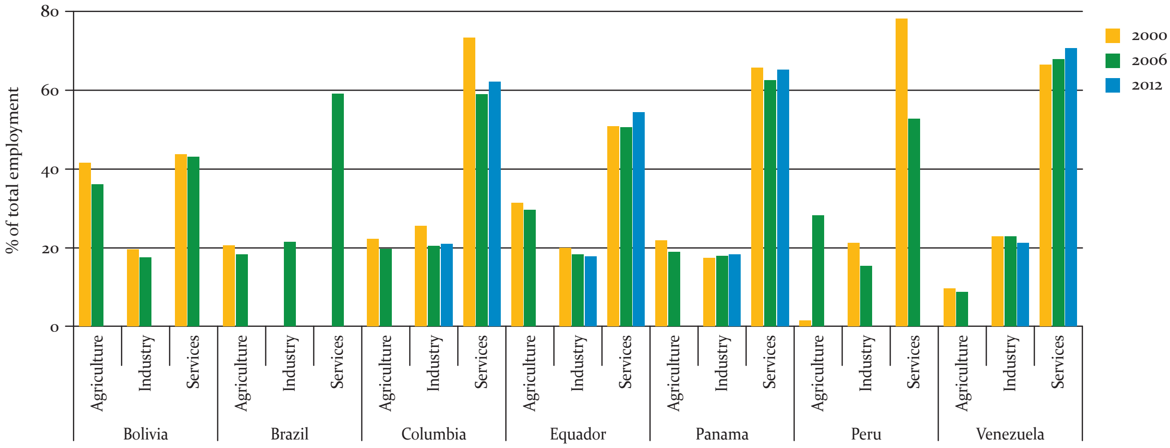


Figure 8: Employment in agriculture, services and industry (% employment; World Bank 2014)

Trade

Growth in most countries of the WA region has largely been down to exploitation of and trade in extensive reserves of natural resources, such as minerals and hydrocarbons (Table 5). A select number of agricultural products such as soybeans, coffee, bananas and flowers are also important export commodities. Only in Panama the economy is more reliant on the exports of value added products (Table 5).

There are a number of regional trade initiatives in the area. Mercosur (the Southern Common Market) established in 1991, aims to promote free trade and the movement of goods, people and currency. There are currently five sovereign member states: Argentina, Brazil, Paraguay, Uruguay and Venezuela. Bolivia became an acceding member in 2012. Chile, Colombia, Peru, Ecuador, Guyana and Suriname are associated members.

The Initiative for the Integration of the Regional Infrastructure of South America (IIRSA) aims to coordinate actions by the governments of South America "*with a view to building a common agenda to foster projects for the integration of transport, energy, and communications infrastructure" (IIRSA 2012)*. Launched in 2000, 12 countries are participating, including all countries of the WA region except Panama.

The Free Trade Area of the Americas (FTAA) aimed to reduce trade barriers throughout the Americas, including all countries except Cuba. However, negotiations were problematic due to differing priorities between the developed and less developed countries, and the FTAA was never fully established.

5. Status and Trends of Biodiversity and Ecosystem Services

This chapter aims to demonstrate the significance of the WA region in terms of biodiversity and ecosystem services. It first considers biodiversity, and in particular the high levels of species richness, endemism and agrobiodiversity of the region, before discussing the supply of ecosystem services, looking at provisioning, regulating, supporting and cultural services in turn.

5.1 BIODIVERSITY

The WA Region is widely recognized as being one of the most important regions in terms of biodiversity in the world. Figure 9 shows the Key Biodiversity Areas (KBAs) and Important Bird and Biodiversity Areas (IBAs) indentified in the WA region (BirdLife International 2013).

Sharp gradients in elevation and humidity, complex soil and bedrock heterogeneity and historical climate variability and geotectonic events have all helped make the Andes mountains one of the most diverse ecoregions in the world, with a huge variety of ecosystems and impressive biodiversity within a relatively small area (Hofstede *et al*. 2010, Hole *et al*. 2009). Some of the most species rich forests and rivers in the world are found within the Andean Amazon region and the lowland forests, with high diversity and richness among many taxa (Finer and Jenkins 2012).

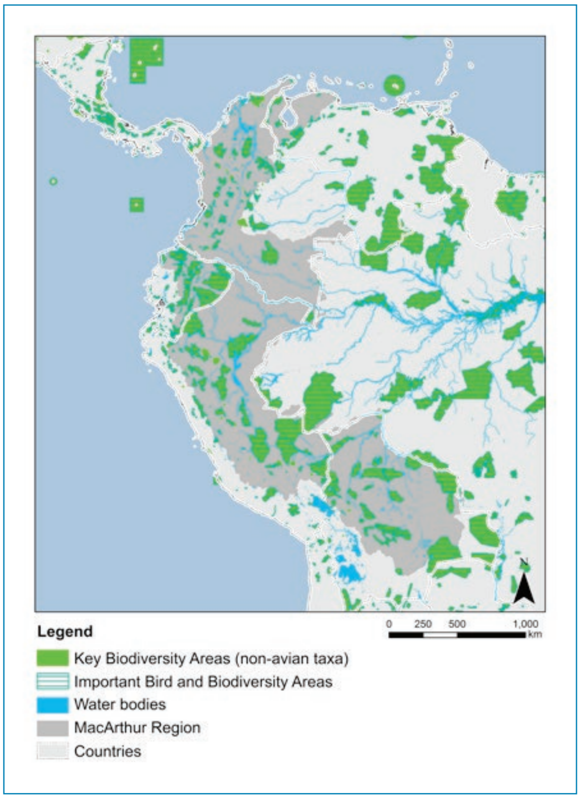


Figure 9: Map of important biodiversity areas in the Waterheds of the Andes region, including KBAs and IBAs (DIVA GIS 2014; BirdLife International 2013; MacArthur Foundation 2012; NGA 2000)

Species richness

Within the hotspot, 3,400 species of vertebrates excluding fish are documented (including over 400 species of mammals), 479 species of reptiles and 45,000 species of vascular plant (Anderson *et al.* 2011; Myers *et al.* 2000). The vascular plant and vertebrate species found in the Andes represent respectively 15% and 12% of known species globally. (Anderson *et al.* 2011). Species richness is higher at low to mid elevations, while rates of endemism increase with elevation (Anderson *et al.* 2011).

Many areas of the WA region are relatively little studied, meaning that new species are regularly described and significant range extensions of known species are common (Pacheco *et al.* in Young 2007). To highlight this, Aguilar *et al.* in Young (2007) noted that 67 species of amphibians are known from neighbouring countries close to the Bolivian border but have yet to be found in the country. Over 50% of tropical Andean biodiversity is thought to remain undescribed, with many species potentially becoming extinct before they are known to science (Larsen *et al.* 2011).

Endemism

The Tropical Andes Hotspot is a major centre of endemism, with more species endemic to the region than any other biodiversity hotspot (Myers *et al.* 2000). Nearly 50% of vertebrates are endemic to the region (Myers *et al.* 2000) and for vascular plants estimates of endemism range between 25% (Larsen *et al.* 2011) and 50% (Myers *et al.* 2000). The endemic plant species found in the Tropical Andes alone comprise approximately 6.7% of all plant species world-wide (Buytaert *et al.* 2006). The high altitude páramo ecosystems are particularly important areas of endemism. Around 5,000 different plant species are found in these ecosystems, of which around 60% are endemic (Buytaert *et al.* 2006).

At the country level, over 5% of Peru's bird species are endemic to Peru alone, and it is thought that 30% of the country's 25,000 species of plant are endemic (BirdLife International 2013a). In Colombia around 3% of bird species are endemic to the country, while in Bolivia and Ecuador this figure falls to under 1% (Birdlife International 2013 b, c, d).

Agrobiodiversity

The Andean region is also of great importance due to the extremely high agrobiodiversity. As one of the most significant centres of crop origin in the world, it is home to a high diversity of domesticated crops and their relatives including tubers, grains and legumes and fruits (Schuler *et al.* 2011). The greatest diversity of the main nine root and tuber groups of the Andes is concentrated in Peru, Bolivia and Ecuador (Schuler *et al.* 2011). Peru alone is reported to host between 182 and 220 native species of domesticated plants, including wild relatives of crops such as cassava, passion fruit, potato, amaranth, nasturtium, parsnip, sweet potato, pumpkin, peppers, cucumber and tomato (Lapeña 2011; Scurrah *et al.* 2008).

These crops are still of great economic importance within the region as a source of food, fibre, fuel and medicines to local populations and they are also strongly linked to local culture and identity. The region's agrobiodiversity is also of global significance as it provides a critical source of genetic raw material that will allow crop species to be adapted to changing environmental conditions, in particular climate change. This genetic diversity also increases the possibility of breeding new varieties with for example greater resistance to pests or diseases (Lapeña 2011).

5.2 ECOSYSTEM SERVICES

Josse *et al.* (2009) estimate that 40 million people in the region depend directly on Andean ecosystems and the services that they provide. Another estimate suggests that the high Andean wetlands provide important ecosystem services to over 100 million people (IUCN, 2002 in Buytaert *et al.* 2006). It is thought that Peru has the most plant species used by humans (4,400 species) in the world (Birdlife International 2013a).

The Millennium Ecosystem Assessment (MA) classifies ecosystem services into four categories: provisioning services, regulating services, supporting services and cultural services (MA 2005). The following section considers ecosystem services provided in the WA region in relation to each of these categories in turn. A summary is provided in Table 6 .

Provisioning Services

Provisioning services, according to the MA, are *"the products obtained from ecosystems, including food, fibre, fuel, genetic resources, biochemicals, natural medicines, pharmaceuticals, ornamental resources and fresh water"* (MA 2005).

Water from the Andes, and in particular run-off from the páramo, is the major water source for the Andean highlands of Venezuela, Colombia and Ecuador, extensive parts of the adjacent lowlands, and the arid coastal plains of North Peru (Buytaert *et al.* 2006). (Figure 10). A central use of this water throughout the region, including in the major Andean cities, is for domestic use including drinking water (Josse *et al.* 2009; Buytaert *et al.* 2006). The water is also used for agricultural purposes, including irrigation and livestock, as well as for industrial consumption and for hydropower generation (Buytaert *et al.* 2006).

The dependency on the paramó for water is only growing as forests and other natural habitats, that would normally ensure a reliable supply of good-quality water, disappear (Buytaert *et al.* 2006). The seven million people of Bogota, Colombia, for example, depend almost entirely on páramo water for drinking and domestic use (Buytaert *et al.* 2006). Around 80% of Quito, Ecuador's domestic water comes from two protected areas, characterised by páramo ecosystems (Echavarria 2002). These water demands will grow with rising populations and increased incomes - in Quito, for example, domestic water requirements are projected to grow by 50% by 2025 (Echavarria 2002).

Very little data exists to quantify water availability and requirements, making current status and trends in water supply and demand hard to quantify, as well as the impacts of increased water use (Roa Garcia and Brown 2009).

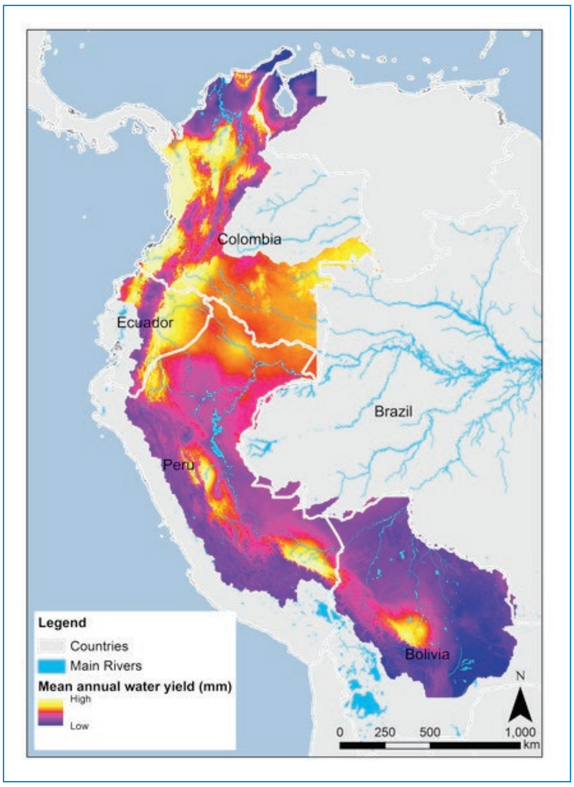


Figure 10: Water yield in the WA region (Mulligan 2014)

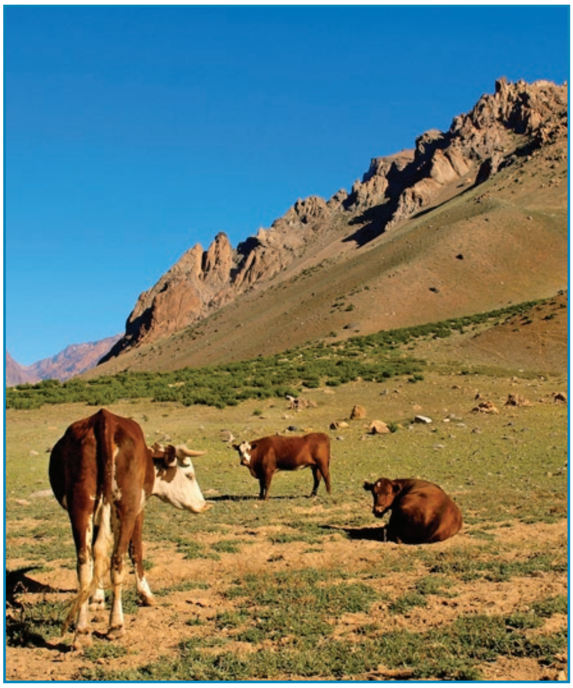
The species-rich Andean-fed rivers are home to many economically and ecologically important Amazonian fish species, including several catfish and characins (Finer and Jenkins 2012). These fish provide nutrition and income for those living in the surrounding areas. For example, in Peru, in 2001 inland fisheries accounted for over 40,000 t of fresh fish catch, of which half were sold fresh and half as cured products (FAO 2003a). While this comprises a small percentage (0.26%) of Peru's total fisheries production (marine and inland) of 15,203,500 t, it is nonetheless significant for inland and rural populations (FAO.org 2003a). The extensive inland waterways and basins also provide ideal conditions for aquaculture, which has been growing rapidly over the past decades (see Section 6.4).

The extensive forests of the Amazon basin and the cloud forests found at higher elevations are highly diverse and species-rich. Consequently, local communities extract many products besides timber for firewood and construction. A study in the Peruvian Amazon, found that fruits, edible plants, resin, animals, eggs, honey, firewood and fish contributed 57% to local income compared to 41% from agricultural products (Gram 2001). Illegally extracted species, such as birds, turtles and fishes to be sold into captive markets abroad, can also be an important source of income (Kvist *et al.* 2001). In a study in the Bolivian part of the WA region, Godoy *et al.* (2002) estimated that forest products (including fish) accounted for over half the total value of household consumption and income from the sale of forest products ranged from around 20% to 45% of total income depending on market accessibility (Godoy *et al.* 2002).

A very important provisioning service in the Andean and Amazon regions is that of medicinal plants. Europeans have learned about and used traditional medicines from the region since the discovery of the Americas, making them of great potential economic importance (Schuler *et al.* 2011). Research by the Alexander von Humboldt Institute of Colombia identified that of around 50,000 plant species in the country, at least 6,000 have some therapeutic use (Bernal *et al.* 2011 in Schuler *et al.* 2011).

As previously mentioned, the region is also home to extremely high agrobiodiversity, and consequently highly valuable genetic resources (Schuler *et al.* 2011).

The opuntia scrublands provide important and valuable services such as grazing for animals, and fruits with a high nutritional value that are used in various ways (Rodriguez *et al.* 2006). They also host the cochineal insects from which carminic acid is obtained. The collection of these insects is of great economic importance in Peru (Rodriguez *et al.* 2006; see also 6.10).



Regulating Services

Regulating services are defined by the MA as *"the benefits obtained from the regulation of ecosystem processes, including air quality regulation, climate regulation, water regulation, erosion regulation, disease regulation, pest regulation, pollination, natural hazard regulation"* (MA 2005).

Much of the WA region is covered by lowland forest (Figure 11). The Amazon region is the largest global reservoir of carbon and regulates global climate. In addition, many other Andean ecosystems are important global carbon reserves. These include the páramo, the puna and the Andean forests (Anderson *et al.* 2011).

The high Andean ecosystems also play an important role in regulating water flows. The high water retention properties of upland soils, such as those of the páramo in particular, provide a high and sustained base flow similar to glaciated catchments, which is of particularly great importance in downstream areas during the dry season (Postel and Thompson 2005; Buytaert *et al.* 2006; Vuille 2013). In addition, vegetation cover such as forests or opuntia scrublands, particularly in steep mountain landscapes, prevents erosion and sediment loss and consequently ensures high water quality (Buytaert *et al.* 2006). This vegetation cover is also important in ensuring down-slope stability and safety (Anderson *et al.* 2011). Opuntia scrublands are also recorded as improving levels of humidity and soil retention capabilities on marginal land (Rodriguez *et al.* 2006). There are many other regulating services that the WA provides, such as waste water assimilation, disease regulation, pest regulation, pollination and natural hazard regulation. However, region-specific literature on these services is sparse.

Supporting Services

Perhaps the hardest to quantify and assess of the categories of ecosystem services, supporting services are those services *"that are necessary for the production of all other ecosystem services"* (MA 2005).

The Andean rivers supply most of the sediment, nutrients and organic matter to the main-stem Amazon River (Finer and Jenkins 2012). They effectively fuel the Amazon floodplain, rendering it highly productive.

