Biodiversity and Ecosystem Services in Monquentiva, Colombia

– a case study of conservation

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Abstract: In the Eastern Andean mountain range in Colombia there is an ongoing project with the aim of preserving important conservation values such as water resources and biodiversity. In the light of climate change and increased land use there is a pressing need of managing remaining natural habitats and the services they provide in the Colombian Andes. As part of a conservation corridor around the city of Bogotá, the proposed protected area of Monquentiva could increase the connectivity and resilience of the remaining ecosystems in the area. The Millennium Ecosystem Assessment states the importance of ecosystems and biodiversity for the provisioning of ecosystem services and as a prerequisite for human wellbeing. From a sustainable development point of view the assessment was used as a basis for a paradigm analysis of conservation values. The main question of the paper is how the protection of an area can incorporate both biodiversity and ecosystem services at the lowest cost possible. The conclusion is that a combination of biodiversity and ecosystem services for more cost efficient conservation strategies is desired. It could bring an increased focus on economical benefits and increase the willingness of decision makers to increase protection of important areas. Intrinsic value and cultural services could be complementing for conservation implementation. For the area of Monquentiva, the willingness of the landowners to participate and contribute with available means seem promising for future ecosystem management.

Key words: Ecosystem services, biodiversity, Millennium Ecosystem Assessment, sustainable development, protected area

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Summary: Ecosystems are important parts of our daily life. They provide us with goods and services such as food and resilience and protection against climate change. The many different ecosystems in the world are the cornerstones of our way of living. The building blocks of ecosystems stated as the biological richness or biodiversity are an important factor for our well-being as we are an integral part of the system. The increased notion of the need to protect nature and its ecosystems for a sustainable development and our future human well-being has brought forward intense research and conservation projects all over the world.

In the Eastern Andean Mountains in Colombia there is an ongoing conservation project with the aim of protecting ecosystem services and biodiversity for a future sustainable development of the region. Private and public organizations and local stakeholders are all involved in the process of creating a conservation corridor around the city of Bogotá. Protected areas will make up the green parts of the corridor that are aimed for harnessing wildlife and keeping viable ecosystems. As one of these protected areas to be, the Páramo of Monquentiva is said to help connect important natural landscapes and function as a safe haven for species in the area such as the spectacled bear (Tremarctos ornatus). The protection of the area could also conserve essential ecosystem services such as fresh water and help prevent natural disasters connected to land use changes. The main question of the case study is how the protection of an area can include both biodiversity and ecosystem services at the lowest cost possible.

The thesis follows the Millennium Ecosystem Assessment which was initiated by the former UN Secretary Kofi Annan to assess the state of the world’s ecosystem and bring consensus for future research and possible actions to counter current and future problems considering ecosystems and their services. The Conceptual framework that was developed has been used as a guideline for the discussions in the paper. Along with the framework other theories and paradigms have been used such as the precautionary principle and the ecosystem approach that speak of caution before action and humans as an integral part of the environment. A holistic analysis was made that shed light on the most important values that need to be preserved in the study area of Monquentiva.

The conservation of ecosystems and their services are vital for a sustainable development and increased human well-being. For a holistic view of environmental problems one need to include all factors that have an impact on each specific case as there are no simple overall solutions. Social and economical aspects are just as important as the environmental aspects when it comes to conservation and protection of ecosystems. In the continuing process of conservation in Monquentiva there are still obstacles that need to be overcome. The decision of protection depends on the governmental willingness to invest in the future of the Andean highlands and the land-owners’ participation and contribution towards conservation.

Key words: Ecosystem services, biodiversity, Millennium Ecosystem Assessment, sustainable development, protected area

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IV
1 Introduction

High up in the Andean mountains, work is being made towards conserving areas of importance for essential services such as water supply and disaster prevention. The project is supposed to increase the connectivity and help prevent further fragmentation in the region. The páramo of Monquentiva is in the middle of the process of becoming a protected area and become a part of the conservation corridor Chingaza – Sumapaz – Cerros Orientales – Páramo de Guerrero in the Eastern Andes in Colombia.

Published in 2005 the Millennium Ecosystem Assessment has worked with questions on ecosystems and human well being. It presents a wide concept and a framework for future studies in environmental studies and development. It states the importance of protecting ecosystems and their services and puts an intrinsic value to nature and the biodiversity that constitutes the life on earth. As part of the assessment the concept of sustainable development is included and brings a holistic view to the discussion.

The paper will bring clarity of the main concepts of the assessment and further discuss aspects connected to the case study of Monquentiva such as ecosystem services and biodiversity. The future of conservation strategies through the managements of protected areas and the roles of corridors in reducing consequences of land use changes and climate change will be discussed. By increasing connectivity and decreasing fragmentation a greater resilience could be reached.

1.1 Aim and Problem formulation

Following the Millennium Ecosystem Assessment (Millennium Ecosystem Assessment 2005) I will analyze connections and tradeoffs between ecosystem services and biodiversity and how they are bound to sustainable development and conservation. The aim of the case study is to investigate how the two factors of biodiversity and ecosystem services overlap on a spatial basis for a more cost efficient conservation strategy. As a means for analyzing the concepts of ecosystem services and biodiversity focus will be put on Monquentiva, Colombia, an area that is currently under investigation to become a protected area. Weightings for a holistic analysis will be decided through discussions and a paradigm analysis following utilitarian and non-utilitarian values based on principles of human preference satisfaction and intrinsic values.

Problem formulation: How can the protection of an area incorporate both biodiversity and ecosystem services at the lowest cost possible and in the light of a sustainable development?

2 Background

Climate change mitigation and conservation efforts are closely related to ecosystem management and services. One way to manage ecosystems is to create conservation corridors which connect fragmented areas that contain high biodiversity and merit intense protection for that reason (Meyer et al. 2000). Correctly implemented, corridors can prevent destruction of ecosystems, enable dispersal of plants and animals, provide clean water downstream, be a location of forest plantations-, and sustainable agricultural management (Bennett 1998, 2003).

The Chingaza – Sumapaz – Cerros Orientales – Páramo de Guerrero conservation corridor, along the Eastern Andean mountain range in Colombia (See fig.3, Appendix 2), is presumed to counter impacts such as habitat reduction and fragmentation, and enable plants and animals to disperse between areas. The aim is to create ecosystems with greater resilience against anthropogenic, ecological and climatic changes and to secure future water resources (Conservation International (CI) unpublished¹). This is being implemented by maximizing inclusion and representation of biodiversity and ecosystem services within protected areas (PAs) at the lowest cost possible (CI and SDA 2010). If the project is successful in protecting the ecosystems in the area, it would not only secure water availability in the region, it could also bring an increased ecotourism and development around sustainable management.