The high variety of ecosystems provides a great diversity of habitats, which in turn supports high levels of biodiversity. This biodiversity plays an important role underpinning the ecosystem services that people depend on at all scales. In particular, interactions between different components of biodiversity support ecosystem functioning and thus ecosystem services supply, and both genetic and species diversity help maintain adaptability and thus resilience to changing conditions (Ash and Jenkins 2007). Finally, it has also been shown that a reduction in biodiversity beyond specific thresholds can lead to the collapse in an ecosystem or in its ability to deliver certain services (Ash and Jenkins 2007).

Cultural Services

Cultural services are defined as *"the non-material benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation and aesthetic experiences"* (MA 2005).

The natural environment of the Andes is strongly reflected in the cultures, knowledge systems, religions and social interactions of the Andean people. Bauer and Stanish (2001 in Anderson *et al.* 2011) noted that high mountains, lakes, certain trees and animals among many others have sacred status in Andean cosmology, which influences management strategies. For example, Rodriguez *et al.* (2006) note that the opuntia scrublands have various cultural and artistic values, including inspiring lyrics for traditional music that give advice and standards for the sustainable use of products and services derived from the opuntia scrublands. Tourism and recreation is also important, and provide a source of revenue for countries. (Anderson *et al.* 2011).

Table 6: Examples of Ecosystem Services provided by Andean Ecosystems (Key: *Relevant; **Important; ***Very important) (Anderson *et al.* 2011)

	Provisioning Services							
	Food			Fresh water	Fuel	Timber	Wild harvest medicinal plants	Hydro energy
Ecosystem	Agriculture	Grazing	Agrobiodiversity					
Lakes and Wetlands		* *	*	***	*			**
High Andean/ Superparamo		*		***			**	**
Puna	**	* *	***	*	**		**	
Páramo	*	**	***	***	**		**	**
Cloud forest		*		***	***	***	**	***
Interandean Valleys	***	***	***	*	**	*	***	*
Dry/seasonal Andean Forest	*	*	**	***	***	***	**	***

	Regulating services		Supporting Services	Cultural Services	
Ecosystem	Carbon storage	Down slope safety	Soil fertility	Recreation	Spiritual and Sacred Values
Lakes and Wetlands	***	*	**	***	***
High Andean/ Superparamo	*	**	*	***	***
Puna	*		*	***	*
Páramo	***	***	*	***	*
Cloud forest	***	***	*	***	*
Interandean Valleys	*	*	**	***	**
Dry/seasonal Andean Forest	***	***	*	***	*

5.3 TRENDS IN BIODIVERSITY AND ECOSYSTEM SERVICES

Species

As in many regions around the world, declines in biodiversity in the WA region are evident. The knowledge gaps that exist around many of these species and their status are also clear. Human impact in the WA region has been extensive, but it is often very difficult to assess or quantify.

The region is home to significant numbers of threatened species and several known species have gone extinct. Table 7 shows current threatened and extinct species for two of the Hotspots that overlap with the WA Region. As mentioned previously, a huge number of as-yet undescribed species, are at risk of being lost without ever being discovered.

Table 7: Number of threatened and extinct endemic species of plant, mammal, bird, reptile and amphibian (adapted from Brooks *et al.* 2002) Th = Threatened; Ex = Extinct.

	Plants		Mammals			Birds			Reptiles			Amphibians		
	Total	Th/ Ex	Total	Th	Ex	Total	Th	Ex	Total	Th	Ex	Total	Th	Ex
Tropical Andes	20,000	78	68	32	0	677	90	2	218	1	0	604	1	0
Choco-Darien-Western Ecuador	2,250	52	60	5	0	85	23	0	63	1	0	210	0	0

Table 8: Forest cover by country ('000 ha; FAO 2014)

Country	1990	2000	2005	2010
Bolivia	62,795	60,091	58,734	57,196
Brazil	574,839	545,943	530,494	519,522
Colombia	62,519	61,509	61,004	60,499
Ecuador	13,817	11,841	10,853	9,865
Peru	70,156	69,213	68,742	67,992
Venezuela	52,026	49,151	47,713	46,275

Numbers of threatened species can prove difficult to interpret as changes to threatened species lists often reflect changes in the state of knowledge rather than the state of the environment (Possingham *et al.* 2002). In addition, simply considering the number of threatened species may mask localised declines at the population level. For example, Lips *et al.* (2005) noted the declines in amphibian populations across the continent, with those species associated with upland habitats (notably in the Andean region) worst affected. Kattan and Alvarez-Lopez (1996) noted that in Colombia local extinctions of birds have been documented, as had population declines at the regional and national levels. Link *et al.* (2010) reported the localized declines and extinctions of spider monkeys following forest fragmentation in Colombia.

Habitat

An important reason behind the significant declines in species and populations of different taxa is habitat loss. CI estimate that only one quarter the original habitat cover of the Tropical Andes Biodiversity Hotspot remains indicating the serious level of threat facing this exceptional area (Conservation International 2014a). In the humid forest region, much past deforestation has been caused by agricultural expansion, particularly from the west along the Andes foothills and from the Southeast (Eva *et al.* 2004).

Despite reforestation programmes, forest cover in the WA Region continues to be lost in most countries (Table 8, Figure 11 and Figure 12). It should be noted that Table 8 presents figures for forest defined for a minimum of 10% canopy cover as defined by FAO for whole countries, while Figure 12 shows the average loss and gain of forest with at least 50% canopy cover only for the area within each country covered by the WA region. Loss in Figure 12 captures clear-cutting of dense natural forest or plantations. Forest cover gain is most likely from afforestation through plantations.

Deforestation leads to a reduction in basic provisioning services that the forest offers, including timber and non timber forest products (NTFPs) such as edible plants, medicine, fuelwood and more, with consequences for national economies and local livelihoods.

Deforestation can lead to changes in river flow, which can in turn affect aquatic habitat and consequently spawning opportunities for fish and biological processes and interactions (Allan *et al*. 2002; Costa and Foley 1997). Decreased flows or rivers blocked due to excess sedimentation or landslides have been shown to restrict migration in the WA region (Allan *et al*. 2002; Killeen 2007). This increased erosion occurs in particular at higher altitudes in the Andes where slopes are steeper (Dourojeanni *et al*. 2010). Forest clearance can increase sediment yields by two or three orders of magnitude, with an important effect on areas downstream in the Amazon basin (Ongley 1996 in Harden 2006). Increased erosion also results in changes to soil infiltration and runoff (Dourojeanni *et al*. 2010). Deforestation of inundated forests directly destroys the feeding and spawning grounds of some of the most economically important fish species in the region (Goulding and Carvalho 1982).

Deforestation can also have significant impacts on climate, not only locally where precipitation levels may be affected but also across the continent and even globally (Foley *et al*. 2007; Eva *et al*. 2004). Forest cover loss can also affect the spread of disease, through changes in local habitat conditions or through regulating populations of disease organisms, their hosts or intermediary vectors (Foley *et al*. 2007). Vittor *et al*. (2006) noted a direct relationship between forest loss and mosquito biting rates, and thus an increase in incidences of malaria.

Another important impact of deforestation and forest degradation is reduction in sequestered carbon, and ultimately carbon emissions. Table 9 estimates the emissions from deforestation in the Amazon, and the value of carbon stocks, based on their replacement value in international markets for energy-based carbon credits (Killeen 2007).

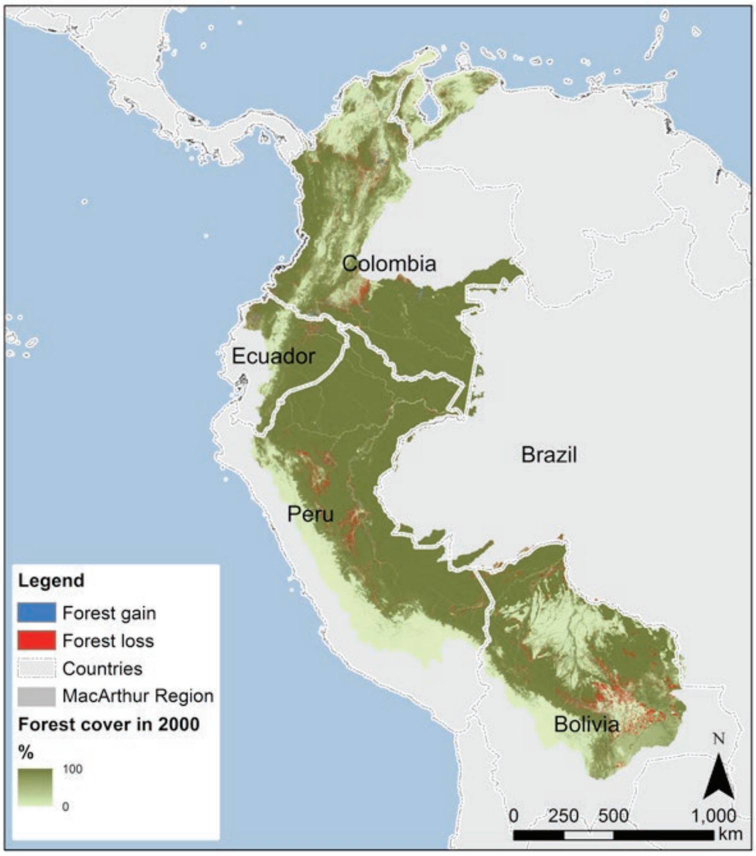


Figure 11: Forest cover in the WA region (Hansen *et al* 2013)

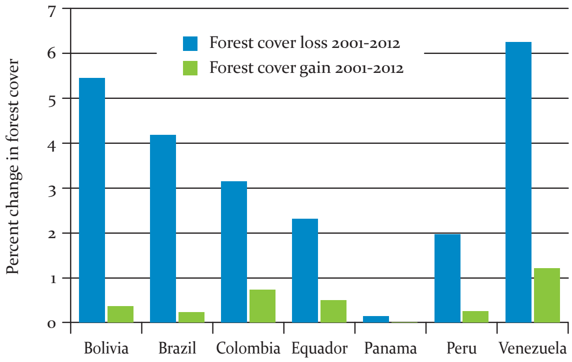


Figure 12: Average forest loss and gain (50% canopy cover) for the areas of countries that fall within the GLR region between 2000 and 2012 (Hansen *et al.* 2013)

Table 9: Value of Carbon stocks in the Amazon forest based on their replacement value in international markets for energy-based carbon credits (Killeen 2007)

	Forest Cover 1990 (x1,000ha)	Forest Cover 2000 (x1000ha)	Forest Cover 2005 (x1000ha)	Annual Rate of Deforestation 1990-2005 (x1000ha/yr)	Carbon Emissions at 125 t/ha (x1000t)	CO_2 Emissions (x1000t)	Value of Emissions at $10/t CO_2 ($Million)
Bolivia	48,355	46,862	46,070	240	30,001	110,105	1,101
Brazil	364,922	348,129	336,873	2,250	281,250	1,032,188	10,322
Colombia	59,282	57,839	57,117	144	18,044	66,221	662
Ecuador	12,333	11,953	11,764	38	4,748	17,423	174
Peru Venezuela	43,258	42,529	42,104	73	9,119	33,466	335

Higher altitude cloud forests have not escaped human impact, with only around 5-20% remaining in most areas, as agriculture has been developed up to 3,700m, and pastures up to 4,000m (Nature and Culture International, 2014). In highly populated areas, only few remnants of the uppermost forests, the ceja andina, survive (Hofstede *et al.* 2010). The natural forest limit has been greatly modified by human activities such as logging and grazing (Ramirez and Cisneros 2007).

Land-use and cover change has also affected the páramo ecosystems, which are often used for grazing, agriculture or for pine tree plantations (Buytaert *et al.* 2006; Harden 2006). In the páramo ecosystems these can seriously impact on the hydrological behaviour, with significant potential consequences for those depending on the water they supply (Buytaert *et al.* 2006, 2007; Harden 2006). For one area of the Colombian páramo, Buytaert *et al.* (2006) quantified increases in cultivated area at 106% between 1970 and 1990, and increases in grasslands at 164% for the same period, while high altitudinal forests decreased by 32% for the same period. They estimated that the increase in cultivated area in the Páramo overall was 24.9 % (Buytaert *et al.* 2006).

5.4 IMPACTS OF CLIMATE CHANGE

As with mountain ecosystems around the world, the ecosystems of the WA region are highly vulnerable to climate change (e.g. Buytaert *et al.* 2011).

As a result of global climate change, average regional temperatures are likely to increase by a minimum of 2°C over the next few decades and 3-5 °C over the twenty-first century (Vuille 2013). Climate projections show increased warming with elevation, with most significant warming at higher elevations (above 4,000m ASL). Accompanying these changes in average temperature will be large fluctuations and long-lasting changes in the distribution and amount of precipitation in the region. The ability of Andean ecosystems to store or sequester carbon, and thus their contribution to climate regulation, may also change (Larsen *et al.* 2011).

More than 99% of the world's tropical glaciers are found in the Andes, and these are melting at an accelerated rate (Harriman 2013). Between the 1950s and the mid 2000s, around two thirds of Venezuela's glaciers and over 50% of those found in Colombia were lost (Harriman 2013). Glacier melt occurs naturally and contributes to the rivers. This is particularly important for water supply to the western coastal regions, mostly during the dry season (Harriman 2013). Most of the major cities of the Andes depend to a large extent on snowfall and glaciers (Herzog *et al.* 2011). However, accelerated melting could cause short-term surges in water supply, increasing the risks of hazards such as landslides or floods (Harriman 2013). The loss of glaciers can also have significant impacts on high altitude wetlands that depend on run off, directly affecting species composition and in particular aquatic species (Harriman 2013; Vuille 2013).

In mountain regions, an upslope displacement of biomes is often predicted under future climate scenarios. According to Tovar *et al.* (2013b), however, while wetter biomes could be expected to displace upslope, most dry biomes show a down-slope expansion and 74.8%-83.1% of the current total Tropical Andes will remain stable. In tropical mountain regions such as the Tropical Andes, such complex responses could be expected due to the climatic and topographic heterogeneity (Tovar *et al.* 2013b). Land-use change will further complicate this situation, particularly as the changing climate facilitates the upward expansion of agricultural areas (Tovar *et al.* 2013b).

In the high altitude páramo ecosystems, given the level of adaptation of vegetation to specific climatic conditions and the high level of endemism, predicted climatic and environmental changes may lead to the extinction of many less mobile or sessile species (Vuille 2013). It is thought that higher temperatures and increased evapotranspiration, together with changes in precipitation amount and seasonality, will result in lower water production and reduced soil water retention capacity from páramos (Vuille 2013). It is also expected that slope stability will be decreased as a result of hydrological changes.

A reduction in water flow or increased flow variability in terms of quantity and timing will impact on water availability for domestic, agricultural and industrial use, as well as on hydropower energy production (Buytaert *et al.* 2006; Harriman 2013; Vuille 2013).

Shifts in species distribution and abundance may affect biodiversity-related ecosystem services – in particular pollination, disease control and others (Larsen *et al.* 2011). The effects of higher temperatures on the spread of invasive species and disease are also a concern (Vuille 2013). Changes to temperature and water availability may also affect the suitability of the most common varieties of agricultural crops, requiring local populations to adapt (Carrascal *et al.* 2011).

6. Commodity development

This section provides an overview of the current status and trends of the major commodity sectors of the WA Region, as well as reported impacts that the development of these commodities have on biodiversity and ecosystem services.

6.1 AGRICULTURE

This section considers agriculture as a whole - its status and trends in terms of cultivated areas for major crops - as well as a special consideration for biofuels, as an important agricultural commodity, the development of which is driven by different forces and has several specific impacts on biodiversity and ecosystem services.

Cultivated areas and major crops

Agriculture is a major source of both food and income for many living in the WA region. For example, in the Peruvian Amazon, swidden agriculture provides higher returns for people than other land-uses such as forest product extraction (Pinedo-Vasquez *et al*. 1992). Markets for agriculture are more dependable than for Non Timber Forest Products (NTFPs), and land is abundant although tenure insecure (Pinedo-Vasquez *et al*. 1992). The majority of agriculture, especially in the Andean regions, is smallholder subsistence agriculture with little market interaction, preventing the establishment of a competitive agricultural sector (Scurrah *et al*. 2008). For example, in the Andean region of Peru, it is thought that only between 15 and 23% of products enter the market (Scurrah *et al*. 2008).

In all countries, with the exception of Venezuela, the contribution of agriculture to GDP has fallen considerably over the past decades, most notably in Ecuador and Colombia (Figure 13). The increase in land area under agriculture has indeed been limited in most countries over the past 15-20 years. Brazil, Panama and Bolivia show the largest increases (Figure 14).

Figure 15 shows the area harvested for a number of agricultural commodities by production for selected countries with a large overlap with the WA region. The commodities in the graphs represent crops that are important in terms of area or because they show notable trends over time. It should be noted that figures for sugar cane, oil palm and soybean in particular may also include those grown for biofuels.

In Bolivia, the crops that show the strongest increases in harvested area are soybean, maize, rice, wheat, sugarcane and sorghum. The harvested area of maize has increased by around 30% since 2000 (Figure 15). The harvested area for soybean doubled between 2000 and 2012, from 0.6 million ha to almost 1.2 million ha (FAO 2014). Soybean has been a major driver of land use change in the region over the past two decades, although mainly in Brazil (almost 0.8 to 28 million ha between 2000-2013, FAO 2014), but Brazilian investors have also expanded soybean cultivation into the Bolivian lowlands (Pacheco 2012).