In Bogotá, Colombia, measures are being taken to preserve natural highland forests and moorlands that are especially important for the headwaters in the area (CI unpublished²). Around the city of Bogotá there are four
larger natural areas that will be connected through a conservation corridor; Sumapaz and Chingaza National parks, Cerros Orientales and the Páramo de Guerrero (See figure 2 in Appendix 2). The conservation corridor will be created mainly by increasing the extent of protected areas in the area. The conservation corridor incorporates many stakeholders including private companies, non-governmental organizations (NGO) and governmental bodies. The two major contributors to the project are Conservation International in Colombia (CI), an NGO with a stated focus on responsible and sustainable care for nature and the wellbeing of humanity, and Acueducto, a private utility company supplying water and sewage systems for the Bogotá area. The conservation corridor mainly is a response to a simultaneously growing scarcity and necessity mainly of water resources as the capital region is in great need of sustainable management of freshwater (CI unpublished¹, Bryan 2008, Ruiz et al. 2008).

2.1 Biodiversity and Protected Areas

Conservation corridors stem from the theory of island biogeography (Bennett 1998, 2003) where it is predicted that species diversity as well as abundance is dependent of the area of an island. Another prediction is that island isolation directly affects species diversity by reducing migration rates (Burns et al. 2010). In the case of corridors, fragmented areas represent islands in the landscape and by connecting these through pathways of similar habitat a larger area will be achieved that will give positive effects on diversity as predicted by the theory (Bennett 1998, 2003). In the corridor Chingaza – Sumapaz – Cerros Orientales – Páramo de Guerrero, there are 116 protected areas ranging in size between 55 ha to approximately 126 000 ha consisting of páramos (high altitude moorland), forests and shrub land that constitute 36% of the corridor area (Conservation international unpublished²). They function as nodes or “islands” in the corridor and represent important habitats for the species in the area. There are currently five areas within the scope of preservation in the corridor that need further studies in order to be considered as protected areas. For these areas many factors need to be considered for them to be stated as protected areas under national guidelines as well as the categories in the management guidelines of the International Union for the Conservation of Nature (IUCN) (Dudley 2008) and indirectly the Millennium Ecosystem Assessment (MA 2005). As mentioned earlier I will focus on the area of Monquentiva as one of the five areas considered for conservation with the framework of the Millennium Ecosystem Assessment as a guideline for the case study.

2.2 Ecosystem services and conservation

Other factors for declaring a protected area that are becoming more important within conservation and resource management are ecosystem services. The issue of incorporating these services into conservation has been dealt with in various ways such as the frameworks created by the Millennium Ecosystem Assessment (MA) called for by the former UN secretary Kofi Annan in 2000, or the Economics of Ecosystems and Biodiversity (TEEB) hosted by the United Nations Environment Programme (UNEP) and supported by the European commission, Germany, the United Kingdom, Netherlands, Norway, Sweden and Japan (TEEB 2010). In Europe, the RUBICODE project was funded by the European Commission and the Sixth Framework Programme as a way of looking into the implications and costs for biodiversity loss by evaluating the specific components that provide valuable services for society (RUBICODE 2010). The list of organizations, conventions and frameworks concerned with the concept of ecosystem services is long and still growing. Different evaluations and projects bring different problems and one could discuss the implementation of only national or international guidelines. My aim in this report is not to make a comparison of each framework. I will instead focus on the before mentioned Millennium Ecosystem Assessment. It will provide a basis for discussion and further bring insights for the holistic analysis conducted as a case study of the area of Monquentiva, Colombia.

3 Conservation for the future

Long-term conservation management and effects of development are important for a sustainable future. We are all dependent on the ecologic, social and economic factors of life. In an attempt to assess the services used on a daily basis and that are needed for human well-being, the Millennium Ecosystem Assessment conducted a vast project that brought together knowledge and consensus in difficult questions about future conservation and sustainable development especially considering ecosystem services and biodiversity (MA Synthesis 2005, Carpenter et al. 2008). Previous efforts in conservation management and attempts to decrease ongoing losses of biodiversity have so far failed to bring overall positive effects (Rands et al. 2011). Problems connected to conservation include monetary issues and the willingness of stakeholders such as governments and organizations to act on long-term management decisions. Drivers of change such as land use, land cover and climate change
have increased during the past decades and radical changes are called for within management and functional frameworks (MA Conceptual framework 2005).

-What does the future have in store? There are a number of questions that need to be dealt with and just as with ecological studies and classic conservation analysis research, the implementation gap will have to be overcome in order for sought after disciplinary changes to take place. According to the MA (Synthesis 2005) approximately 60% of the ecosystem services studied in the assessment is considered to be degraded or used in an unsustainable way, including for example fresh water, capture fisheries, purification of air and water, and regulation of services such as climate, natural hazards and pests. One of the findings of the assessment also states that the diversity of life on earth has and continues to be significantly and often irreversibly changed with biodiversity loss represented to a large extent. It is also stated that anthropogenic climate change may grow to become the dominant driver of biodiversity loss, and changes in ecosystems globally (MA Synthesis 2005).

3.1 Theories

As stated earlier, the Millennium Ecosystem Assessment was brought forward by the former UN secretary in order to increase the knowledge base and improve decision making and analyzing around ecosystems. Conventions involved in the program include the Convention on Biological Diversity, the Convention to Combat Desertification, the Convention on Migratory Species, and The Ramsar Convention on Wetlands. The underlying goal is to help achieve the United Nations Millennium Development Goals but also to carry out the Plan of Implementation of the 2002 World Summit on Sustainable Development (MA Conceptual framework 2005).

Research in the area of human health and environment is constantly expanding and with the greater need for scientifically based information, the MA has pushed development forward and created opportunities and enhancement for the contribution of ecosystems and their services to human well-being. In spite of recent progress there are still a number of barriers that need to be dealt with. There are questions about frameworks and methods and especially of following up after implementation of projects for future improvement and evaluation (Carpenter 2008). The notion of adding ecosystem services into conservation management is a rather recent development and therefore one needs to expect certain degrees of speculation in decision making concerning the subject.

While the MA includes a number of Conventions and organizations it also follows the ecosystem approach, as the concept provides a strategy and framework for analyzing and working with connections between people and the environment. It takes into account that humans and the culture they represent are an integral part of many ecosystems. The CBD for example states in the assessment that the ecosystem approach brings out an integrated management of land, water, and living resources that promotes conservation and sustainable use in an equitable way (MA Synthesis 2005).

As important as considering humans as an integral part of ecosystems the MA framework states the importance of acknowledging the limits of information and human understanding and the consequences that might follow certain plans of action. Anticipatory models such as the precautionary principle that is proposed to protect humans and the environment against uncertain risks of human action is mentioned. Instead of implementing post-damage control it may be less costly and more sustainable to consider a pre-damage control of risks, especially since many actions may lead to irreversible changes. (MA Conceptual framework 2005, UNESCO 2005) Apart from considering the holistic and precautionary viewpoints around the MA, economic factors around environment and conservation such as least-cost principles have been implemented by CI throughout the projects concerning Monquentiva and the conservation corridor Chingaza - Sumapaz – Cerros Orientales – Páramo de Guerrero (CI and SDA 2010 unpublished).

3.1.1 The Conceptual Framework

The foundation of the MA is to put the main focus on human well-being but also to consider intrinsic value while assessing ecosystems and their services. The range of ecosystems is wide and encompasses natural systems, mixed landscapes and agricultural land as well as urban areas which are also the focus in the conservation corridor Chingaza – Sumapaz – Cerros Orientales – Páramo de Guerrero. Considering the interactions between people and ecosystems a multi-scale approach is needed for assessment and decision making in order to encompass situations and associated problems. One of the main points of the framework is as mentioned ecosystems and their services but the core question of human well-being, including the reduction of poverty, is also deeply based in the assessment. The MA (Conceptual framework 2005) structures human wellbeing and how it is affected by ecosystem changes by pointing at five important questions which are,
security, access to basic material for a good life, health, social relations and freedom of choice and action. All of these parameters may be enhanced by a greater protection and sustainable use of ecosystems and their services.

Ecosystems are affected by many factors and the most significant ones are by the MA (Conceptual framework 2005) stated as drivers of change. These may affect different systems either directly or indirectly and there may be ways of influencing such drivers from a decision maker’s point of view. Examples of direct drivers are changes in local land use and cover, species introduction or removal and climate change. For the indirect drivers there are among others demographic, economic and sociopolitical factors affecting ecosystems (MA Conceptual framework 2005). A common factor for all drivers is that they are all in constant transformation just as the environment they affect. As mentioned earlier a direct factor such as climate change has experienced large changes the past few decades. Considering shifting economic situations worldwide there are also obvious difficulties in predicting future scenarios and conducting research based on old assumptions.

There are many dimensions that need to be considered according to the MA (Conceptual framework 2005). With such complex issues as ecosystems and changing drivers, cross-scale interaction is called for in the assessment. In order to encompass all aspects, considerations for variations of temporal and spatial scales need to be taken. There are consequences for all types of development even if they are based on short term changes, local scale or long term large scale basis. Impacts may not be noticed from start, but years later when countering actions may not be effective or functioning. There are many examples of changes in ecosystem services that may be overlooked in a too narrow scope and the largest of all may perhaps be the effects of climate change. (MA Conceptual framework 2005)

In Colombia, the past years have brought extensive floods and disasters due to extreme weather but also in some cases because of changes in land use and water regulation that reduce the natural flow of water (Rodríguez and Botero 2010). The Colombian climate is highly regulated by the El Niño/Southern Oscillation (ENSO), and since 2010 the country has been in the cold phase or “La Niña” with increased rainfall and following disasters such as floods and landslides as a result (Poveda and Alvarez 2011). Implications for human health and well-being are large in some areas in the country and hundreds of people have been injured or died as a result of heavy rains. In total more than 3 million people have been affected directly or indirectly as agriculture and important community services such as infrastructure, water provision and health facilities have been damaged (Barajas and González 2011). Previous damages to ecosystems and the country’s rich but sensitive diversity have weakened nature’s buffering capacities to extreme events and further worsened the situation.

3.1. 2 Values and ways of going forward

When it comes to conservation one must put together many different factors. Interdisciplinary work is a necessity for the holistic viewpoints that permeate the aim of many conservation and sustainability strategies.

The two important paradigms considered in the framework are different in many ways even though they may overlap on occasion. They are both used in decision-making but often in conflicting manners. The Utilitarian or anthropocentric paradigm states that ecosystems in a sense provide value to people. The concept is divided into direct or indirect “use values” that provide a certain utility to people but also “non-use values” with examples such as cultural values, that are merely valued but not used as are other services. The non – utilitarian value paradigm or intrinsic value, is something that can be of value in and for itself not taking into account its value for someone else (MA Conceptual Framework 2005).

There are many different methodologies for utilitarian values that may quantify services and bring understanding. However, the knowledge is largely spread, where some services provide more information and others are more complex and require different approaches. For intrinsic values there are ethics and cultural aspects involved which proves even more difficult when it comes to decision-making in development strategies concerning ecosystems (MA Conceptual Framework 2005). As mentioned earlier the two paradigms of utilitarian and intrinsic value often collide. The question is what principle weighs the most in every given situation when it comes to the value of conversion or the value of conservation.

The MA states that these particular issues are often decided on a political level and to a lesser extent as economic decisions. Considering a developing country such as Colombia and environmental management one might question the strength in political actions working for improving ecosystems and their services. Economic short-term factors may sometimes prove a stronger incentive for development with environmental and long-term consequences as secondary factors.
There are many considerations in multidisciplinary work on ecosystems, with different types of inputs on global or local scales, sometimes with considerable biases involved. This also includes temporal and geographic data as well as the type of data collected. A map can be many things depending on the information needed. It may be difficult to see possible connections and relationships between drivers or services with available information. Data for certain resources may also be more readily available than for other resources, especially biodiversity is seen as a data deficient resource surrounded with speculations and assumptions. There is also the fact that there are more and better available data from industrial countries than from many developing countries. With a lack of information and data the use of indicators and models may provide a sufficient substitute that can provide certain estimates. Consequences for certain actions may be estimated as well as those consequences that might come from climate change through integrated models and also those that bring more holistic conclusions for many changing services or drivers. According to the MA (Conceptual framework 2005), what must be included in any assessment are traditional and local knowledge that may bring value and information to the process. Most important is critical assessment of any information that might be of use for decision-making of any kind.

The Millennium Ecosystem Assessment not only aims to bring information and improve decision-making towards being more interdisciplinary and holistic. It also aims to spread knowledge and bring education and investment where it is needed. With a natural limited understanding of ecosystem dynamics, learning from previous situations and being aware of changes is vital. The MA points to the importance of risk assessments and precaution, since viable ecosystems and our dependence of them are a necessity for human well-being and a sustainable development (MA Conceptual Framework 2005).

The future for Bogotá and its surroundings including the area of Monquentiva with a growing population and greater need for development is unclear. Drivers such as climate change with possible water scarcity as a consequence may pose large problems to the district. A city that in other aspects have worked with and improved its sustainability approach on an urban cultural basis could do the same considering the environment (Dalsgaard 2009). Hopefully this change will spread to surrounding areas and bring holistic and sustainable changes to the whole region and also to a larger extent considering environmental aspects.