In Colombia coffee remains an important cash crop and its area is larger than many food crops in the country. Rice and oil palm are the two main growers in Colombia in terms of harvested area whilst the area of sorghum has significantly decreased (Figure 15).

Coffee and rice were the main growers in terms of area in Peru, although oil palm is showing an increase since 2010 (Figure 15).

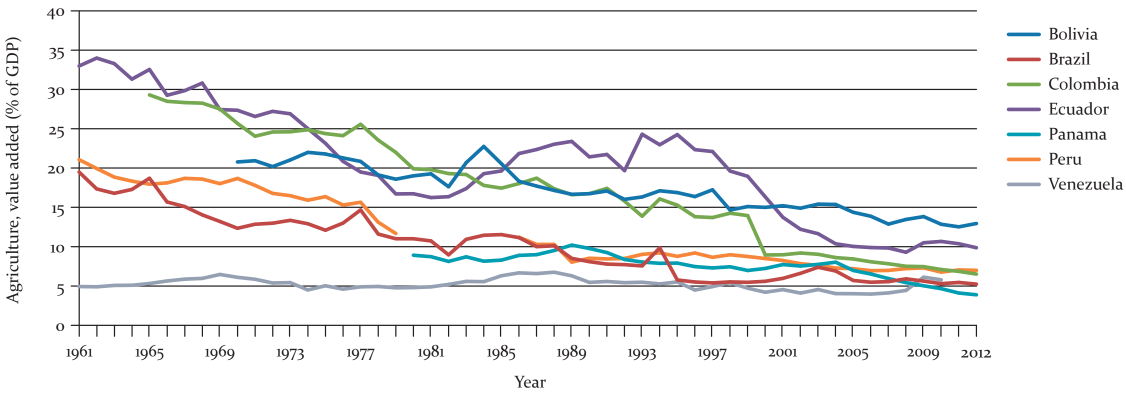


Figure 13: Contribution of agriculture (value added) to GDP (World Bank 2014)

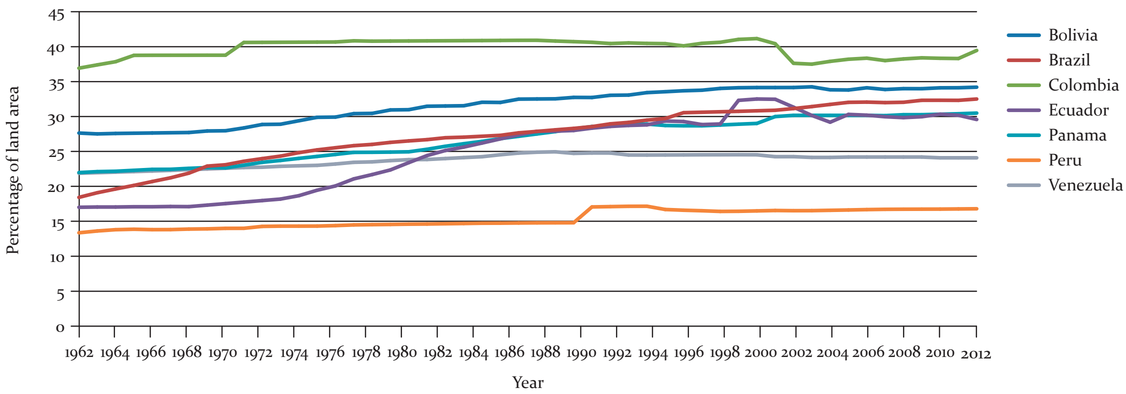
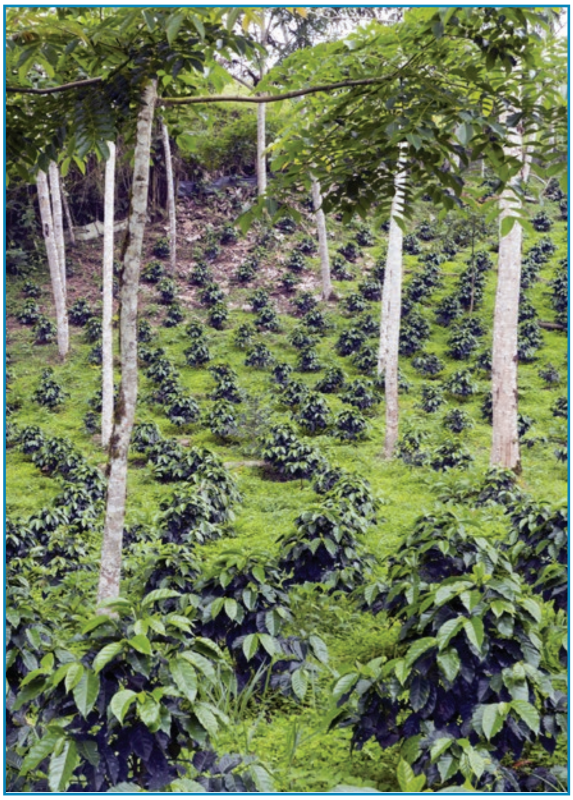


Figure 14: Agricultural land as a percentage of land area (FAO 2014)

In Ecuador the most notable change is taking place in coffee cultivation, with a strong downward trend. Maize, on the other hand, showed a strong increase in harvested area in 2010-2011. The area of oil palm in Ecuador is on the rise since 2008 (Figure 15).

Even though traditional staple crops for the domestic markets have increased, the expansion of commercial agriculture has greatly contributed to local and national economic growth (Pacheco 2012). This expansion has been driven by increased international demand for agricultural commodities, such as feed and fuel.



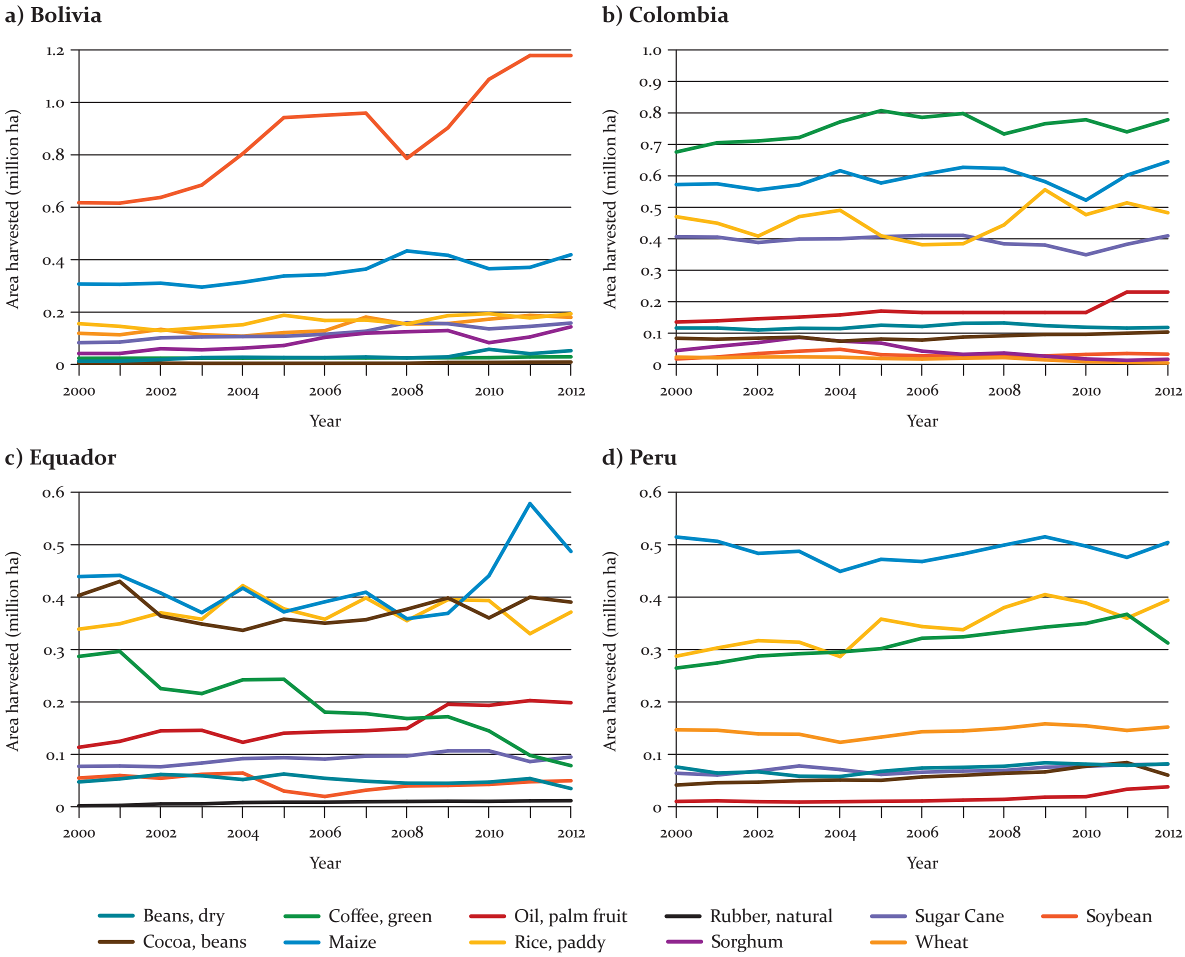


Figure 15: Harvested area of selected agricultural commodities by country (FAO 2014)

Biofuels

Biofuels are a commodity subject to much controversy that are in rapid growth throughout Latin America and the WA region. Growth in biofuel production is largely due to energy policies moving towards diversified renewable energies and independence from fossil fuels, although this growth is hampered in certain countries by the lack of a legislative framework (Vega 2012).

Bioethanol and biodiesel are both produced and consumed in most countries in the region. Bioethanol is mainly produced from sugarcane and biodiesel from palm oil and soybeans (Barros 2013; Vega 2012; Nolte 2013; Pinzon 2012). Outside of Brazil, the area of oil palm is expanding most rapidly in Colombia and Ecuador, but also in Peru (Figure 15 and Killeen 2007). Vega (2012) estimated that 240,000 ha were planted with oil palm in Ecuador and Nolte (2013) noted that an increase of 45,000 ha of arable land was expected in Peru in 2013 as a result of the growing bioethanol industry.

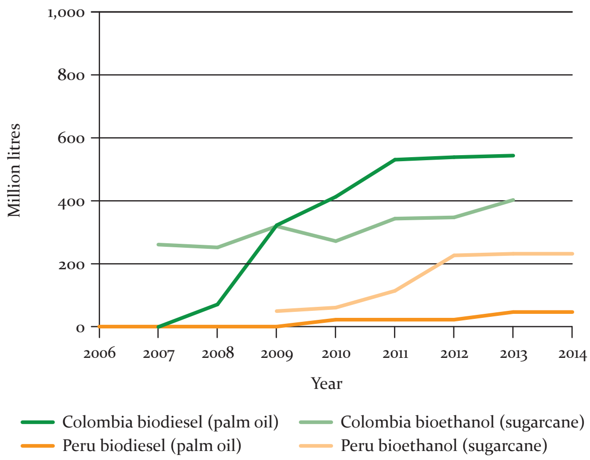


Figure 16: Biodiesel and bioethanol production per year (Barros 2013, Nolte 2013, Pinzon 2012)

Current and reliable biofuel production figures are not readily available for most countries of the WA region and Figure 16 shows production figures only for select countries (Langewald *et al.* 2013). Brazil was not included in Figure 16 as its production is much higher than the other countries, oscillating around 2600 Ml (Barros 2013, Nolte 2013, Pinzon 2012).

Precipitation in the region can vary enormously, and many areas of cropland require irrigation (Tovar *et al.* 2013b). For example, 30% of Ecuador's total agricultural area was irrigated in 1997 (Buytaert *et al.* 2006). Irrigation in the WA region draws largely from the upland water supply, which supplies agricultural activities far beyond the limits of the study region, such as large-scale banana plantations in the coastal plains (Buytaert *et al.* 2006). This surface water has been used for irrigation since pre-Columbian times, expanding in particular following agrarian reform during the 1950s and 1960s (Harden 2006; Buytaert *et al.* 2006). Despite most irrigation being small scale due to small landholdings, in Bolivia, Ecuador and Peru more than 80% of surface water withdrawals are for agricultural irrigation (Harden 2006). In Colombia, irrigation consumes about 37% of the country's water supply and this demand is expected to increase strongly (Buytaert *et al.* 2006).

Impacts of agriculture development

Agricultural expansion overall is widely considered to be the greatest threat to the conservation of the Amazon Wilderness Area and the Tropical Andes Hotspot (Killeen 2007).

Population growth, increased urbanization and soil degradation in lower valleys have pushed the agricultural limit upwards (Buytaert *et al.* 2006). This upward expansion may also be encouraged by increased temperatures, permitting cultivation at higher elevations (Tovar *et al.* 2013b). In addition, lowland agriculture is also expanding at the expense of the Amazon forests. However, there is little information available which differentiates between the extent of upland and lowland agriculture.

The expansion upwards of the agricultural frontier is of serious concern, in particular as it extends into vulnerable ecosystems such as the páramo. Here, low density grazing and burning has taken place for centuries which is not thought to have a major effect on hydrological properties, but intensive agricultural practices such as grazing and the cultivation of potatoes and beans are increasing (Crespo *et al.* 2010; Buytaert *et al.* 2006). These have a strong impact on the water cycle (Buytaert *et al.* 2006). Changes in or removal of the vegetation in upland areas affect evapotranspiration and, consequently, may affect soil properties and in particular runoff and erosion and therefore water supply and regulation downstream (Buytaert *et al.* 2006). Crespo *et al.* (2010) noted that increase in peaks and significant reductions in low-flows had been observed in semi-cultivated and intensively grazed areas, thus leading to a loss of water regulation.

Upland agriculture also exerts pressure on the upper limits of the cloud forests, both due to direct clearance and practices such as burning (Hofstede *et al.* 2010). This is particularly significant given the importance of the cloud forests for hydrological functioning and for water supply for large areas of lowland (Hofstede *et al.* 2010).

Grazing and cultivation, in particular the use of use of heavy machinery, compact soil which reduces infiltration capacity (Harden 2006). This pressure increased greatly after the Spanish brought cattle, sheep and horses to the Andes in the 1500s (Harden 2006). It has been noted that, under cultivation, burning and grazing, the compacted soil surface in the páramo ecosystems leads to 300% faster runoff and less infiltration, as well as erosion rates that are 5-10 times higher than when not under cultivation (Buytaert *et al*. 2006). This increased runoff and erosion can have a significant effect on water supply downstream (Buytaert *et al*. 2006). For example, in the Rio Paute basin in Ecuador, increased erosion has caused elevated sediment loads in rivers used for urban waters supply and hydropower (Buytaert *et al*. 2006; Vuille 2013).

Irrigation systems have expanded over recent years. The large quantities of extracted water reduce flow and therefore reduce the dilution of sediment, increasing sediment loads (Harden 2006). This effect is enhanced during dry season when water flows are naturally lower. Irrigation systems also convey water across steep slopes with high erosion potential (Harden 2006). Although this can also reduce erosion by improving vegetation cover, too much water added rapidly can destabilize slopes (Harden 2006). Poorly managed and constructed irrigation infrastructure have been found to lead to the formation of gullies, through water spill over from canals and reservoirs (Harden 2006).

It has also been noted that the abandonment of traditional agricultural terraces such as are typical in the dry central Andes of Peru, can increase soil erosion rates and sediment yields (Inbar and Llenera 2000 in Harden 2006).

In the lowlands, agricultural expansion is a major force behind the loss of forests of the Amazon basin. Soares-Filho *et al.* (2006) predicted that by 2050, agricultural expansion would eliminate a total of 40% of the Amazon forests (both inside and outside the study region), releasing 32 Pg of carbon to the atmosphere. Henrich (1997) noted the changing agricultural practices of indigenous peoples of the Amazon region, where commercialisation has altered traditional crop cultivation practices in Peru, expanding and intensifying land usage including using fertilisers to maximise yields and extending the periods of time under cultivation. This does not only impact the area of land under cultivation and the land directly converted for agriculture, but also the quality of soils and water in the wider area.

The cultivation of biofuels is widely criticised for its negative environmental effects. Due to high prices for biofuels, many farmers are turning to crops for biofuels rather than for food, reducing food availability and increasing prices (Raswant *et al*. 2008). This leads to a dual expansion of area used for agriculture to meet both the demands for food and fuels, with the consequential destruction of natural habitats (Raswant *et al*. 2008). Also, biofuel crops can have high demands for water and nutrients and their intensive cultivation can have serious impacts on the soil and water quality and availability (Raswant *et al*. 2008).

Biofuels are often seen as a low-carbon alternative to fossil fuels, yet it has been found that the carbon emitted through harvesting the crop, combined with the carbon released through the associated land use change, undermines the reduction in greenhouse gas and carbon dioxide emissions from using non-fossil fuels (Raswant *et al*. 2008; Langewald *et al*. 2013; Rosamond *et al*. 2007).

Still, Wassenaar *et al*. (2007) found that livestock, rather than crops, were likely to be the main land use after deforestation, driven largely by the increasing consumption of meat in Latin America and globally. The study identified 'deforestation hotspots' throughout Latin America, the majority of which were due to conversion to pasture rather than to cropland. Growth in meat and milk production in Latin America is expected to reach 2.6% and 2.1% respectively, and will partially be met by improved productivity but also by increased number of animals and increased feed production, which will in turn require further deforestation.

As mentioned previously, the WA Region is an important centre of agrobiodiversity. The expansion and commercialisation of agriculture is in part responsible for a decline in this diversity, with the introduction of commercial crops at the expense of native crops, and less land available for wild relatives to grow. Climate change and urbanization are also factors in this (Scurrah *et al*. 2008).