4 Biodiversity and ecosystem services

The Millennium Ecosystem Assessment states that biodiversity contributes extensively to many components of human well-being. It is seen both as a resource and a service since it is the building element to all that we rely on. Biodiversity is specified as the variety of genes, species and ecosystems and it is the factor that constitutes life on earth. According to Rands et al. (2010), as a significant part of the system we depend on, biodiversity should be represented as a global public good to sustain a higher level of management and protection.

Many and varying are the attempts to conserve and protect this valuable asset but on a global scale there is still a marked decrease in biodiversity. Pressures are increasing as anthropogenic environmental impacts increase. The most pressing drivers apart from climate change are as mentioned overexploitation of species, invasive alien species, pollution and degradation and destruction of habitats (Butchart et al. 2010, Rands et al. 2010). The current rate of biodiversity loss is alarmingly high at around 100 times the background rate at the lowest. Species are not only disappearing, it is also a question of global homogenization of species as a consequence of invasive species that are moved around the globe (MA biodiversity synthesis 2005). On a smaller scale and most probably due to changes in climate, the distribution of species is changing with both negative and positive implications.

The focus of biodiversity conservation has changed over the years formerly concentrating on single species. To an extent this is still the case with large and iconic species such as the giant panda (Ailuropoda melanoleuca), the tiger (Panthera tigris) and in the case of Colombia the spectacled bear (Tremarctos ornatus) (Cantillo et al. unpublished). A conservation focus has also been put on a larger scale as with ecosystem and habitat protection and biodiversity hotspots (Myers et al. 2000). The latest wide spread addition to biodiversity conservation are the ecosystem services that are created by ecosystems, but perhaps with a more comprehensible value. Rands et al. (2010) points to the importance of incorporating biodiversity conservation into public and private decision-making and creating an interest such as that given to the use of carbon and the following climate change. There is a need for a “cultural” change around biodiversity and its implications. As stated by the MA there should also be a focus on intrinsic value and not only on the benefits that are presented to us by nature.

The many types of ecosystem services can be divided into different groups depending on their use and functions. The MA (Conceptual framework 2005) made a classification with four groups: supporting, regulating, provisioning and cultural services. The supporting services such as primary production, nutrient cycling and
production of oxygen are of vital importance since they make all the other services available. Regulating services are the services that bring us direct benefits including water purification, climate, and disaster and disease regulation among others. One of the groups, provisioning services, is readily affected and often manipulated to bring more benefits and incorporates services such as fresh water, food, wood and fibers. The last group represents cultural services such as aesthetic, spiritual and recreational services.

Ecosystems need to be kept intact or at least managed in a sustainable way. Bennett et al. (2009) state the importance of multi-management of ecosystem services as there are often antagonistic or synergistic relationships among ecosystems and their services. A particular service may bring large benefits to human society and well-being and at the same time decrease or degrade another service. Such services are often managed on short term basis when taking into account future benefits and implications. Large scale agricultural production or water regulation such as dam systems for energy production and irrigation may create future damages and unsustainable use of resources reducing biodiversity and natural ecosystems. Some of the problems concerning ecosystems and their services are the values related to them as well as the costs. Some services are marketed and are thus easier to manage than the ones that are not. There might also be a bias towards marketed services since they bring benefits to the economic market. Tradeoffs between economic interests and ecosystem protection are difficult considerations and need to be dealt with. Degradation and misuse of ecosystems are bringing high costs to society and will only grow if preemptive measures are not taken (MA Biodiversity Synthesis 2005).

Restoration as a means of sustainable management is one option brought forward by Birch et al. (2010) in situations where it is possible and the systems or services are not too heavily degraded. They also conclude that passive restoration is the least expensive option in their particular case but that more research and follow up is needed for management of restoration projects. One study made in the case study area of Monquentiva, concluded the importance of restoration and that a number of conditions need to be considered in restoration projects (Diaz-Santamaria and Torres-Torres 2001). However, an important aspect brought forward by Cantillo et al. (unpublished) is the time scale perspective. There might be increased difficulties in reforestation projects with native species as the soil characteristics change with amount of disturbances to the area, thus natural or passive restoration may not be feasible.

5 Protected areas

The International Union for Conservation of Nature (IUCN) defines a protected area as a “clearly defined geographical space, recognized, dedicated and managed, through legal or other effective means, to achieve the long term conservation of nature with associated ecosystem services and cultural values” (IUCN 2010). There are over 160 000 protected areas worldwide and they provide many benefits for ecosystems as effective tools of conservation (Rands et al. 2010). They are presented as giving protection to biological diversity, delivering ecosystem services and bringing protection from natural disasters. They are said to conserve cultural values, tourism and education but also to bring important benefits to economies (IUCN 2010).

The IUCN (2011) have divided protected areas into six different categories based on their management objectives. The first category is divided in two where strict nature reserves and wilderness areas bring the highest protection and are aimed for biodiversity conservation and preservation of natural character. The second category, national parks, is set to conserve ecological processes. The remaining four categories presented there are; natural monument or feature, habitat/ species management area, protected landscape/ seascape and at last protected area with sustainable use of natural resources.

Protected areas are seen as very important to conservation management but there are many questions concerning their effectiveness (Hockings 2003, Eken et al. 2004, Chape et al. 2005, Rands et al. 2010). Eken et al. (2004) points out the gap problem in protected area management. They state that current systems when it comes to protected areas lack systematic conservation designs and that they are not effective in including sensitive species. Species with low density over wide areas and colonially nesting species are especially sensitive. According to Rands et al. (2010) up to 20% of the known threatened vertebrates are not included in current protected areas. In some cases there are resource problems and insufficient management. There is also the need for larger scale conservation that encompasses environmental, ecological and evolutionary processes keeping functional ecosystems and their services (Eken et al. 2004).

In a review made by Chape et al. (2005) it is concluded that there are several mismatches in protected area management. Identified conservation priorities for certain countries and regions sometimes do not match the area
establishment in question and in many cases there are severe threats to management actions, especially in the
tropics. Problems concerning the extent of protected areas are surroundings that may isolate and create damaging
fragmentation as well as conversion and degradation of the ecology through land cover changes or over use of
services provided. They further conclude that there is no current method of indicating conservation effectiveness
of protected areas.

Within protected area management there are many different categories and aims, both national and international,
apart from the ones stated by IUCN. Chape et al. (2005) state that there are over 1000 different terms used in
conservation management for protected areas around the world. In Colombia, a recent clarification on protected
areas has been developed by CI, Colombia and Fundación Biocómbia (Vasquez and Serrano 2009). Some
differences in, for example, categories and management are presented as well as similarities between the
international and national frameworks. As stated by Vasquez and Serrano (2009), at the time being there is no
legal rule or standard that requires and develops the concept of protected area management in Colombia. There
are however 14 different management categories that correspond to the ones presented by the IUCN. Apart from
these 14 categories there are others that do not suit the descriptions of a protected area. The most elaborate
category as described by the IUCN, a strict nature reserve, does not seem to have a parallel in the Colombian
system. The fifth category, protected landscape/ seascape, found a possible equivalent in “Vía Parque” as the
most suitable option (Vasquez and Serrano 2009).

Considering the criticism that is posed against the management of protected areas, the discussion of what should
be called a protected area is highly relevant. Could it be a random area not intended for any productive use that
happens to have some value for biodiversity and ecosystems, or should it be given a more precise term for a
biologically rich area that is protected with the specific aim of conservation (Dudley 2008)? If the management
of protected areas would follow the first suggestion, it could lead to bias towards areas with poor soil quality
and/or areas that are difficult to reach. Another important aspect of protected area management discussed by
Armenteras et al. (2003) is their legal protection status. As could also be relevant for the area of Monquentiva
and the other protected areas and parks in the corridor Chingaza-Sumapaz-Guerrero is that despite protection
there are often levels of human intervention in many areas dedicated to conservation. Armenteras et al. (2003)
concluded that out of eleven parks that were analyzed, seven of them showed human land use changes with
different degrees of degradation that had been performed after the declarations of area protection.

6 Corridors and Fragmentation

Preserved or produced corridors are seen as a response to habitat destruction, fragmentation and isolation in
human dominated landscapes. Natural areas that could be suitable for protection are becoming scarcer as
managed landscapes are becoming more common. As mentioned earlier the concept of conservation corridors
stems from the island biogeographical theory where it is predicted that species diversity as well as abundance are
dependent on the area of an island. Since many of the natural areas left in land conversions have inadequate sizes
for the conservation of biodiversity and ecosystem services, corridors are seen as a suitable tool for connecting
or linking such natural patches (Bennett 2003). However, there is much controversy surrounding the concept of
corridors as a solution to increased fragmentation (Beier and Noss 1998, Bennett 2003, Chetkiwicz et al. 2006).

There are many different types of corridors integrating conservation management in a variety of ways, such as
biological, ecological, sustainable use and conservation corridors as with the case of Monquentiva and the
Chingaza-Sumapaz-Guerrero corridor. They are all focused on conservation management and biodiversity
protection on different levels but also in some cases with the addition of sociopolitical and economical values
(CI and SDA unpublished). The general notion of corridors is that they are varying both in size and shape. They
may be linear habitats linking natural patches together in a continuous manner, or shaped in other configurations
such as stepping stones, or habitat mosaics. Other models are larger and encompassing regional issues such as
landscape linkages (Bennett 2003). The design of corridors include everything from artificial tunnels and
underpasses helping animals to counter barriers such as roads and railways as well as green passages and natural
forests (Bennett 2003) There are also cases of corridors that are aimed for urban recreation and human needs that
have lesser impacts for biological conservation such as parks and green ways.

As previously addressed, corridors and their management are surrounded by much controversy as there are many
considerations linked to corridors as a conservation tool. One issue often mentioned is the general focus on
binary landscapes instead of actual distribution and mobility patterns of targeted species and processes
(Chetkiwicz et al. 2006, Rouget et al. 2006). For corridors to be efficient one needs to study and include
movement patterns and behaviors such as resource selection and habitat selection. All of these factors show and
determine how animals move across the landscape and would be invaluable for corridor implementation. Many of the references mentioned are concerned with vertebrates and invertebrates although there are also several studies of the dispersion of flora and fungi. Among others, Chetkiwicz et al. (2006) are open to studies and evaluations that might bring more objective and holistic approaches to the management of corridors.

Apart from the considerations that should be integrated into corridor planning there are further problems that need to be dealt with for a sustainable and effective management (Bennett 2003, Chetkiwicz et al. 2006). In many cases there is a general lack of scientific data for the above discussed considerations. The linkages that would be most suitable for the conservation aims are often based on weak data and loose predictions. Corridors are seen as an appealing practical tool, easy to apply in situations where changes in land use are apparent or ongoing with increased need for protection of remaining natural habitat, particularly with regard to climate change and future range shifts (Bennett 2003, Gilbert-Norton et al. 2009). Badly implemented designs and placement may lead to severe consequences as with the case in Canmore, Alberta and the wandering grizzly bear (Ursus arctos) where ultimately a young woman was killed (Chetkiwicz et al. 2006). Better management is needed with structural and behavioral elements for analyzing and decision-making. Another factor that is pointed out by Chetkiwicz et al. (2006) is the time scales that could prove positive or negative outcomes for corridor management. There are few examples where studies have been made through the whole process of habitat change from the first disturbance to the following fragmented landscape. And even if such components would be added into scientific studies there would be years and centuries before any conclusive results could be presented. In many cases a time lag has also been shown considering the loss of biodiversity in fragmented areas supposed for conservation, and as with many other tools in conservation management there is a general need for prediction and scenario planning (Bennett 2003). Bennett points out the importance of evidence on efficiency or possible negative effects from corridors such as decreased population viability, colonization and gene flow. Corridors could in the worst case scenarios become sinks for populations and thus work against previous goals and assumptions of positive outcomes.

As one of the main problems and reasons for coining the term and concept of corridors, fragmentation is a widespread and negative consequence of land use changes. It is generally described as a situation where connected vegetation is cleared in such a way that it leaves multiple smaller fractions of vegetation that are no longer in contact with each other. This transformation often leads to a reduction and loss of habitat and gradually to increased isolation of the fractions or patches in the landscape (Bennett 2003). One important comment on fragmentation is that it is not always that easy to detect. The most obvious pattern is the patchy landscape as seen from above but in cases of largely managed land in forestry or energy production and plantations there is also a form of fragmentation. Thus, the main issue concerning fragmentation is the isolation and loss of species which is often connected to changes in species composition, as invasive species take over matrix areas and intrude on patches. Such radical land changes may lead to disturbances in ecological processes involving both flora and fauna. (Bennett 2003)

But all does not seem to be negative when it comes to corridors and fragmentation (Rouget et al. 2006, Gilbert-Norton et al. 2009). Studies with well founded information based on systematic planning principles may prove effective in identifying suitable areas for protection aside from decisions based on expert judgment or distribution of single species protection (Rouget et al. 2006). In a large scale study with the aim of capturing key biological processes and biodiversity under the concept of irreplaceability, Rouget et al. (2006) managed to incorporate all targets into several corridors. The study was compared with a simpler model considering river buffers in the area and overachieved on every level apart from the goal of vegetation types. By avoiding areas in conflict with future land use pressures, the systematic approach was also slightly more cost effective, which is often an imperative factor in conservation planning and management. Gilbert-Norton et al. (2009) found in a review that corridors increase movement between fragmented habitats by approximately 50% in contrast to areas without connections. With this said they were careful to conclude that the results does not point to an increased population viability in connected habitats, adding that long term studies are needed if evidence is to be shown.