6.2 CULTIVATION OF PLANTS FOR DRUG PRODUCTION

While Dourojeanni *et al.* (2010) note a general increase in drug production, including poppies and marijuana, coca production and trade is still a serious environmental, social and economic problem and is increasing across Peru, Bolivia and Colombia in particular (Harden 2006). Production is very difficult to quantify as official figures are rarely accurate. For example, the UNOCD (2013) noted that Peru's official figures for the area under coca cultivation were somewhat lower than the figures produced through remote sensing – the latter would suggest that Peruvian production has now exceeded that of Colombia (See Table 10).

Coca cultivation and traditional use in medicine and shamanic practices is thought to have been practiced for as long as 5,000 years and to continue today (Piperno and Pearsall 1998 in Salisbury and Fagan 2011). In Peru, over 4 million people are thought to still use coca in a traditional way, yet over 25 times the amount these people use is produced, mostly driven by the illegal drug trade (Salisbury and Fagan 2011).

Cultivation typically involves a slash-and-burn approach, with producers abandoning fields and clearing new fields regularly to evade authorities. It is thought that coca production has led to the clearance of 2.4 million ha of forest across the Andean region since the 1980s (US State Department 2001 in Harden 2006).

Coca production is also reported to be increasing much more rapidly in protected areas than outside them in Bolivia, and to be a serious problem within protected areas in Peru and Colombia as well (UNODC 2005b and c in Salisbury and Fagan 2011). The impacts of this cultivation on biodiversity and habitats extend to its eradication, which often involves aerial spraying with a large margin for error (Messina and Delamater 2006 in Salisbury and Fagan 2011). Protected areas are attractive to coca cultivators due to their often remote location, the lack of state presence and the low population levels.

Coca cultivation leads to high soil erosion. This is in part due to the areas in which it is planted as the optimal altitude for cultivation is 1,000-1,200 m ASL where rainfall is extremely high and slopes are very steep, providing good drainage but promoting erosion (Dourojeanni 1992). Cultivation requires intensive weeding and tillage after each of the three to six harvests per year, which removes the top 15 cm of soil (Dourojeanni 1992). These frequent harvests expose the soil regularly to rain and wind erosion (Dourojeanni 1992).

Fertilisers are often used which are harmful to the environment, particularly in combination with the high erosion. Herbicides are often used to kill off the undergrowth. These can pollute water sources and threaten aquatic life and human health (Dourojeanni 1992).

The actual preparation of cocaine paste contaminates air, soil and water as it commonly uses large quantities of chemical substances (Dourojeanni 1992). As coca fields are often clustered near waterways, which are the primary modes of transport of the processed coca paste, these chemicals may impact human, animal and vegetation health for many miles downstream (Salisbury and Fagan 2011).

Table 10: Illicit coca cultivation 2002-2011 (ha) (UNODC 2013) NB figures for Peru in 2011 in brackets show net area as on 31 December; figures out of brackets for 2011 and all other years are interpreted from satellite imagery.

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Bolivia	21,600	23,600	27,700	25,400	27,500	28,900	30,500	30,900	31,000	27,200
Colombia	102,000	86,000	80,000	86,000	78,000	99,000	81,000	73,000	62,000	64,000
Peru	46,700	44,200	50,300	48,200	51,400	53,700	56,100	59,900	61,200	64,400 (62,500)
Total	**170,300**	**153,800**	**158,000**	**15,960**	**156,900**	**181,600**	**167,600**	**163,800**	**154,200**	**155,600**

6.3 FORESTRY AND FOREST PRODUCTS

Afforestation

A tendency towards afforestation with exotic monocultures throughout the WA region has provoked debate about the risks for biodiversity and ecosystem services.

Eucalyptus was first introduced to South America from Australia in the nineteenth century (Luzar 2007). Various species are found throughout the continent, yet little information on their distribution or importance exists for most countries.

In Peru, eucalyptus first really began to become an established and popular species in the mid-twentieth century, following threats to imported forestry supplies during World War Two (Dickinson 1999 in Luzar 2007). It was promoted in particular during agrarian and land reforms of the 1960s and 70s, as a source of fuel, building materials (in particularly for the mining industry) and income (Luzar 2007).The species is currently considered an important component of the regional economy, and the most economically important species for communities of the southern Peruvian Andes (Luzar 2007).

Eucalyptus is considered to have many important negative environmental impacts. It is a fast growing species, draining large amounts of water and nutrients from the soils together with high rates of transpiration. It is also thought that eucalyptus can actually increase soil erosion, run off and sediment yield (Inbar and Llerena 2000; Luzar 2007).

Another concern is the increasing afforestation in the lower areas of the páramo ecosystems. Over past decades, this has been seen as a way of increasing the economic return of these regions, which are less suited to agriculture, as well as a means of reducing erosion and sequestering carbon (Buytaert *et al*. 2007). Mexican weeping pine, Pinus patula, is a common species, used for timber and mushroom harvesting (Buytaert *et al*. 2007). However, it has been found to reduce water yield by approximately 50% (Buytaert *et al*. 2007). This may in part be due to high water consumption of trees compared to the short páramo vegetation, but also due to soil destruction during afforestation that may reduce infiltration, increase surface runoff and therefore decrease river flows (Buytaert *et al*. 2007). The effectiveness of carbon sequestration is also uncertain as the species alters the composition of the páramo soil, potentially reducing the soil carbon content by up to 60% (Buytaert *et al*. 2007). In addition, these species alter chemical and microbial composition of the soil (Buytaert *et al*. 2007).

Timber production and logging

The extensive forest cover in the countries of the WA region has made it an important area for timber extraction.

Table 11 shows the production of roundwood by country. It shows in all countries an increase until 2006-2008, and then a stabilization in most countries, except in Brazil, possibly due to the global financial crisis and withdrawal of FDI, followed by a gradual increase again. According to the REDD Desk, the forestry sector contributes just 1.1% to Peru's GDP (The REDD Desk 2013a). In Bolivia, the contribution of forestry, hunting and fishing combined was even lower at 0.89% (The REDD Desk 2013b).

The lowland and montane forests of the WA region are an invaluable source of high-quality hardwood timber. In the Peruvian Amazon alone, 7.7 million ha have been conceded for formal timber extraction, but informal logging occurs throughout the region (Dourojeanni *et al*. 2010). As with other sectors, official figures do not give the whole picture as illegal and unreported logging is widespread throughout the region. A number of industrial-scale concessions have been granted over recent years (CEPF 2000).

Mahogany is considered the primary timber tree species of Latin America, yet this species is highly depleted to the point where in Bolivia no commercially viable trees remain across almost 80% of the species range, and in Peru its range has decreased by 50% (Kometter *et al.* 2004). Illegal logging of this low-density tree is threatening the future of the species (Kometter *et al.* 2004).

From a study of the Amazon Basin, Foley *et al.* (2007) noted that selective logging is often more pervasive and less recognized than clear cut deforestation. Indeed, the allocation of an area of forest as a commercial logging concession results in a much greater area of degraded forest. The construction of roads promotes the invasion of indigenous, protected and undisturbed areas by other loggers and migrant farmers (Cotter 2003; Dourojeanni *et al.* 2010), Heavy machinery leads to soil compaction which results in erosion and reduced regeneration. The presence of a non-resident workforce leads to habitat degradation for the construction of campsites and wildlife depletion from uncontrolled hunting (CEPF 2000; Dourojeanni *et al.* 2010). Other impacts shown from studies in the region include increased fire risk exacerbating carbon loss, changes to the ecosystem and negative impacts on biodiversity, increased mortality of young trees and non-target species, seed loss, air and water pollution from timber processing (Dourojeanni *et al.* 2010; Quintero *et al.* 2009; Foley *et al.* 2007; Harden 2006).

In fact, Dourojeanni *et al.* (2010) suggest that for 7.3 million ha of concessions granted in the Peruvian Amazon, the total forest area that will be degraded can be estimated at between 11.7m ha and 16.1m ha. In that regard, Mahogany has also been described as a "catalytic" species in the deforestation of the Amazon region (Cotter 2003).

Table 11: Annual round wood production by country (FAO 2014)

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Bolivia	2,728	2,856	2,958	3,061	3,180	3,199	3,219	3,242	3,263	3,281
Brazil	230,911	255,903	243,255	255,743	257,537	261,351	256,306	264,149	271,501	284,019
Colombia	11,610	11,993	10,462	11,927	10,470	10,440	11,137	11,216	11,216	11,216
Ecuador	6,304	6,319	6,632	6,648	5,840	6,082	6,016	6,855	7,031	7,040
Panama	1,337	1,334	1,312	1,360	1,349	1,334	1,322	1,313	1,304	1,300
Peru	8,769	8,436	8,921	9,106	9,258	9,425	9,119	8,690	8,690	8,921
Venezuela	5,108	4,803	5,319	5,286	5,557	6,061	6,262	6,359	5,420	5,345

Other forest products

Many rural communities in the WA region depend on NTFPs for subsistence and income. An economically important activity around a non-timber forest product is the collection, processing and transportation of Brazil nut, which grows at high densities in the south-western Amazon (Killeen 2007). Northern Bolivia alone supplies 50% of the global production of Brazil nuts (Killeen 2007), yet the viability of what is considered a relatively sustainable sector is under threat by commercial logging concessions, many of which overlap with productive Brazil nut zones (CEPF 2000).

Improving market access in the WA Region, largely due to IIRSA(see 4.6), will bring major changes to the forest products industry (Killeen 2007).

6.4 FISHERIES AND AQUACULTURE

Fisheries

Despite being the location of some of the world's largest and most biodiverse freshwater resources, freshwater fish has never been a significant part of the diet in much of Central and South America, and the entire region accounts for just 2% of the world's freshwater fish catch (Bennett and Thorpe 2008). Accurate figures for fisheries and fishing are hard to find due to ambiguity in definitions and the fact that fishing is often combined, and reported, with agriculture, as well as due to the remoteness of many of the more rural areas where fishing is an important activity (Bennett and Thorpe 2008).

In certain areas of the WA Region, however, fish does constitute an important part of diets. For example 61% of animal protein comes from fish in the Ucayali valley (Bennett and Thorpe 2008). Fishing is generally an important occupation for just the most rural and unqualified of households, mostly in the Amazon basin, where it is often conducted concurrently with agriculture (Bennett and Thorpe 2008).

Inland fisheries are relatively rare in the high altitude areas, where topography is steep and water courses are narrow and fast flowing. Inland fisheries in the Amazon Basin are more common, and employ a wide range of fishing gear to catch a large variety of fish, most of which is caught during the dry season (Bennett and Thorpe 2008).

Table 12: Marine and freshwater fisheries production in Central and South America (FAO FISHSTAT PLUS and FAO Waicent in Bennett and Thorpe 2008)

	Freshwater fisheries (MT)	Marine fisheries (MT)	Total	Freshwater as percentage of total
1965	150,200	8,645,065	8,795,265	1.7
1970	143,500	14,442,840	14,568,340	0.9
1975	251,138	5,409,696	5,660,834	4.4
1980	279,247	7,428,839	7,726,086	3.6
1985	319,136	11,440,871	11,760,007	2.7
1990	306,664	13,695,296	14,001,960	2.2
1995	376,166	18,837,534	19,213,700	1.9
2000	356,300	17,116,213	17,472,513	2
2001	351,735	13,962,671	14,314,406	2.4

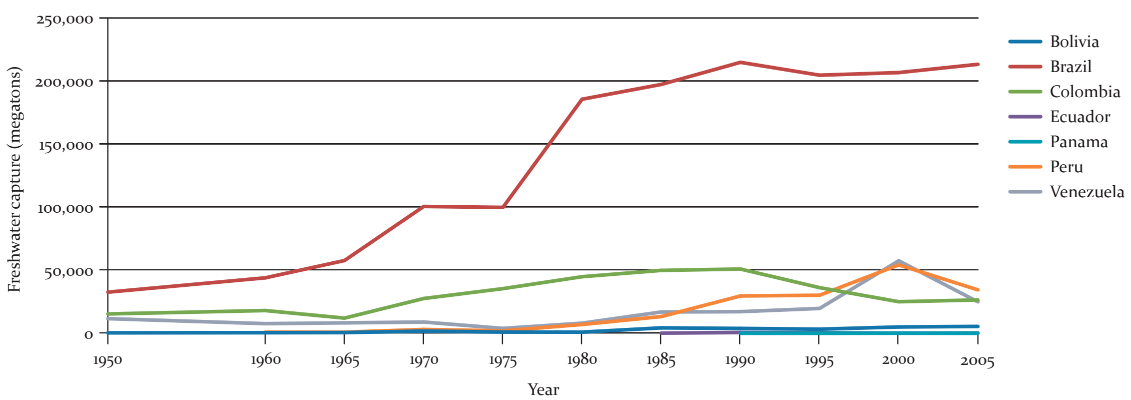


Figure 17: Freshwater capture production in mt in countries of the WA Region (FAO FISHSTAT Plus, adapted from Bennett and Thorpe 2008)

Marine fisheries are important for the WA Region, particularly for Peru, but most catch is for fishmeal production rather than for food (Bennett and Thorpe 2008). Fish capture for the aquarium fish trade is also an important economic activity in some areas. Relative to marine fisheries, freshwater fisheries production is extremely low and has not grown significantly for the past fifty years (see Table 12).

Nonetheless, absolute numbers for fish catch have increased in all countries over the past decades, albeit not consistently.

Figure 17 shows the freshwater fisheries production in tonnes of each of the WA countries. Production is clearly highest in Brazil, but nonetheless appears to have levelled off over the past three decades. For Peru, Venezuela and Colombia freshwater fisheries production is considerably lower, but still important. Despite being in decline since the mid-1980s, over half of those employed in fisheries and aquaculture in Colombia were working in inland fisheries (FAO 2003b). In Bolivia and Panama freshwater fisheries production is considerably lower than in all other WA countries.

Little data was available regarding the impacts of fisheries in the WA Region, but there are indications of at least local cases of overfishing.

The Magdalena River Basin in Colombia provides an example of the impacts of overfishing. Early in the twentieth century, fisheries focused on larger species and fish were consumed locally due to the lack of infrastructure to transport the fish elsewhere (Galvis and Mojica 2007). However, as transport improved and populations grew up into the 1960s, so did the size and intensity of fisheries with maximum estimates of up to 80,000 t per year – over 60% of the fish consumed in the country (Galvis and Mojica 2007). Stocks of larger commercial species soon decreased and fishing turned its focus to lower quality and smaller species. By the 1990s, yield had reduced to around 10,000 t due to overfishing and some years of drought (Galvis and Mojica 2007). Besides increased demand from a growing population the collapse of fisheries in the Magdalena River Basin was also linked to habitat loss (in particular to agriculture), pollution from human waste from cities and agricultural chemicals, and increase in sedimentation from gold mining (Galvis and Mojica 2007).

In fact, overfishing, together with poor water quality, are the main reasons behind the decline in inland fisheries in Colombia that has been seen since the mid 1980s (FAO 2003b and Figure 17).

Overfishing can have serious impacts not only on the harvested species but on the entire ecosystem. Taylor *et al*. (2006) documented the effects of declines in a harvested migratory detrital-feeding fish, *Prochilodus mariae*, in a river in Venezuela. The fish, found throughout the study region, modulates carbon flow and ecosystem metabolism. Downstream transport of organic carbon and increased primary production and respiration were observed following natural declines and experimental removal of the species (Taylor *et al*. 2006).

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Aquaculture

While 85% of freshwater fish production in Latin and Central America comes from capture fisheries, aquaculture is growing rapidly. Aquaculture production grew 168% in just 5 years between 1995 and 2000, mostly in Brazil and Colombia (Bennett and Thorpe 2008). The two most important species in the region are shrimps in coastal areas and tilapia in both coastal and inland waters.

In Bolivia, aquaculture has not to date played an important economic role (FAO 2005a). The sector is growing, but is still underdeveloped, consisting of around 7% of the total value of Bolivian fisheries. Trout aquaculture is practiced widely high on the Bolivian Plateau. Tilapia aquaculture has been practiced in places since the 1990s, but most aquaculture is of threatened indigenous species which are of most value to local markets (FAO 2005a).

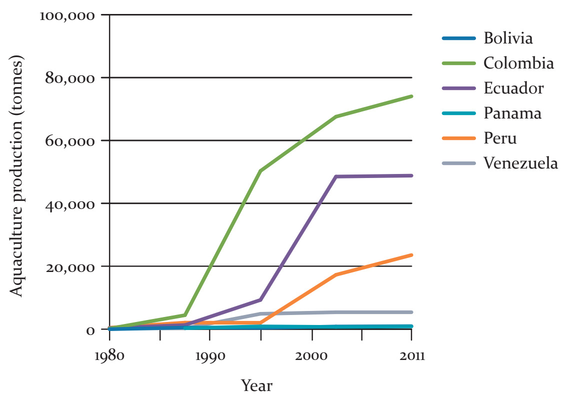


Figure 18: Aquaculture production by country (t) (FAO 2014)

Colombia's aquaculture sector is relatively well-developed, having increased steadily since 1985, although sale prices have remained relatively stable in the face of increasing input costs (FAO 2005c). Approximately 22,000 people are directly employed in aquaculture (compared to 4,000 in inland fisheries; FAO 2003b). Primary species cultivated are marine shrimp in Atlantic coastal areas, and tilapia, cochama and trout in inland areas (FAO 2005c). Most tilapia exports are to the US (Fitzsimmons 2000).