7 Conservation and sustainable development

One of the definitions of sustainable development as given in the declaration Our Common Future (1987) or the Brundtland report, is “[...] development that meets the needs of the present without compromising the ability of the future to meet their own needs” (Brundtland 1987, p. 43) As a short version of a complex issue one may still evaluate this description from a number of perspectives. Although the fairness and equity of inter-generational resource allocation does not give the whole picture of sustainable development, it constitutes a large part of the concept. Meeting people’s needs on an intra-generational scale should be the first step to a sustainable
development (Jabareen 2008). In general, the Brundtland report aimed at changing destructive development and spreading the idea of sustainable economic, environmental protection and social equity by focusing on poverty reduction and a limited amount of resources available through the environment. Sachs (1999) mentions the powerful image of the blue planet as the notion of the finiteness of life on earth and the message it gives towards a sustainable development.

The three pillars of sustainable development are strongly connected to the interdisciplinary work of today’s conservation management. The broad definitions of the concept bring, however, complexity and competition among interests and political agendas. Jabareen (2008) mentions the issue of the “ethical paradox” where sustainability, largely directed from ecology, and development often represents highly different methods and goals and end up being conflicting in many decision making processes. Generally, the conflicting disciplines of ecology and development, so often represented as economic growth may be brought together, creating a different kind of progress. However, human needs are still the main focus of sustainable development and the three pillars are far from being equal in size in today’s management and decision-making (Jabareen 2008). Hopefully there will be a larger focus on the sustainability of environmental questions such as climate change and land degradation.

Economic aspects of biodiversity and ecosystem services are important for a sustainable development. Without economic incentives, natural systems would have less protection in the anthropocentric and market dominated society of today. Intrinsic value is an important factor to conservation but it is not strong enough in itself to protect the areas needed for viable ecosystems. Stenmark (2007), who talks about the values of sustainable development, points to “the man-apart-from-nature view” the “view of unlimited natural resources” and the “view of nature’s robustness” (p. 39) to have been revised towards modern environmental and ecological views. By recognizing that humans are an integrated part of vulnerable ecosystems and that in fact there are limits to natural resources, a new holistic ethics has been reached. However, the focus is still on the well being of humans with the environment as a means to reach the goal. Thus, even if concern has been put on nature and its intrinsic value the statements that have been made are considered weak and difficult to interpret (Stenmark 2007).

Coming back to the economic aspects of nature and sustainability, Liu et al. (2010) bring forward the value of protecting what is often said to be “invaluable” or “priceless” and point out the importance of economically valuing ecosystems and their services such as through Ecosystem Services Valuation (ESV). One of many assessing tools that provide monitoring compares and evaluates natural capital in a wide sense against conflicting resources and overall changes (Liu et al. 2010). Including ecosystems and their services into economic models is somewhat of a complex thing since they are case sensitive and need strategic solutions. They also need to be of interdisciplinary manner and incorporate spatial as well as temporal scales as stated by the MA. Short term models that do not include appropriate precautionary principles and post-implementation assessments often fail to support a sustainable development. It is possible to add ecosystems and biodiversity in economic models as there are many examples of working with such services and connecting them to the economic market (Mäler et al. 2008, Liu et al. 2010).

As with the Millennium Ecosystem Assessment there are many who bring forward human well being as an indicator of sustainable development and viable ecosystems for the future including the Brundtland report among others that speak of poverty reduction and equality (Brundtland 1987, MA 2005, Sachs and Reid 2006, Mäler et al. 2008). The dimension of equity and social questions concerning sustainable development are diverse and in constant change. Vallance et al. (2011) intend to clarify the “conceptual chaos” (p.342) that has evolved over the years. The general notion of social sustainability encompasses important aspects such as the distribution of power and resources and the existence of basic services including infrastructure, employment and education. Freedom, justice and influence in decision-making are also important for a social sustainability and it is clear from the previously mentioned conceptual framework that the MA includes mostly the same elemental social necessities. Further there are other social aspects considering sustainable development mainly related to urban development and the willingness to act and change towards sustainability as well as social capital and cohesion (Vallance et al. 2011).

Independent of the extent of development or country, one concern brought forward by the Brundtland report (1987) is the driver where people only actively begin to address environmental concerns when their basic needs are met. This should not come as a surprise as they must have more pressing and personal day to day problems of sustaining their own survival and development. Vallance et al. (2011) concludes that a large extent of sustainable technology lies beyond the boundaries of poverty and need to be dealt with in a more equitable way. Considering the social dimension there need to be sufficient conditions to support an ecological sustainability.
In Colombia, being one of the world’s most diversity and resource rich countries, there is a wide need for development and the question of sustainable development is pressing. Cerón et al. (2008) discuss the possibilities for biodiversity driven economic growth and concludes that substantial investigations are needed. Such investigations are needed not only to find possible ways of extracting natural material for economic gains through national and multinational companies, but also to explore products and values that are integral for the country itself. They point out the importance of state influence and open processes with equal allocation of yields and distribution among local communities. Above all, resources should be made available for independent academic ecological and social investigations in order to measure and identify key areas for conservation or strong sustainable development in order to counter possible exploitation for economic growth.

Toro et al. (2010) highlights the fact that more than half of Colombia’s natural vegetation cover has been transformed by human activities over the years. Recent changes in priority have led the government to focus more attention on environmental problems and implementing programs for recovery and conservation. As previously discussed there are questions about the effectiveness of such actions as with the management of protected areas. Still there are several guidelines and tools linked to environmental regulation in Colombia such as the Natural Resources Code of 1974, political constitutions, laws and decrees as well as international treaties and conventions, the United Nations Conference on Human Environment and the Convention on Biological Diversity among others (Toro et al. 2010). Toro et al. (2010) conclude that there are important problems that need to be dealt with considering Colombian environmental management such as limits to legal measures and administrative support as well as deficit follow up and control mechanisms.