Shrimp aquaculture makes up over 95% of Ecuador's aquaculture along the whole of the country's coastline (FAO 2005d). Cultivating tilapia - a species that can thrive in salt, brackish and fresh water - in abandoned shrimp ponds has become extremely common in Ecuador, as shrimp ponds have been severely impacted by disease since the start of the twenty-first century (FAO 2005d). Most tilapia exports are to the US and Europe (Fitzsimmons 2000).

Peruvian aquaculture is mostly limited to shrimp and scallop in coastal regions, trout in the mountain regions and tilapia and some Amazonian fish in the Peruvian Amazon (FAO 2005f). The sector is relatively under-developed although with great potential due to the diversity of species and large demand (FAO 2005f). However, culture of non-native species is highly restricted and in places such as the Amazon basin it is forbidden. For this reason tilapia culture has decreased over recent years (Fitzsimmons 2000). Around 10,000 people are employed in the aquaculture sector (FAO 2003a).

In Panama, shrimp is the main cultured species, along with widespread culture of tilapia and carp (FAO 2005e). Originally promoted in order to improve food security and nutrition, the sector now generates considerable revenue for the country (FAO 2005e).

Aquaculture has been practiced in Venezuela for almost 200 years, but has grown rapidly over the past 20 years with shrimp culture in coastal areas, which currently constitutes around 90% of aquaculture (FAO 2005g). Other important species are tilapia and trout in inland areas, as well as the native tambaqui, which has been increasing recently (FAO 2005g).

In Brazil, production grew by over 800% between 1990 and 2002, and 300% between 2002 and 2011. Over 60 species are cultured with tilapia, carp and native round fishes the most common (FAO 2005b). There is also a widespread culture of mussels, oysters, scallops, shrimps and prawns (FAO 2005b).

While aquaculture can provide an important contribution to food security and nutrition for many rural poor, it can also have many negative environmental effects (Cole *et al*. 2009). Inputs such as nutrients, antibiotics, pesticides, hormones and food lead to increased organic and chemical waste which can in turn lead to algal bloom, reduced oxygen and reduced water quality (Cole *et al*. 2009). There is also concern about the use of antibiotics, genetic modification and disease outbreaks that can spread to wild fish (Cole *et al*. 2009).

Habitat modification and destruction is often caused both directly for the establishment of the fish farms and also through changes in species composition, which lead to changes in ecosystem processes and functioning (Cole *et al*. 2009). There is little data on the effects of aquaculture specific to the WA region, but for example in Ecuador, shrimp pond construction is documented to have been the cause of loss of at least 53,000 ha of mangroves over the past four decades (Andes 2013). This then results in a loss of the many services provided by mangroves, including flood defence, fuel, wood and more.

6.5 HYDROPOWER

Hydropower potential and growth

Over the last decades, the emphasis on hydropower has grown considerably in the WA region, seen by governments as a reliable means of meeting growing energy demands while diversifying from fossil fuels (Finer and Jenkins 2012). It is also driven by the desire to process minerals in country, rather than simply exporting ore, an activity which has huge energy requirements (Killeen 2007).

The Andean region in particular has enormous potential for hydropower production due to the high precipitation and steep slopes, while the flat Brazilian Amazon is less favourable and projects require greater flooded areas (Finer and Jenkins 2012).

Finer and Jenkins (2012) collected data from government agencies and strategic planning reports on planned and existing dams in the Andean Amazon over 2MW capacity, categorizing dams as medium (2-99 MW), large (100-999 MW) and mega (≥ 1000 MW). The study identified 48 existing dams and 151 planned dams greater than 2 MW capacity in the Andean Amazon (Finer and Jenkins 2012; Table 13). More than half of these planned dams would be 100 MW or greater and 17 would fall under the 'mega' classification (Finer and Jenkins 2012). Over half of all planned projects identified by Finer and Jenkins (2012) were located on the Marañón River and its tributaries across Ecuador and Peru. Most hydropower plants are found in areas over 500m, where slopes are steeper (Finer and Jenkins 2012). In Figure 19 shows the location of existing and planned dams.

It is estimated that over 7,000 additional MW will be required across Ecuador, Peru and Bolivia alone by 2020, not just due to growing demand but due to changing energy policy. Hydroelectric energy is also exported – for example Peru has agreed to supply at least 6,000 MW of hydroelectric energy to Brazil over the next 30 years (Finer and Jenkins 2012).

Peru has the most existing and planned large-scale hydropower plants, with a clear trend towards the bigger plants (Finer and Jenkins 2012). In Peru, 85% of the potential 206,000 MW hydropower is located in the Amazon basin (Dourojeanni *et al.* 2010).

Ecuador follows Peru, and boasts one of the largest plants in the region on the Rio Paute catchment, with a capacity of 1,075 MW and providing 55-60% of Ecuador's electricity (Buytaert *et al.* 2006; Finer and Jenkins 2012). Between 25-50% of the water fuelling this dam comes from the páramos (Buytaert *et al.* 2006) The country has a number of smaller existing dams and many more are planned – including five with a capacity over 1000 MW (Finer and Jenkins 2012).

While Finer and Jenkins (2012) reported that Colombia had no existing and two proposed dams, a more recent report by Mejía *et al.* (2014) noted that in reality over two thirds of the country's electricity capacity - 9800 MW - is based on hydroelectric power.

Bolivia is also planning several new dams primarily for exporting energy to neighbouring countries (Finer and Jenkins 2012).

Table 13: Existing and planned dams over 2MW by country and capacity (Finer and Jenkins 2012)

Country	Existing	Planned	Capacity (MW)
Peru	0	10	≥ 1000
	7	43	100-999
	19	26	2-99
	26	**79**	**Total**
Ecuador	1	5	≥ 1000
	3	13	100-999
	12	42	2-99
	16	**60**	**Total**
Bolivia	0	2	≥ 1000
	1	6	100-999
	5	2	2-99
	6	**10**	**Total**
Colombia	0	0	≥ 1000
	0	1	100-999
	0	1	2-99
	0	**2**	**Total**
All countries	1	17	≥ 1000
	11	63	100-999
	36	71	2-99
	48	**151**	**Total**

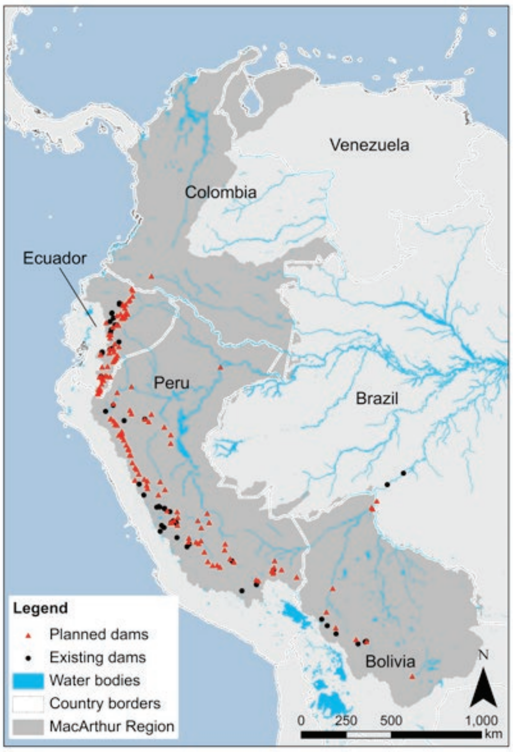


Figure 19: Hydroelectric dams of the Andean Amazon sorted by status and size (Mulligan *et al.* 2011)

Impacts of dams

Finer and Jenkins (2012) found that rivers originating in the Ecuadorian and northern Peruvian Andes were most threatened by dams, in contrast to those originating in Colombia. In their study, Finer and Jenkins (2012) assessed 47% of the planned dams in the region as having high impact, 34% as moderate and 19% as low impact.

A primary impact of dams derives from the creation of reservoirs, which involves inundating a large amount of natural habitat. Often this results in the loss of forest or other habitat. In lowland areas, the area that must be flooded is generally greater and shallower, and consequently more prone to siltation (Finer and Jenkins 2012). This not only affects biodiversity and habitats, but also human populations who may be displaced or lose access to resources due to flooding.

Dams also trap sediment, which would normally be carried downstream. For example, the storage capacity of the Daniel Palacios dam on the Paute River in Ecuador was reduced from 120x106 m3 in 1983 to 95x106 m3 in 1993 due to sedimentation, demonstrating the enormous quantities of nutrient-rich sediment no longer reaching the lower stretches of the river (Harden 2006).

The creation of a dam can also strongly alter the flow of the river. The effects of flow modification, together with that of sediment trapping, can lead to reduced fertility and productivity of floodplains downstream of the dam (Harden 2006; Killeen 2007).

Connectivity of rivers is critical for many fish species, and many economically and ecologically important Amazonian fish spawn in Andean-fed rivers and migrate from the lowlands of the Amazon basin to the foothills of the Andes (Finer and Jenkins 2012). Developments that affect connectivity, such as hydropower dam construction, can have devastating effects on migratory fish species. While some projects aim to mitigate this impact by building in fish ladders, it has been shown in other parts of the world that the diversity of migratory species and their specific requirements mean that these are unlikely to be entirely successful (e.g. Sverdrup-Jensen 2002).

In Colombia, the construction of the Urrá dam on the Sinu river basin in the 1990s led to a drop of over 2/3 in fishing production, from 6,000 to 1,700 t per year, which then impacted the populations for whom fish represents the primary source of animal protein (Correa 1999 in Bennett and Thorpe 2008). However, in the Magdalena Basin in Colombia, the constructed dam has not impacted fish populations as it was built above the upper limits of fish migration (Galvis and Mojica 2007).

The break in connectivity caused by dams can impact more than just fish populations, flow and nutrient-rich sediment but also other taxa and the overall health of aquatic systems. Finer and Jenkins (2012) found that 82% of the planned dams on Amazon tributaries would represent a high or moderate fragmentation event and 60% would cause a first major break in connectivity between the Andean headwaters and the lowland Amazon.

The submerging of large amounts of biomass during the creation of a reservoir can also cause eutrophication, leading to an increase in aquatic plants. If the eutrophication is severe enough it can impede navigation and fishing, and has been shown to cause an increase in mosquitoes (Killeen 2007). Such submerged vegetation can also create anoxic benthic environments, leading to increased methane and carbon dioxide (Killeen 2007). In other regions, it has been noted that stratification of water occurs in reservoirs over 10m deep, where a thermocline forms and warm water overlies cooler water. Oxygen trapped in this cool bottom layer is then consumed during the decomposition of organic material, which then decays anaerobically producing toxic substances and rendering the bottom layer toxic to fish (Sverdrup-Jensen 2002).

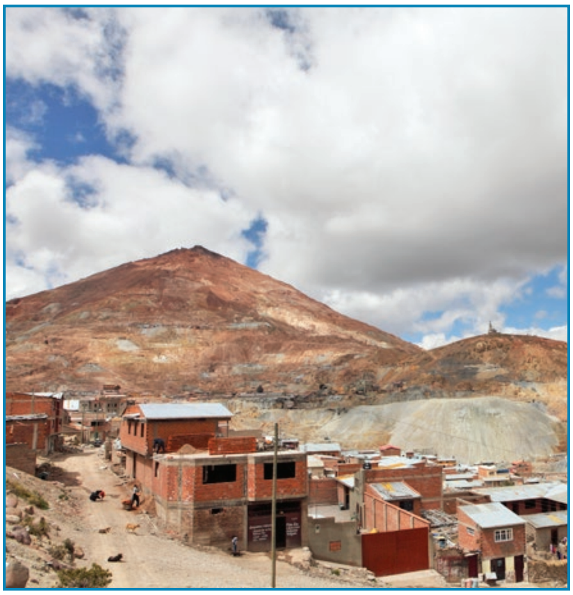
6.6 EXTRACTIVE INDUSTRY: MINERAL AND HYDROCARBON EXPLOITATION

Trends in the extractive industry

The Andes are renowned for deposits of gold, silver, and other valuable metals, with interest dating back to the Spanish conquest (Harden 2006). Important mined substances in the region include gold, copper, iron, lead, manganese, zinc, tin, silver and bauxite (United Nations 1990 in Harden 2006; Bebbington *et al.* 2010; Killeen 2007). The region is also widely recognized to contain large potential hydrocarbon reserves (Killeen 2007; Figure 20 and Figure 21).

The inaccessibility of much of the region increases the costs of exploration, production and transportation and is the primary reason for the slow increase in exploitation compared to other parts of the world (Killeen 2007). Oil exploration started in the first half of the twentieth century, booming in the 1970s and growing ever since (Finer *et al.* 2008). In recent years, increasing hydrocarbon prices and technological advances that increase commercialization of natural gas in particular have stimulated exploration in less accessible and less economically attractive areas (Killeen 2007).

Mineral extraction has grown in intensity most notably since the 1990s (Harden 2006). For example, gold extraction more than doubled in Bolivia, Colombia, and Venezuela between 1950 and 1985 and production grew by 80% in just one district of Ecuador between 1994 and 1999, yet huge potential still remains (United Nations 1990 in Harden 2006; Tarras-Wahlberg and Lane 2003 in Harden 2006; Tovar *et al.* 2013b). Mined areas have expanded and pushed upwards – currently some areas over 3,600 m ASL are under opencast mining for gold (Tovar *et al.* 2013b). Exact figures for mining area and production, however, are difficult to find – Dourojeanni *et al.* (2010) noted that while titled mining rights cover over 10 million ha of the Amazon basin, informal gold exploitation is in full expansion yet often unreported. Table 14 summarises select figures for hydrocarbon and mineral extraction for countries of the WA Region.



Bolivia produces globally significant amounts of a number of minerals, yet many parts of Bolivia have not yet been explored and much potential remains in the country for further extraction (USGS 2013a). Hydrocarbon exploitation is expanding into new areas and the government is setting aside large areas of highlands as potentially containing hydrocarbon reserves (Bebbington *et al.* 2010). Bolivia has very little oil reserves, but natural gas production has been increasing rapidly and the country is now the largest net-exporter in Latin America (Manzano and Monaldi 2008). In the mid-1990s the national oil company was privatized in a way that encouraged much FDI (Manzano and Monaldi 2008). Foreign investors currently hold a significant amount of Bolivia's reserves, for example Petrobras hold 14% of Bolivia's natural gas reserves, as well as holding shares in the pipelines connecting these to Brazil (Killeen 2007). In Bolivia, extraction is legally allowed within even the highest category of national park (Ricardo and Rolla 2006 in Killeen 2007). Concessions have long been granted in many parks to both national and international oil companies, including Madidi National Park, Isiboro-Sécure National Park, Carrasco National Park and Amboró National Park (CEPF 2000).

Table 14: Selected figures for mining, quarrying and hydrocarbon production for countries of the WA Region in 2011; * = minerals and oil and gas combined (USGS 2012 a, b; 2013 a, b, c, d, e; Reuters 2012)

Country	% Contribution to GDP		Top mineral commodities (exc. Hydrocarbons)	FDI (US$)	
	Mining and quarrying	Hydrocarbons		Hydrocarbons	Mining and quarrying
Bolivia	9.6	5.9	Tin , silver , boron, zinc , antimony , lead, tungsten	384M	238M
Brazil	4.5*		Gold, iron ore, iron & steel, manganese, coal, bauxite, phosphate rock, graphite, copper, chromium, nickel, zinc, asbestos, gemstones	66.7 B	
Colombia	11.3		Copper, gold nickel	3.03B	
Ecuador	1.3	8.4	Gold		
Panama	1.5				
Peru	5.7		Copper, gold, lead, molybdenum, silver, tin, zinc, camium, mercury, phosphate rock, selenium, silver		5.4B
Venezuela	1	12 (oil only)	coal, bauxite, alumina and primary aluminium, iron ore and steel, gold, nickel, and diamond		

In Colombia, extractive industries provide an important contribution to GDP and export income (US EIA 2014b). Following a steady decline for almost a decade, Colombia's hydrocarbon production has grown dramatically since exploration began to increase in 2008 and is predicted to continue to grow until 2015 (US EIA 2014b; see also Figure 20). Natural gas production has risen greatly due to rising consumption, growing export opportunities, and increased exploration and investment (US EIA 2014b). Most of the country's reserves are concentrated near the Caribbean coast and in the Andean foothills (US EIA 2014b). The country has recently begun exporting natural gas to Venezuela, while the US, Panama, Chile and Spain are Colombia's primary oil export destinations (US EIA 2014b). In 2010 construction started on the $4.2 billion Oleoducto Bicentenario pipeline in Colombia, the first phase of which started operating in 2013 and transporting up to 120,000 barrels per day.

Peru is a leading global producer of a number of minerals. Oil exploration is also increasing rapidly, now covering two thirds of the Peruvian Amazon (an increase from just 14% in 2004) with foreign investment playing a significant role (USGS 2013e; see also Figure 20). A big new natural gas field has recently been discovered, increasing prospects for the oil sector and are likely to catalyse exploration in that area (Manzano and Monaldi 2008; Finer and Jenkins 2012). In Peru, extraction is only permitted in lower-level protected areas, nonetheless with high biodiversity significance. The government of Peru has established several large hydrocarbon exploitation blocks in the Tambopata Region, including in the Tambopata Reserved Zone and up to Manu National Park (CEPF 2000).

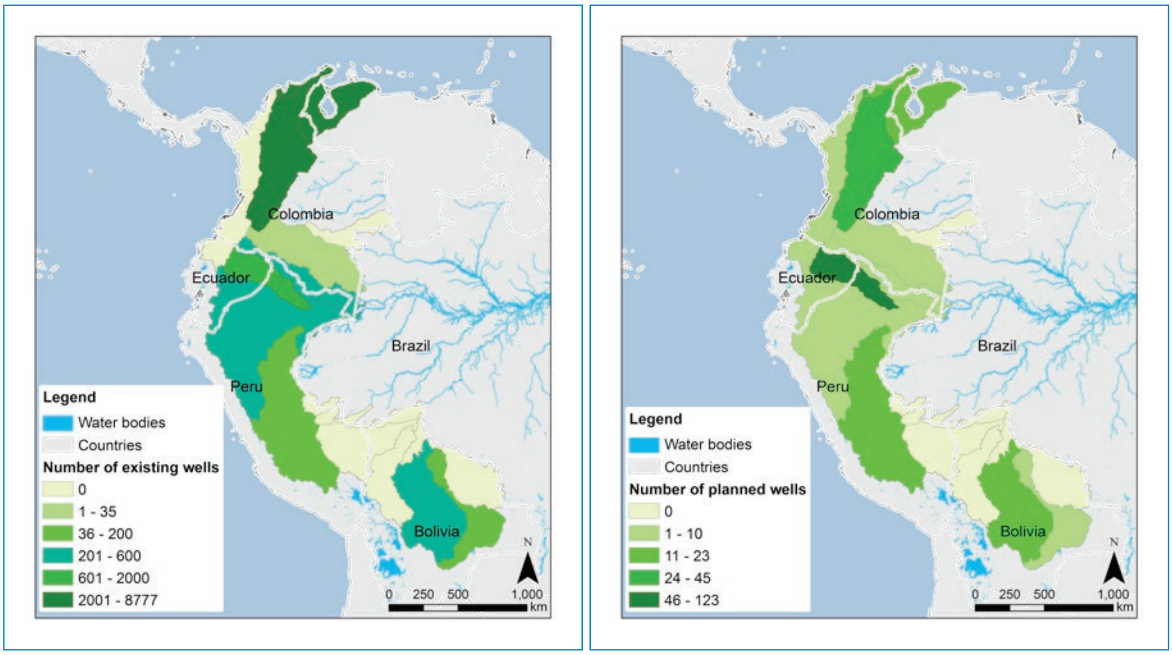


Figure 20: Existing and planned oil wells in the WA region watersheds (IHS 2013)

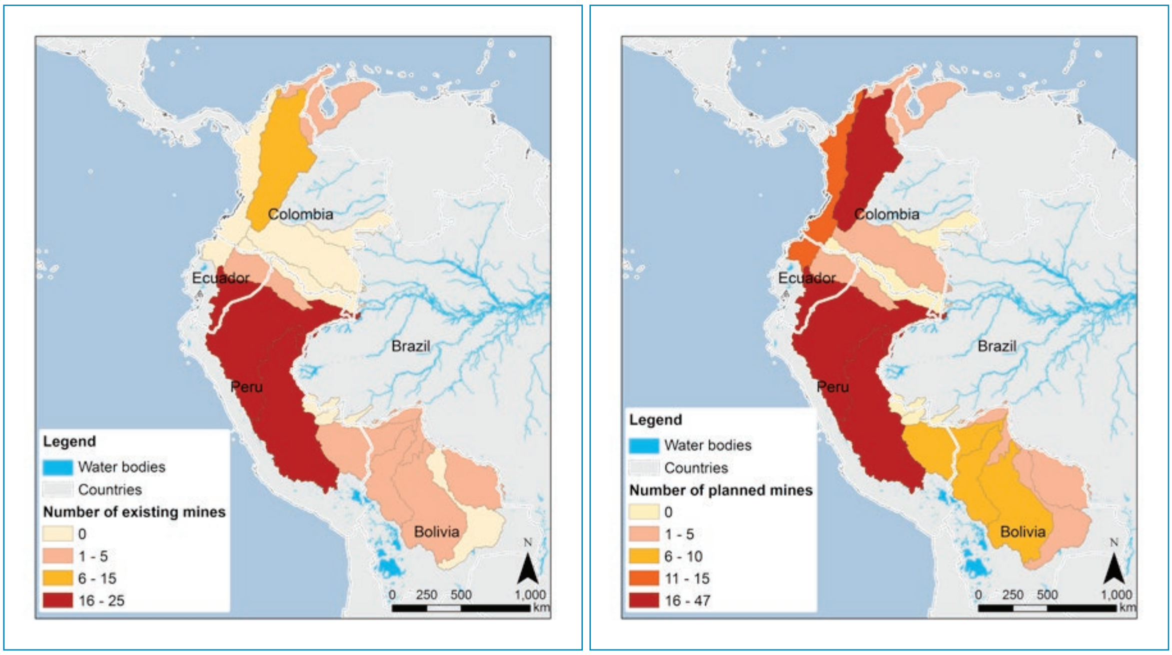


Figure 21: Existing and planned mines in the WA region watersheds (SNL 2013)

Ecuador is not a globally significant mineral producer but is the 3rd largest oil exporter in Latin America and has the fourth largest reserves (USGS 2013b; Manzano and Monaldi 2008). The country is increasing its oil production to fulfil the potential of the Heavy Crude Oil Pipeline, completed in 2003 and capable of transporting up to 450,000 barrels of oil per day along its 475 km stretch. It has since been extended up to 500 km in length, crossing the border into Colombia and was due to start transporting Colombian oil in 2013 (EuroInvestor 2013). While Ecuador's government has been recently showing a trend towards nationalisation in the oil sector, an increasing proportion of the country's oil is being extracted by private companies (Manzano and Monaldi 2008). For example Killeen (2007) noted that China's CNPC had acquired 36% stake in the pipeline, ensuring control of reserves and the transport system to bring these reserves to their domestic market.

Around two thirds of the area east of the Andes in Ecuador is subdivided into exploration and exploitation blocks, and the country is the fifth largest producer of oil and gas in Central and South America (Bebbington *et al.* 2010; US EIA 2014a). Ecuador's government has recently approved oil extraction in Yasuni National Park in the Amazon Rainforest, which in addition to extremely high biodiversity is also home to indigenous peoples in voluntary isolation (The Guardian 2013; CEPF 2000; See also Figures 20 and 21).

Brazil has long exploited its mineral deposits, yet has only recently become a net exporter of oil, having opened to private investment in the mid-1990s (USGS 2013d; Manzano and Monaldi 2008).

Economic prospects in Venezuela are mostly dependent on oil prices, which accounted for almost 12% of GDP and 95% of export earnings (USGS 2013e). As the only founding member of the Organization of the Petroleum Exporting Countries (OPEC) in the region, Venezuela has the largest reserves and is the largest producer (Manzano and Monaldi 2008).

Impacts of mining and oil exploitation

The number of small or illegal mining concessions, coupled with the remoteness of typical extraction sites, makes regulation of mining extremely difficult (Killeen 2007). However, the impacts of mining can be huge, not just on the immediate area surrounding the site but on areas much further away. Rural communities often suffer the most, but stand to gain the least, as the resources on which they depend are removed, modified or polluted. It has been estimated that by 2006 in Peru, over half of all peasant communities were affected by mining activity (Bebbington *et al.* 2010).

Habitat destruction and biodiversity impacts:

A direct impact of mining activities is the destruction of habitats. For the establishment and operation of an extraction activity, roads and other infrastructure must be constructed to allow heavy machinery to access the site.

During exploration, seismic activities are used to test for oil. This intensive phase requires the construction of camps, sub bases and numerous heliports (Finer and Orta-Martinez 2010). There is a large amount of deforestation associated with this infrastructure development, as well as noise pollution, and non-resident workers invading formerly pristine areas (Finer and Orta-Martinez 2010). In addition hundreds of kilometres of seismic lines must be cut through the understory of the forest, facilitating access by hunters and loggers, and thousands of seismic explosives must be detonated. Finer and Orta-Martinez (2010) estimate that 20,000 km of seismic lines will be cut in what they call Peru's second hydrocarbon boom.

The effects of seismic activities on biodiversity are little known, but a study by the Smithsonian Conservation Biology Institute in 2009 found that 2D seismic testing in the Peruvian Amazon led to a significant reduction in group sizes of the endangered White-bellied Spider Monkey (Ateles belzebuth) demonstrating the need for further research in this field (Finer and Orta-Martinez 2010). CEPF (2000) also note the important damage in national parks in Peru, where native vegetation has in places been completely eliminated.

While industrial mining operations may occupy large areas, the effects of small-scale mining can also be highly significant. The most common form of gold-mining throughout the Andes and the Amazon makes use of rudimentary technologies to plough the land with large dredges and access gold in sediments from ancient riverbeds (Killeen 2007). Mining, especially for gold, is taking a serious toll on habitats within the Vilcabamba-Amboró Corridor.

Water consumption:

The extractive industries consume large quantities of water, much of which is eventually returned to the hydrological cycle strongly polluted (Buytaert *et al.* 2006). Mining companies often divert water courses to access water required for production and open-pit extraction results in the removal of water-bearing hill tops, with significant effects on water supply and quality downstream (Bebbington *et al.* 2010).

It is thought that mining consumes 5% of Peru's available water, yet Bebbington and Williams (2008) note that this does not stress the significance of this use sufficiently: many mine sites are located in headwater areas and have long lasting effects on water quality, which can be highly significant for long stretches of river downstream of the site itself, with major implications for local communities (Bebbington and Williams 2008). Bebbington *et al.* (2010) also cite a number of examples where concessions are given in areas that have been protected due to their significance as water sources for cities and communities, including Aguarague National Park in Bolivia, which is believed to be the sole source of water for an area that is home to numerous communities as well as an important intact forest area.

Sediment:

Mining activities increase sediment levels in water through a number of ways. In the Andes, many excavations take place on steep slopes, which can increase the frequency of landslides (Harden 2006). This can also cause debris to fall into streams and rivers below, while the steep slopes also facilitate their passage along the river (Harden 2006). The deforestation required at a mining site may also decrease soil stability.

A study in Ecuador on the effects of gold mining found that concentrations of suspended sediment from mining were more apparent in dryer years than wetter years as there was less water to dilute it, while gold mining in Colombia was found to be an important cause of the sediment concentrations in the Magdelena River, which are among the highest on the continent (Harden 2006).

In-stream extraction is another cause of suspended sediment in rivers at all flow levels. This type of extraction of sand, gravel and rock has reduced over recent years, largely due to the recognized environmental consequences, yet its effects are still important (Harden 2006).

Pollution:

Mining activities can seriously affect water quality of huge extents of ground and surface water relative to the size and extent of the actual mine site. Tarras-Wahlberg *et al.* (2001) observed that river sections contaminated by mining discharges in Souther Ecuador saw reduced species diversity and abundance. In particular the study noted a lack of benthic organisms in the contaminated region, up until a confluence of another river. Even further downstream, where life was seen again, the number of taxa was clearly reduced. It was observed that impacts of mining can reach further than 160 km downstream of the mining district (Tarras-Wahlberg *et al.* 2001).

Acid mine drainage:

Acid mine drainage occurs when sulphide-bearing minerals are exposed to air or water, forming sulphuric acid, which then dissolves metals present in soils and rock, rendering ground and surface water toxic (Bebbington *et al*. 2007). While many trace metals are naturally present in the Andean environment due to its geomorphologic characteristics (Yacoub *et al*. 2012), these have been shown to be largely sediment-bound under ambient pH conditions and therefore have no or little affect on aquatic life. However, the acidic conditions resulting from acid mine drainage cause them to dissolve and become bioavailable (Tarras-Wahlberg *et al*. 2001; Van Damme 2008). Acid mine drainage can occur many years after a mine has been abandoned, making it an extensive and significant impact.

Cyanide:

Industrial-scale gold mines use cyanide to leach the mineral gold from the rock, producing residue that poses an environmental threat for centuries as cyanide is highly toxic (Tarras-Wahlberg *et al*. 2001). While the use of containment dams is common practice in order to isolate the treatment ponds where cyanide is removed and heavy metals are extracted, these ponds can fail, with significant consequences for areas downstream (Tarras-Wahlberg *et al*. 2001).

Small scale and artisanal mining operations use mercury amalgamation to extract gold from heavy mineral concentrates, and small cyanidation plants to treat residues. Slurries containing free cyanide and metal cyanide complexes are then discharged (Tarras-Wahlberg *et al*. 2001). In the Portovelo-Zaruma region a study found that total cyanide and free cyanide concentrations exceeded environmental criteria for the protection of aquatic life downstream of the discharges, with concentrations particularly high when water levels are lower in the dry season (Tarras-Wahlberg *et al*. 2001).

Mercury:

Mercury is commonly used in mining operations, and is of great concern as its impacts on neurological function and causes birth defects and is extremely persistent in the environment (Killeen 2007; CEPF 2000). It has been shown to be increasing in the Amazon over recent decades and bioaccumulation is causing elevated concentrations at higher trophic levels (Maurice-Borguin *et al*. 2000 in Killeen 2007). Elevated levels of mercury have been detected in human populations and in the catfish they eat in Puerto Maldonado, an important mining district in Peru and the Rurenabaque area in Bolivia (CEPF 2000).

Killeen (2007) highlighted a recent study in Venezuela that found that mercury levels in fish populations were several times higher in the reservoir of a dam than in populations downstream. The result suggests that the flooding of huge vegetated areas creates the anoxic conditions that allow methylation of mercury into mercury-methylate, which is more rapidly absorbed by organisms.

Cadmium:

Cadmium is a heavy metal associated with oil exploitation, which is highly toxic and carcinogenic. It has been found that around 99% of the Achuar population that inhabits the Corrientes River watershed show unsafe blood levels of cadmium (Finer and Orta-Martínez 2010).

Oil spills and waste dumping:

In the eastern Andes, high rainfall and unstable topography are conducive to accidents, and are at least part of the cause of several recent oil spills in the region (Killeen 2007). While numerous spills caused widespread contamination back in the 1970s, Finer *et al*. (2008) cited the recent example of the Camisea field which saw five major spills in its first eighteen months since starting operating in 2004 as well as numerous leaks.

In Peru and Ecuador, local communities and indigenous populations have taken legal action against US oil companies, claiming they have dumped billions of gallons of toxic waste in forests (Baker 2008 and Hearn 2008 in Finer *et al*. 2008).

Social impacts:

In the WA region, many poor and landless citizens see the presence of foreign companies as a motive to lay claim to land and the resources found upon it, catalysing deforestation and land-cover change (Killeen 2007). Bebbington *et al*. (2010) also noted that the impacts for indigenous resource governance are significant once land is opened up for extractive activities, with potential effects on social organization. In addition, the opening up of previously inaccessible areas, including reserves for groups living in voluntary isolation, brings risk of diseases for these vulnerable populations with little resistance (Defensorìa del Pueblo 2006 in Finer and Orta-Martinez 2010).

6.7 INFRASTRUCTURE DEVELOPMENT

As mentioned above, commodity development typically comes hand in hand with infrastructure development, whether in the form of roads, pipelines, cables, or otherwise.

In the Peruvian Amazon alone, almost 8,000 km of roads have been reported as being built to support the mining industry, yet this figure is thought to be around half the actual amount once municipal and private roads have been accounted for (Dourojeanni *et al*. 2010). These types of road serve farmers, loggers, miners and oil companies and comprise 60% of Peru's road infrastructure (Dourojeanni *et al*. 2010). The construction of several thousand km of railways as well as 4,200 km of waterways is also planned (Killeen 2007).

As well as direct habitat destruction for their construction, road building has a number of impacts, including sending large amounts of soil and rock down the steep Andean slopes into rivers and streams below and altering aquatic systems (Killeen 2007). Road construction also requires raw materials such as gravel, the extraction of which can have many environmental impacts. Roads modify underground water elevation and drainage patterns, as well as degrading habitats and culturally important sites. Pollution from vehicles can be severe, and roads can obstruct movements of wild animals (Malky *et al*. 2011).

The development of infrastructure is associated with a number of other impacts – an influx of non-resident workers to construct the roads can degrade natural habitats, create waste and increase hunting and fishing pressure (Malky *et al*. 2011). Infrastructure creation then opens up previously inaccessible areas to deforestation, hunting and other forms of exploitation.
For example, CEPF (2000) reported how the construction of a road between Cotapata and Santa Barbara encouraged an increase in gold mining activity by allowing access to new areas. Increased population along waterways in the region will potentially lead to increased fishing pressure (Killeen 2007).

6.8 WILDLIFE TRADE

Trends in wildlife trade

The Amazon region has been an important source of much traded wildlife for many years, in particular live specimens for exotic pets or research and pelts for fashion.

During the 1960s and into the 1970s there was a boom in trade, in particular of cat skins, as these became fashionable in Europe and America (Payán and Trujillo 2006). Between 1968 and 1969 in the Amazon region 2,000 jaguars were reported as hunted (Gieteling 1972 in Payán and Trujillo 2006). Yet Gitzgerald (1989 in Payán and Trujillo 2006) estimated that in the late 1960s as many as 15,000 jaguar pelts were exported to the USA and Europe. Of the four species of spotted cat found in the region, the ocelot was most heavily exploited with an estimated 200,000 hunted annually (Gietelin 1972 in Payán and Trujillo 2006). Trade in cat skins dropped in the 1970s with the implementation of national laws and the entry into force of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and had effectively ended by the late 1980s (Broad 1987 in Payán and Trujillo 2006).

Wild birds are also subject to much trade, both within the countries of the WA region and internationally (Weston and Memon 2009). Parrots and parakeets are particularly popular. A study by Gastanaga *et al.* (2010) noted that of 34 parrot species being traded, four were threatened, one was near-threatened species and an additional species was listed in CITES Appendix 1. The study found that the numbers of individuals traded were far higher than the official legal maximum (Gastanaga *et al.* 2010). In Peru the legal trade is based on a quota determined by relevant authorities that is often based on very little scientific evidence by an understaffed and underfunded agency (Munn 2006 and Mendoza 2008 in Weston and Memon 2009). Illegal trade is more common, as although it has been banned since 1973, laws are poorly enforced.