8 Case study – Monquentiva

“Páramo” of Monquentiva was chosen for the study since it was in the process of becoming a protected area within the larger project of the Conservation corridor Chingaza – Sumapaz – Cerros Orientales – Páramo de Guerrero. The area is situated in the municipality of Guatavita and covers three “veredas” or sub-divisional departments of the municipality: Monquentiva, which forms the major part of the study area, Amoladero and Juiquín. It also partially covers the departments of Carbonera Alta, Potrero Largo, Guandita and Corales (Alvarado Camacho unpublished). As mentioned in the introduction the aim of the corridor is to create ecosystems with greater resilience against anthropogenic, ecological and climatic changes and to secure future water resources (Conservation International unpublished). By implementing protection of the areas and aiming for resilient ecosystems, their services and the unique biodiversity they harbour will hopefully be preserved.

8.1 Materials and methods

Field work was carried out in Monquentiva (X=1035190, Y= 1041311 N, X=1035043, Y= 1025112 S, X=1043670, Y=1037522 E, X=1027710, Y=1031662 W) municipality of Guatavita north east of the city of Bogotá, Colombia (See Appendix 2). The “páramo” of Monquentiva has a total area of 14,141.7 ha and is located at an altitude of 2800-3400 m a.s.l. (Camacho unpublished). The area was visited on two occasions while conducting ground truthing and reconnaissance of the area, and attending a workshop with landowners. Most of the work was conducted at the Conservation International office in Bogotá. ArcGIS 10.0 (Geographical Information System) was used for the holistic analysis. Weightings were obtained through discussions and a paradigm analysis considering utilitarian and non-utilitarian values based on principles of human preference satisfaction and intrinsic values. During the field work a GPS (Garmin GPS 60) was used to point out visited sites and general important areas for the project. As part of my project I attended two workshops concerning the area in question. The first workshop, conducted at the office in Bogotá and involving experts from each discipline within the study, was aimed to create a better understanding and to pinpoint strategic areas important for the environment such as biodiversity, geology and ecology. The second workshop was conducted towards the end of the project integrating landowners in order to get their point of view as stakeholders. Apart from the information gathered during my field visit, data for the case study analysis were kindly provided by Conservation International Colombia. For further information I used relevant articles and literature.

1 Ref. system: MAGNA_Colombia_Bogotá
8.2 General state of and pressures on conservation

According to direct observations and conclusions made by Rodriguez (CI unpublished), there are many similarities between the departments of Guatavita as most include different types of agriculture and production management but also natural vegetation to varying extents. The most common practices are potato cultivation and livestock production, primarily for dairy production. Management types and development of mechanisms and technical methods for agriculture and dairy production are highly variable with many farms being underdeveloped and using unsustainable methods. In some cases there is also a resistance towards change and development of technical methods but there are many who aim for development and more effective and sustainable management. Several of the farms have well managed livestock production, good techniques and improved breeds, especially around Monquentiva, Potrero Largo and Carbonera Alta. This is due in part to the extensive initiative by the dairy farmers in Monquentiva who created a cooperative in order to improve management and profitability. Those connected to the cooperative have substantially improved their living and social standards (Carta Fedegan Unknown date, PNUD Unknown date).

There is an ongoing expansion in some areas of the agricultural productions into natural vegetation such as high Andean forests, páramo and sub-páramo. On some farms grazing practice and cultivations reach high up along the hillsides often causing weakness in soil structure and increased risk of landslides. In an informative study made by the Colombian Institute of Geology and Mining (Ingeominas unpublished) concerning disaster prevention, an evaluation was made of the major landslides and flooding in Monquentiva in the spring of 2005. The landslides occurred in the higher parts of the department and caused much damage to the area. The main bridge and the aqueduct were damaged and a local aquaculture farm was destroyed. The near 200,000 trout killed in the event generated pollution and bad odors in the area due to decomposition (Ingeominas unpublished). Recommendations for prevention and minimization of negative effects were made for the area.

In many departments there is an extensive use of agricultural chemicals such as fertilizers and pesticides which pollute the surrounding environment. Protective measures towards leakage and pollution are minor if existing and there is a need for improvement (Rodriguez CI unpublished). There is a lack of sustainable methods of irrigation and general water use, and in many areas the utilization of private hoses connected to district water supply is not reported and therefore illegal. The water supply systems are also in many cases underdeveloped and in need of upgrading. Several properties in each department have inconclusive successional ownership and many have been taken over by the municipality and are now aimed towards conservation. Privately owned properties often vary considerably in size and management, and production aims from small scale farming to larger scale cultivation or dairy production. There is frequent use of hedges with native or exotic species such as alder, pine and other fast growing plants to demarcate land (Rodriguez CI unpublished).

There is substantial natural and well preserved vegetation within the study area of Monquentiva. As much as 75% (Alvarado Camacho unpublished, p. 58) is stated as natural habitat which brings good conditions for biodiversity and ecosystem service protection. Large properties managed by the municipality have as previously mentioned been dedicated towards conservation and many areas show signs of recuperation. The biodiversity is rich in the area and in Juiquin and Monquentiva there are reports of sightings of foxes, deer and species described as threatened on the IUCN’s redlist such as the spectacled bear (Tremarctos ornatus) and the large rodent “el tinajo” (Agouti taczanowskii) (Rodriguez CI Unpublished). Due to the large areas of native vegetation and preserved ecosystems there are possibilities of contemplation and eco-tourism that could bring positive opportunities for the departments. However, careful management and control is needed to avoid damages to the environment and cultural traditions (Rodriguez CI Unpublished).

8.3 Forest plantations and possible implications

Apart from the natural habitats there are several forest plantations in the study area, with Mexican pine tree (Pinus patula) as the dominating species, especially in the sub-department of Monquentiva and Amoladero. They were planted around 15 years ago to secure soil stability by the Regional Autonomous Corporation (CAR) responsible for the management and protection of environmental resources of the department. According to personal observations and Rodriguez (CI unpublished), management is deficient and native species are re-inhabiting the area. There are also apparent difficulties for commercial use of the imported pine tree. Pinus patula as an exotic species has strong negative effects on diversity and native species composition (Cavelier and Tobler 1998, Van Wesenbeeck et al. 2003). Several studies point to the fact that it is generally known that planting of pines in areas dominated by shrubs and lower vegetation may considerably change habitat conditions and put pressure on sensitive species. As a result there is a decrease in species richness when soil characteristics and available light change due to the cover from the pines and the chemical footprint of the litter (Cavelier and
including conservation of water resources. Implementing integrated management of agriculture and conservation may be a difficult task, especially when considering the conclusions of Robineau, Roa-Garcia and the ratification of law 99 (1993) the discussion of such as water were brought forward with an increased protection of strategic ecosystems such as páramos. Protected areas and the conservation of resources such as water are known for their richness of amphibian species that are said to be sensitive towards climate induced changes. Increased temperatures may create more favorable environments for disease agents such as fungi that can heavily affect many species of amphibians. As stated by the MA (Synthesis 2005), a greater resilience of ecosystems and biodiversity could antagonize possible negative effects of climate change in the Andean regions of Colombia. Creating protected areas such as Monquentiva may be essential for future possibilities and the protection of ecosystem services and biodiversity.