In 2004 in Medellin, Colombia, the confiscation of 256 mammals was reported (Moreno *et al.* 2005 in Moreno and Plese 2006). Sloths have also been traded for many years, and this trade has recently seen an increase despite greater attention being paid by local authorities (Moreno and Plese 2006).

Monkeys are another target for many traders. During the 1970s and 1980s, the Amazon basin was a principal source for primates for export overseas – between 1961-1975 Peru legally exported almost 400,000 primates while in Colombia over 50,000 were exported over a three year period in the 1970s (Neville 1975, 1977 in Maldonaldo *et al.* 2009; Smith 1978). Today this trade continues, and much of it is illegal. For examples, Maldonaldo *et al.* (2009) considered three species of night monkeys – no trade was reported under CITES by Brazil, Colombia or Peru, yet their study suggested that between 2007 and 2008, 4,000 night monkeys were traded to a value of over US$100,000 (Maldonaldo *et al.* 2009).

Yet, the countries of the WA Region implemented laws to prohibit or regulate wildlife trade, even before CITES came into force in 1975. Brazil prohibited commercial wildlife exploitation in 1967, Peru placed wild cats under protection in 1970 and Colombia banned the trade in skins or live individuals of a number of species in 1973 (Smith 1978). However, these laws saw little enforcement (Smith 1978).

Impacts

The trade in live animals can decimate wild populations. Many individuals of target species die during capture and transport. Smith (1978) estimated that 4-5 monkeys die in capture for every one successfully exported from the Peruvian Amazon. Weston and Memon (2009) reported that 8-43% of parrots die during capture, depending on the species, and 31% die on average during transportation. Many species die shortly after sale and are then replaced by the owner (Moreno and Plese 2006; Weston and Memon 2009).

Moreno and Plese (2006) also noted that, in the case of sloth species, young are often taken from their mothers by poachers, and the mothers are then often mistreated and sometimes killed for meat.

The hunting and trade of wild cats did not just take its toll on the populations of the target species. Primates and many other species were used as bait for the cats and populations of certain monkey species were drastically reduced (Defler 1980 in Payán and Trujillo 2006). The reduction in populations of these species, as natural prey for the cats, then hindered the recovery of the harvested felids (Payán and Trujillo 2006).

6.9 TOURISM

Tourism is a very important industry in the Amazon and Andean regions; Killeen (2007) gives a conservative estimate of the value of Amazonian tourism at $100 million per year. Tourism is increasing in the high Andean ecosystems, including the páramo, and management is essential if damage to the environment is to be avoided (Buytaert *et al.* 2006).

In Latin America, tourism's direct contribution to GDP for the region as a whole has grown by 7% since 2006 (WEF 2013). Increasing incomes in the region mean that almost 2/3 of tourism is from within South America (WEF 2013). Figure 23 below shows the travel and tourism industry's total contribution (both direct and indirect) to GDP and employment in 2012 in the countries of the WA region.

The number of tourist arrivals has grown enormously over recent years across the continent - between just 2011-2012 tourism increased in Venezuela by 19.3%, in Bolivia by 17.8%, in Ecuador by 11.5%, in Peru by 9.5%, in Panama by 9.1% and in Colombia by 6.4% (World Tourism Organisation 2013).

The tourist industry requires four main goods and services in a given location – accommodation, food, transportation services and entertainment services (Eugenio-Martin *et al.* 2004). The construction and operation of facilities and services for tourists has significant environmental impacts which vary greatly in their geographical and temporal scales (Roe *et al.* 1997). These include habitat destruction for construction activities, waste generation, effects associated with recreational activities and changes in population dynamics and densities (Roe *et al.* 1997).

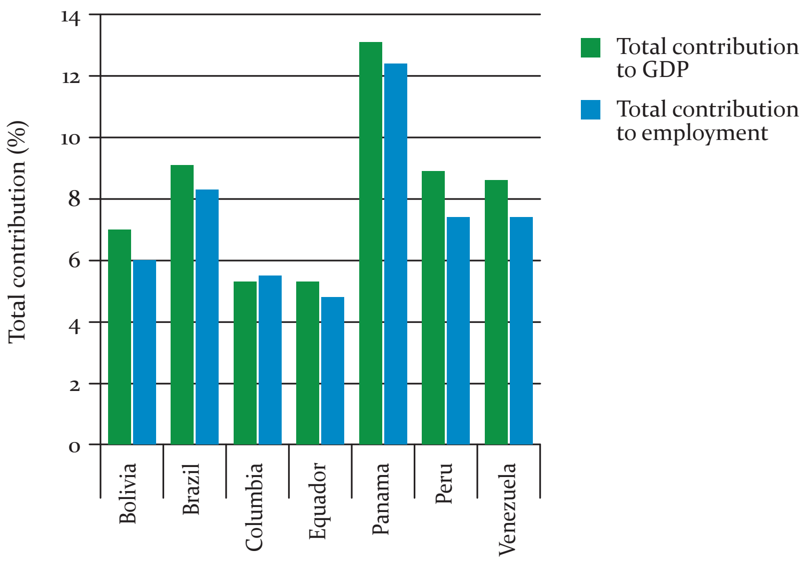


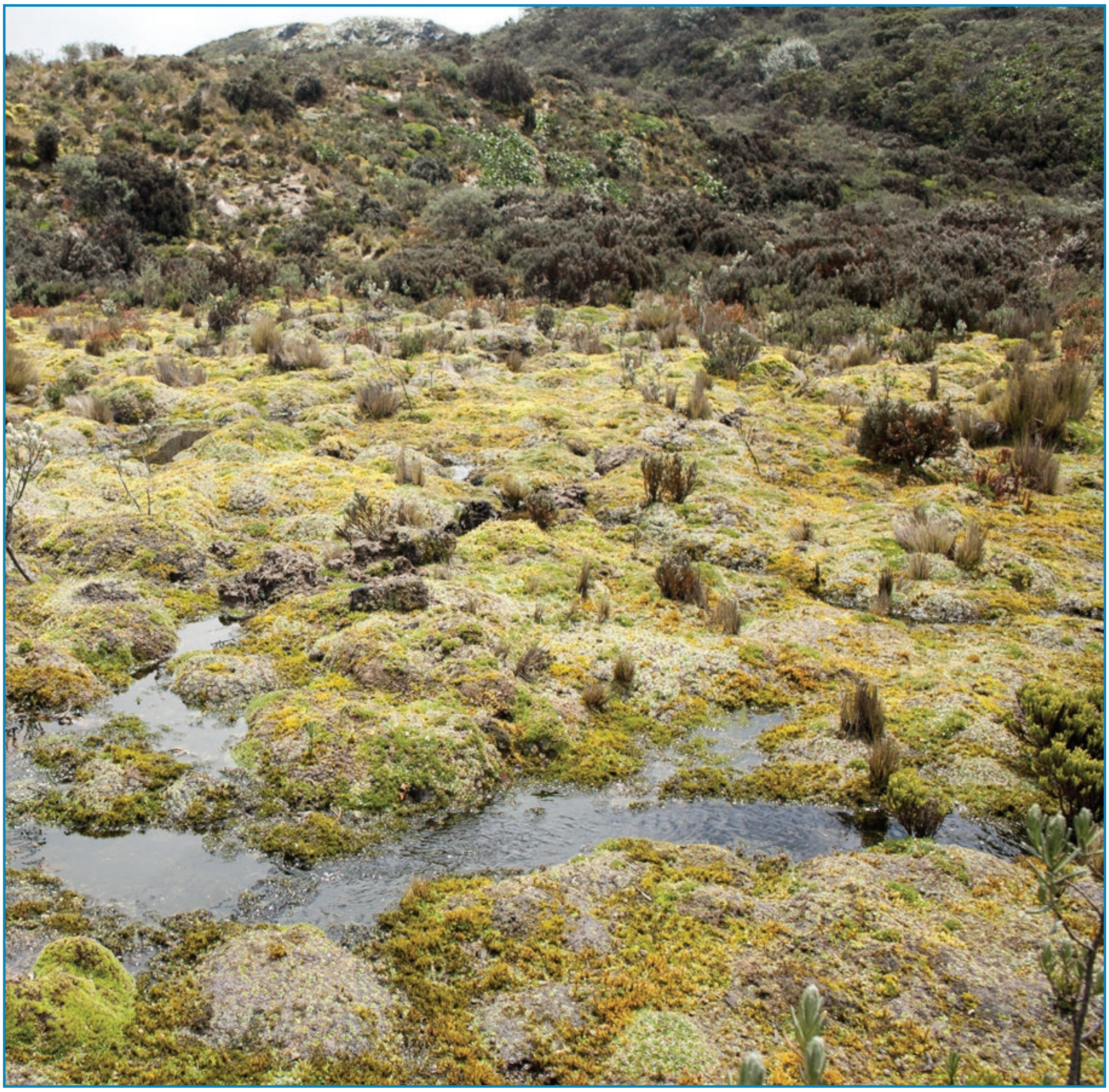
Figure 22: Total contribution of travel and tourism to GDP and employment by country in 2012 (WTTC 2013a, b, c, d, e, f, g)

6.10 COCHINEAL INSECTS

A commodity that also merits mentioning is the cochineal insect, found in the Opuntia scrublands. From these insects carminic acid is obtained, a natural dye used in the food, textile and pharmaceutical industries. Collection of these insects has been of great economic importance for local communities for centuries, Particularly common in the Andean areas of Ayacucho, Peruvian production represents between 85% and 90% of the global market (Rodriguez *et al*. 2006). The impacts of the collection of this insect on its populations and on the opuntia scrublands, which also provide other benefits to human populations, are not reported.

6.11 PEAT

Peatlands are particularly important for carbon storage and water purification (Bain *et al*. 2011). Just 3% of the world's land surface is peatlands, yet they store over 30% of all soil carbon globally (Bain *et al*. 2011). Peat soil has been removed and sold as fuel or for horticultural purposes in Bolivia, Peru and Ecuador, which impacts on the water retention and nutritional qualities of the land (Harden 2006). Very little information exists on the extraction of peat in Latin America but given its slow rate of formation, the impacts of extraction at any scale are likely to be significant.



7. Initiating and Responding to Change

This chapter presents some of the tools and approaches employed in order to initiate or respond to change in the WA Region. These include land management and planning (including protected areas, and watershed-level planning), environmental law, policy and controls, transboundary cooperation and land tenure. Two case studies from the region provide further information. Finally, the chapter concludes with a brief consideration of data and information gaps encountered in producing this report.

7.1 LAND MANAGEMENT AND PLANNING

Protected Areas

In the tropical Andes, protected areas have long been the primary tool for the conservation of biodiversity and ecosystem services (Hole *et al.* 2011). Over the past two decades the extent of terrestrial protected area coverage has increased importantly. Evolution in terrestrial protected area coverage between 1990 and 2012 is shown in Table 15.

Table 15: Terrestrial Protected Area Coverage 1990 and 2012 (WDPA 2012)

	Terrestrial Protected areas 1990 (ha)	Terrestrial Protected Areas 1990 (% coverage)	Terrestrial Protected areas 2012 (ha)	Terrestrial Protected Areas 2012 (% coverage)
Bolivia	9,548,295	8.76	22,707,093	20.83
Brazil	5,994,0915	7.02	224,091,981	26.26
Colombia	22,086,152	19.29	24,247,673	21.18
Ecuador	5,640,352	21.85	6,124,616	23.73
Panama	1,378,803	18.17	1,560,865	20.57
Peru	6,138,702	4.73	24,751,574	19.06
Venezuela	36,828,244	40.15	48,595,633	52.97

However, while protected areas may be growing in number and area, many protected areas in the region are designated simply on the basis of socio-economic opportunity, rather than to protect vulnerable species or priority ecosystems (Hole *et al*. 2011). Over 60% of the region's IBAs and KBAs are under formal protection (Figure 23; Table 16).

Effective management and protection still remains a serious issue. CEPF (2000) cites as an example the Vilcabamba-Amboró corridor, which straddles the Peru-Bolivia border, where a lack of protection has resulted in both human and corporate encroachment with concessions for hydrocarbon, timber and other resource extraction common to numerous areas. In addition, the study notes the lack of management plans, and insufficient human and financial resources as key barriers to effective functioning of the protected area network in Peru (CEPF 2000).

In Peru, while the legal framework for protected areas is comprehensive and a system-level plan was designed after an extensive and participatory process, the implementation and enforcement of this plan are not sufficiently effective (Solano 2011). Resources – both human and financial – are insufficient, as is political support. These factors, together with a lack of capacity and determination to fight back, facilitate the illegal use of protected areas (Solano 2011).

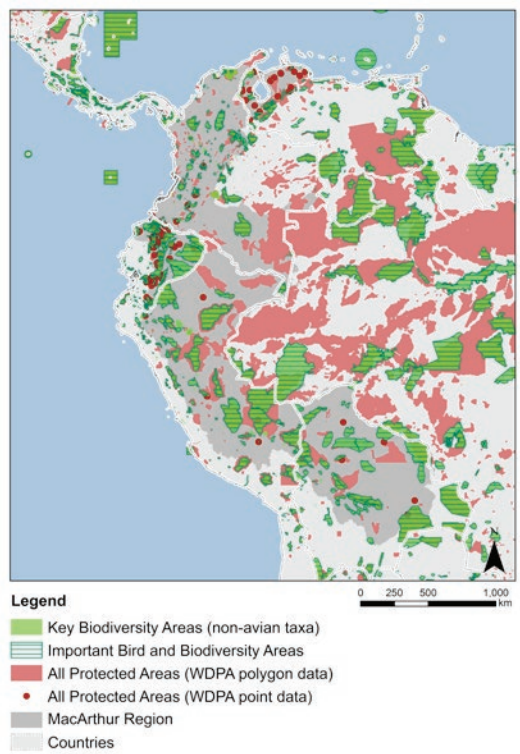


Figure 23: Overlap of protected areas and important biodiversity areas in the WA region (BirdLife International 2013; IUCN and UNEP-WCMC 2014; MacArthur Foundation 2012; NGA 2000)

Table 16: % of each biodiversity measure within WDPA within the MacArthur region

Measure	Intersect area (within WDPA; ha)	Total area (ha)	%
IBA	30,597,723	47,650,837	64.21
KBA	31,240,245	49,223,431	63.47

Watershed-Level Planning

Effective land-use planning is particularly important in the páramo regions, which are vulnerable to global climate change and where any land-use changes may have a serious impact on huge areas and numbers of people downstream (Buytaert *et al*. 2006). An improved understanding of páramo hydrology will be needed in support of decision-making (Buytaert *et al*. 2006).

In the light of recognized pressures on watersheds emanating from numerous sources, and the fact that the effects of activities upstream can be felt by those far away downstream, a number of watershed-level schemes have been implemented in the region. Box 1 describes one decentralized scheme in Colombia while Box 2 describes an example of watershed forest protection from Peru.

Box 1: Decentralised Environmental Management in Colombia

Colombia has a long history of decentralised environmental management, with the establishment of "Corporaciones Autonomas Regionales" (Regional Autonomous Corporations, or CARs) which are public or private entities, created by law and covering either a single ecosystem or a geopolitical, biogeographical or hydrological unit (MinAmbiente 2014). They have financial and administrative autonomy, and are legally responsible for the management of the environment and natural resources and for ensuring sustainable development, as per the legal and political dispositions of the Ministry for the Environment (MinAmbiente 2014).

The first CAR in Colombia was established in 1954 in the Valle del Cauca. By 1988 18 CARs existed, with varying functions. Under a new law in 1993, these CARs were recast as environmental mana

The CARs are now charged with implementing Colombia's "Plan Verde" (Green Plan) – the Strategic Plan for the Restoration and Setting Up of Forests in Colombia that was approved in 1998. This plan aims largely to restore strategic ecosystems for protective and agricultural forestry purposes, in order to improve the supply of ecosystem services, to offset degradation and to improve the well-being of local communities.

– An analysis of the CARs by Blackman *et al*. (2006) noted eleven challenges faced:

– An urgent need for reliable data on environmental quality and institutional performance.

– The existence of significant financial and jurisdictional conflicts between CARs and entities with which they are supposed to be cooperating to facilitate environmental management, and confusion over roles which leads to overlap in work.

– Inadequate prioritization of financial risks and allocation of funding.

– High variation in CAR performance, dependent on size, age and level of poverty of the CAR.

– A need to encourage CARs to explore new means to generate revenue in order to mitigate inequalities in funding level.

– A great variation in human and technical resources across CARs.

– An imbalanced influence of certain social groups on the activities of CARs and the weakness of NGOs.

– The role of CARs in financing, owning and operating sanitation infrastructure conflicts with their role to stringently regulate it.

– The existence of tensions between the Colombian Ministry of Environment, Housing and Territorial Development (MAVDT) and CARs, inherent in the design of a system which aims to coordinate a number of entities with a relatively high level of autonomy.

– Inadequate and inconsistent enforcement of environmental regulations by CARs.

– Ineffective use of voluntary clean production agreements and voluntary environmental guides.

Another challenge noted by Cardenas *et al*. (2009) is the limitation in what the CARs can achieve given their purely local scope.

The Corporacion Autonoma Regional de Cundinamarca is responsible for developing and implementing a watershed management plan for the Fuquene watershed. There is, however, widespread discontent with their lack of action and progress (Cardenas *et al*. 2009). There is little civil society involvement in the Fuquene region, and few examples of community mobilization in order to address watershed level issues at the political level (Cardenas *et al*. 2009). Besides a limited number of examples of collective resource management within communities and collective action to defend legal water-rights against large landowners, attempts to manage watershed-level issues both up and downstream through local collective action have been unsuccessful. This is in a large part due to limited communication between different areas of the watershed, limiting the collective understanding of the challenges faced (Cardenas *et al*. 2009).

Box 2: Watershed-Level Management in Peru

Another example of watershed level management comes from northern Peru. The government created the Alto Mayo Protected Forest in 1963, not only to protect the threatened forest habitat and endangered species in the upper Mayo River basin, but also to protect the water supply in the valley of the Mayo River. The water originating from this river is used for agriculture, industry and human consumption elsewhere in the region (Parkswatch 2003).

However, the protected forest has not met with much success. A buffer zone and management committee were established in 2001, but in 2003 neither were yet official and the management committee's operative capacity was very limited (Parkswatch 2003). Human pressure is high both in the protected forest and its buffer zone due to the opening of a road traversing the forest in the early 1970s, and migration is still an issue. In the buffer zone intensive agriculture and ranching are practiced (Parkswatch 2003). Small budgets limit management and controls and decision-making are inadequate. Industry occurring outside the buffer zone has impacts such as air pollution on the protected forest (Parkswatch 2003).

Major governance issues in the Alto Mayo basin are due to little presence of the state and the lack of clear sustainable policies and a clear vision, as well as the fact that few resources are allocated to the region (InWEnt 2009). There is an evident indifference among civil society and the little public action is inefficient and ineffective (InWEnt 2009).

Payments for Ecosystem Services

There are also a number of examples of Payments for Ecosystem Services (PES) systems established in the region. One example is in Quito, Ecuador, where around of the city's water supply originates in two protected areas that are also used for cattle, dairy and timber by the local populations of around 27,000 people (Postel and Thompson 2005). A Watershed Trust Fund (FONAG) was established in 2000 through seed funding from the Nature Conservancy (TNC) and Quito's water provider (EPMAPS). The fund initially engaged EPMAPS to provide 1% of drinking water sales on a monthly basis (later becoming 2%) and a short while later the Quito Electricity Company (EEQ) committed to provide an annual sum of US$45,000 (Postel and Thompson 2005; FONAG 2012). An independent financial manager invests the funds, and returns are used for watershed protection measures (Postel and Thompson 2005). Downstream beneficiaries, such as irrigators, flower plantations, municipal water suppliers and hydroelectric power plants give voluntary contributions to the fund (Postel and Thompson 2005). Currently, the municipal drinking water company contributes 2% of all its sales of drinking water to the fund. This voluntary nature of contributions, and the fact that the fund relies largely on two main contributors are the two main challenges to the long term sustainability of this scheme (Postel and Thompson 2005). However, the lack of scientific understanding and information on land use and its hydrological linkages and on the economic value of watersheds make the establishment of user fees difficult (Postel and Thompson 2005). Strong political support for the fund has helped ensure its initial success, but longer term commitments from beneficiaries may be required, which in turn will need a more concrete demonstration of the value of this protection (Postel and Thompson 2005).

Nonetheless, thanks to the fund, the management of over 65,000 ha of watersheds has been improved, with farmers in upstream areas receiving support for watershed protection programmes rather than cash payments and over 1,800 people thought to have benefitted economically from the watershed management and conservation (UNEP no date).

7.2 ENVIRONMENTAL POLICY AND LEGAL FRAMEWORK

Environmental Impact Assessments

As extractive operations in the region increase in number and scale, environmental impacts are inevitable. Environmental Impact Assessments (EIAs) are required by all countries in the WA region prior to the development of major projects and in most cases have been required since the 1970s.

In Peru EIAs are required for major infrastructure and development projects prior to a project being approved. However, the reliability and quality of these assessments has often been questioned. For example, Tarras Wahlberg (2012) reviewed the EIA carried out for the controversial Conga mine project, and found significant weaknesses in relation to its clarity, wording and accessibility, and fails to use real data to support its predictions. Peru has recently (in 2012) streamlined its EIA process for extractive industries to take assessment of EIAs produced by companies out of the hands of the mining ministry, which is often suspected of corruption (The Guardian 2012). This follows a random review of EIAs by the Peruvian government, which found that in 86% of cases examined, it was unclear how approval had been granted (IPS News 2012). In Colombia EIA regulations are ineffective because of limited scope, inadequate administrative support and the inexistence of effective control mechanisms and public participation (Toro *et al.* 2010).

In the WA region, there is an important need for Strategic EIAs that consider impacts of activities such as mining, oil extraction or dam construction at a regional scale, and that consider cumulative and long-term impacts (Finer *et al.* 2008). The WA Region shows a clear need for this strategic regional planning in order to maintain free-flowing connectivity from the highlands to the Amazon Basin. Two mega-dams are under construction on the Madeira River, which makes it even more important to reconsider the planned dams on the Marañon, Ucayali, Napo, and Caqueta Rivers, that would fragment the river entirely (Finer and Jenkins 2012). This is particularly complicated due to the transboundary nature of the challenge (Finer and Jenkins 2012).

Multilateral Environmental Agreements

All the countries of the WA Region are signatories to major multilateral environmental agreements (MEAs) such as the Convention on Biological Diversity (CBD), Ramsar Convention, Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), United Nations Convention to Combat Desertification (UNCCD) and United Nations Framework Convention on Climate Change (UNFCCC).

However implementation of these conventions is not always straightforward. For example, the enforcement and control of international trade of wildlife by police and wildlife agencies remains extremely limited. In Colombia, there is a lack of legal instruments to regulate the management of wildlife that have been confiscated and few reliable statistics exist on illegal traffic and confiscation (Rodríguez and Echeverry 2005 in Moreno and Plese 2006). Resources and capacity to follow up on cases are also lacking. This is demonstrated by the fact that between 1996 and 2004, 251,776 wild animals were reported as confiscated yet only 1,639 legal investigations were initiated (Moreno and Plese 2006). Of these legal investigations, just 45 fines were issued and 263 lesser sanctions (Moreno and Plese 2006). Equally, a study carried out in 2007-2008 by Maldonaldo *et al.* (2009) suggested that, despite no officially reported trade in night monkeys during the period, over 4,000 individuals were actually traded with a value of over US$100,000.

This shows a violation of international trade regulations, possibly stemming from a lack of capacity to adhere to them as well as a lack of transboundary cooperative management from environmental and conservation authorities and CITES management authorities in different countries (Maldonaldo *et al.* 2009).

Enforcement

A number of the examples and studies cited earlier in this report demonstrate a lack of enforcement and control for environmental laws. In the Magdalena basin, where fisheries have suffered a collapse due to overfishing, recovery will only be achieved if a total ban of fishing is implemented – yet there is no control or enforcement in the region, and there is no presence of the state (Galvis and Mojica 2007). In addition, fish stockings are poorly planned and random (Galvis and Mojica 2007).

CEPF (2001) cites the positive example of Ecuador, as a country that has recently improved and strengthened environmental legislation and shown a tendency towards decentralization, which gave rise to new opportunities for participatory land-use planning and local control over natural resources.

It is also important for decision-makers and policy-makers to prioritise awareness raising among the most remote populations where many of the environmental and social problems faced are more intense, yet where very little attention is focused (Galvis and Mojica 2007). In these areas, generating food and income for survival is of highest priority, and subjects such as biodiversity, conservation and management are less widely recognized (Galvis and Mojica 2007).

7.3 TRANSBOUNDARY COOPERATION

Given the transboundary nature of so many of the rivers and watersheds in the WA Region, a lack of cooperation between countries represents a major challenge. This is also the case for the Amazon Rainforest, a transboundary ecosystem that provides important ecosystem services at the local, national, regional and global scales.

Examples of transboundary cooperation on local environmental management, such as at the watershed scale, were not found during the review of published literature.

Some provisions are in place for cooperation at the regional level. For example, Mercosur has dealt with environmental themes since its foundation and members have coordinated their positions for major environmental conferences (EC 2007). Mercosur's environmental policy addresses: "inclusion of environmental costs in cost analysis; adoption of adequate practices and sustainable management of natural resources; control of potential adverse activities; adoption of minimization and treatment practices; cleaner technologies and recycling; monitoring of shared ecosystems; co-ordination of international acts and, institutional strengthening and environmental management of tourism" (Virasoro 1996). However, despite adopting the Framework Agreement on the Environment in 2001, environmental issues have never been high on the agenda (EC 2007). This is a major focus of the EC's negotiations for entering into a trade agreement with Mercosur (EC 2007).

The FTAA, although never successfully established, has also sought to address environmental issues. The US has pushed for the improved enforcement of environmental laws in negotiations, while it was also recognised that improvement of technical and legal capacity was also important (Block 2003). The US has set up a number of bilateral agreements with countries in Latin America, all of which highlight the importance of environmental improvement and law enforcement (Block 2003).

Other regional initiatives, such as the IIRSA do not have explicit environmental objectives, but may have significant impacts.

7.4 TENURE RIGHTS

It is generally recognised that ill-defined property rights fail to exclude some users and mean that the benefits from good stewardship are not limited to title-holders, minimising the incentive to protect natural habitats and ecosystems (Swinton *et al*. 2003). In the WA region, the recognition of farmers' rights, is extremely important to ensure the maintenance of the region's rich agrobiodiversity, for both regional and international food security (Scurrah *et al*. 2008).

Since the major political changes in the region during the 1990s, changes have been made to the systems for allocation of land tenure rights in order to increase security. However, these changes have often been overridden by the State in order to pursue economic interests.

In Brazil there are approximately 410,000 indigenous people making up 2.2% of the population but occupying over 12.5% of the country (Stocks 2005). The 1988 constitution gives indigenous peoples' land rights precedence over other land rights (Stocks 2005). The state respects these indigenous lands, although they are held in 'trust' status (Stocks 2005). However, demarcation of indigenous land following the new constitution was slow and contested, leaving lands open to invasion and exploitation (Stocks 2005).

Colombia underwent constitutional change in the early 1990s including decentralisation and new land regimes (Stocks 2005). Indigenous lands were protected under colonial law and this protection has been maintained (Stocks 2005). However the situation allows for private property to exist alongside communal property which is often seen as risking social stratification (Stocks 2005). Many also see that, by making the indigenous territories part of the state political apparatus, indigenous leaders are rendered less active due to the associated bureaucracy and procedures (Stocks 2005).

In Bolivia, constitutional changes of the early 1990s allowed indigenous people, who make up nearly 50% the population, to lay claim to original community lands (Stocks 2005). A total of nearly 20 million ha were designated in the following years, which suffer from invasions and governance issues (Stocks 2005).

In Ecuador, agrarian reforms in the 1960s and 1970s brought an influx of colonists to forested areas, ignoring ancestral claims and classifying large areas of land as unsettled (Holland 2014). The 1990s saw numerous shifts in policy, overall focusing on expansion of oil claims often at the expense of indigenous lands (Holland 2014). A new constitution in 2008 changed this, defining indigenous land tenure and assigning legal rights to indigenous people over more than half of Ecuador's forest land (Holland 2014). Indigenous land territories are currently recognised as communally held and cannot be sold (Holland 2014). To obtain a title can take a long time and be expensive, and are often contested, providing a prime opportunity for invasion of the lands and conversion of forests in order to establish a claim (Holland 2014).

In Peru, land tenure law has fluctuated over the past years, with 1974 seeing a law passed that gave legal recognition to "Native Communities", allowing them forest and subsurface rights (Stocks 2005). However, as multi-communal territories were not permitted, communities were often spatially distinct leaving large gaps to be occupied by invading loggers (Stocks 2005). This law was replaced in 1978, revoking ownership of forests and subsurface resources for all subsequent community titling, and giving the state the right to construct infrastructure without consultation (Stocks 2005). In 2000, there were still 139 pending Native Community titles, 300 more that were not in the process, and expansion applications for 85% of already-titled communities (Stocks 2005). Peru's 1993 law reasserted the state's overall control and ownership of natural resources, allowing huge expansion of the extractive industries (Dean 2002 in Stocks 2005).

The historically insecure land tenure rights in the region as detailed above are widely acknowledged to be a cause of the failure of many conservation initiatives.

Socio Bosque ('Forest Shareholder') is a Payments for Ecosystem Services scheme in Ecuador, providing an incentive to landowners in possession of a legal land title and who agree to conserve native ecosystems for 20 years (Schoegel 2012). Less than 0.75% of the total area participating in the scheme is in the Rio Paute Basin despite extensive outreach and a large number of applications (Schoegel 2012). The main limiting factor has been the requirement of having a land title in order to enrol (Schoegel 2012). Many forests in the Rio Paute Basin have been disqualified, largely due to land titling irregularities (Schoegel 2012). These irregularities arise from inconsistencies and contradictions in legal frameworks implemented since the 1960s, the absence of an efficient mechanism for land legalisation and also the presence of conflicts due to overlapping land titles (Schoegel 2012). Contracts are allocated based on threat level, environmental service provision and also, at a lower weighting, poverty (Schoegel 2012).

Lastarria-Cornhiel *et al.* 2012 draw a number of lessons from the scheme based on a case study from the Ecuador -Colombia border:

- The importance of resolving conflicting claims to land, despite the challenges presented by this.
- The importance of involving local communities in the delineating of indigenous areas.
- Capacity within state institutions is required to enforce land tenure rights and to prevent the invasion of allocated areas by neighbouring groups.

7.5 DATA AND INFORMATION GAPS

The production of this report has brought to light a number of data and information gaps.

The most important, in terms of gaining a comprehensive overview of the impacts of commodity developments on the WA region, is the lack of information or data pertaining specifically to the MacArthur-defined region. This is largely due to the fact that the WA Region is not an administrative region, nor does it correspond entirely with any other geographically or ecologically delineated area, such as a biodiversity hotspot. Information available in published literature does not relate to the region as a whole, and conclusions have had to be drawn based on country-level studies, data and other literature that do not directly address the MacArthur Foundation study region.

Particular subject areas also proved problematic in terms of gathering information even at the country level.

There was little specific information on areas devoted to growing crops for biofuels or quantities of crops grown. This is largely because most of the crops used to produce biofuels are also grown for food, such as sugar cane or soya and there is little or no data or information that distinguishes between these two end uses, hindering understanding of trends in this commodity.

Information on fisheries was also lacking, in particular region-specific information on the impacts of both freshwater capture fisheries and aquaculture. While some figures are available on the status and trends of fisheries in the region, there were very few examples of the impacts of this commodity development in the region, and no overall evaluations.

Domestic water use is another subject area where it is recognised that very little information is available on the availability of water and water requirements and there is no clear information on the impacts of increased domestic water use (Roa Garcia and Brown 2009). Domestic water use is however, likely to be an important area given the high or even total dependence of many rapidly growing cities, not to mention rural populations, on water originating in Andean rivers.

There is also very little information available on tourism, at the regional, national or even sub-national level. This dearth of information is evident both in terms of status and trends in number of visitors and in the impacts of these visitors, despite widespread recognition of the important impacts of mass tourism on specific sites such as Machu Picchu in Peru.

These information gaps, even at the country level, suggest the importance of further research into specific areas in order to quantify and better understand the status, trends and impacts of commodity development on this vulnerable region.

8. Conclusions

The exceptional biodiversity of the Andes and the vastly important ecosystem services they provide to the wider region are under pressure from rapid developments driven by natural resource-based economic growth policies.

The impacts of traditionally less damaging activities such as small-scale agriculture, NTFP collection and selective logging are increasing due to increased access to markets and commercialization. At the same time, large scale agriculture, in particular for biofuels, hydropower development and extractive industries are expanding and intensifying.

Protected areas are increasing but they are often not able to withstand the pressure from commodity developments driven by strong economic interests: concessions for extractive industries are sometimes allocated within their boundaries. Most ecosystem services, however, originate outside protected areas, but environmental laws and policies to protect them or mitigate impacts are often inadequate and enforcement of existing laws is weak.

Initiatives addressing some of the pressures identified here already exist in the region, including through local projects by various conservation organisations. For example, the Critical Ecosystem Partnership Fund (CEPF) is working In Peru and Bolivia (Vilcabamba-Amboró Corridor) and in Colombia and Ecuador (Chocó Manabí Conservation Corridor), on strengthening transboundary collaboration, including for protected area management, and the environmental legal and policy frameworks. They have also supported the expansion of protected areas within these two corridors. Such initiatives need to be expanded, preferably up-scaled, but especially coordinated within the wider WA region. Building on the needs already identified by the CEPF, this review proposes the following actions for the WA region as a whole:

- Support mechanisms for watershed level land use planning and transboundary collaboration on the development of extractives.
- Strengthen the legal status of protected areas and support transboundary protected area management.
- Improve EIA processes including monitoring of impacts to better include downstream and longer term impacts. Increase the environmental standards for investment and strengthen control mechanisms.
- Influence the policies of donors, investors, operators and other key actors to adopt higher standards regarding environmental and social impacts.
- Support the implementation of MEAs in particular in relation to the threats from commodity developments.
- Support devolution of rights on land and resources to local communities and strengthen their capacity for sustainable management in the face of external pressures.
- Generally strengthen national and regional environmental policy and legal frameworks and processes.

National governments are responsible for higher-level environmental policy and legal frameworks, including those surrounding watershed planning, improving transboundary collaboration, EIAs and monitoring and MEA implementation. Whereas civil society can play a strong role in promoting environmentally sustainable policies and government of investor accountability, as well as the devolution of rights to local communities. Further, national and international civil society organisations and donors should work together to support and strengthen government processes and capacity to address the adverse impacts of commodity development on biodiversity and ecosystem services within the region.

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