8.4 Important ecosystems

The Andean ecosystems are some of the most species rich ecosystems in the world with high rates of endemism and they bring important services such as water regulation, disaster prevention and not to mention aesthetic services (Etter and Villa 2000). There is a diversity of threats to the Andean systems with agriculture, livestock production, mining, non-native forest plantations and uncontrolled tourism. As one of the most important drivers of change as mentioned by the MA (Conceptual framework 2005), climate change is also predicted to have a large effect on the Andean ecosystems. Expected outcomes are drier and warmer climate with rises in temperature for the Andean Mountains ranging between 2 and 3 °C. Such changes often lead to range shifts and a general movement of animals to higher locations to better suit their needs (Bush et al. 2011). Species with low adaptability and restricted means of movement may suffer extinctions as a consequence. The Andean ecosystems are known for their richness of amphibian species that are said to be sensitive towards climate induced changes. Increased temperatures may create more favorable environments for disease agents such as fungi that can heavily affect many species of amphibians. As stated by the MA (Synthesis 2005), a greater resilience of ecosystems and biodiversity could antagonize possible negative effects of climate change in the Andean regions of Colombia. Creating protected areas such as Monquentiva may be essential for future possibilities and the protection of ecosystem services and biodiversity.

High altitudinal moorlands and grasslands, or with the more common name páramos, are especially important as sources for headwaters in the capital area. They are also sensitive to anthropogenic disturbances and in the face of climate change the need of protection has become apparent (Alberto-Ortiz and Reyes Bonilla 2009). The study area of Monquentiva is considered to be highly important for the water supply and current management aims towards conservation and sustainability (Rodriguez CI unpublished). However, Robineau et al. (2010) bring forward the idea of integrating farming and páramo conservation in order to avoid re-settlement of farmers currently living in areas that are up for protection. They discuss the possibility of improving technical farming methods, decreasing the extensive use of chemicals and fertilizers, and more efficient land use keeping slots of natural vegetation within the farm to increase connectivity. Above all, they highlight the growing problem of increasing commercial potato cultivation as a means for rotation and renewal of pastures. Larger areas are being cultivated and more chemicals are used in the process, polluting water resources. The focus of the study made by Robineau et al. (2010) was on farming and biodiversity conservation and thus failed to incorporate the highly relevant and important question of land use and water regulation often mentioned in the context of páramos. Roa-Garcia et al. (2011) point the discussion forward and mention the terrestrial element of the water cycle in a study conducted in the Andean mountains of Colombia. They conclude that there are negative impacts of land use changes, such as cattle grazing, which may lead to increased runoff, soil instability increasing the risk of land slides, and decreased resilience to dry seasons considering water flow.

To protect these environments there are laws and regulations and as with the aims of the conservation corridor Chingaza – Sumapaz – Cerros Orientales – Páramo de Guerrero, the ratification of the law 99 in 1993 gave way for an increased protection of natural resources and biodiversity (Alberto-Ortiz and Reyes Bonilla 2009, Robineau et al. 2010). Law 99 states the importance of a sustainable development with inclusion of the principle and a general reinforcement of Colombia’s environmental law. Protected areas and the conservation of resources such as water were brought forward with an increased protection of strategic ecosystems such as páramos. Considering the conclusions of Robineau, Roa-Garcia and the ratification of law 99 (1993) the discussion of implementing integrated management of agriculture and conservation may be a difficult task, especially when including conservation of water resources.
8.5 Implementation of a protected area – Workshops and reflections

The MA states that “.../ the management of any particular ecosystem must be tailored to the particular characteristics of that ecosystem and to the demands placed on it” (MA synthesis 2005, p. preface VIII). Holistic thinking and multidisciplinary management through the whole working process are just as important as cross-scale interactions over temporal and spatial ranges. For a project to be successful it needs to incorporate all concerned stakeholders, expertise and available information (MA synthesis 2005). Through open and objective processes decisions will be made on cooperative and participatory basis (Robineau et al. 2010). In the case of Monquentiva, CI Colombia and Acueducto, a private utility company in Bogotá, are the prime initiators of the project with the Regional Autonomous Corporation (CAR) as the main decision making authority. Throughout the project, reports have been written by involved experts from numerous disciplines such as geology, biology and social sciences. Several synthesis proposals were then brought forward to the project stakeholders as a way of integrating local knowledge and professional guidance and expertise.

As stated in the Materials and Methods section two workshops were attended in the planning process of the proposed protected area of Monquentiva. The initial workshop was held at the CI office in Bogotá where the disciplinary experts presented their work and came together in discussions over the conservation values of the study area. An overall SWOT analysis\(^2\) was made and physical aspects such as geology, hydrology, biology and climate were discussed. Further debates were concentrated on biotic aspects, such as ecosystems and species, and social, cultural and economical aspects among others to bring about a holistic conclusion. One large and final part of the workshop was the use of large scale maps of the “páramo” of Monquentiva and matching transparencies where one could indicate areas of special importance. The conclusions from the workshop were then summarized for the second and essential workshop in the community of Guatavita where the landowners were presented with the proposal and able to speak their mind and give suggestions on the proposed protected area as stakeholders. Just as with at the previous workshop, large maps of the area had been printed out with necessary information and the landowners were equipped with markers and transparencies where they could mark areas of conflict and/or where they agreed on the proposed plan. This mostly led to lines being pushed back on the map but the area could also on some occasions be expanded in favor of protected land.

A number of important issues were brought to light during the second workshop such as land use changes, ownership of properties and mining. The landowners, mostly farmers talked about their rights and concerns, especially considering the selling of land to private prospecting companies but also to the government and municipality. The option is to weigh the possibilities of having to relocate due to the protected area against future probabilities of being relocated due to mining or other activities considered as public interests. In such a case they seemed eager to prevent further mining in the area and were thus positive towards conservation as long as it would be well managed and not left without proper management as the old \textit{Pinus} plantations. There were also discussions about the transparency of the project and their role as stakeholders; would the responsible decision makers actually consider their point of view and were there any catches to the proposal?

Where to draw the line and what to preserve is the question. On one hand there is the need to sustain a living for the farmer in the area, and on the other hand the general public interests in the conservation of biodiversity and ecosystem services such as the supply of water and resilience to climate change and disasters. In order to customize and facilitate this decision an analysis was made combining the most important conservation values with the aim of achieving simultaneous conservation of possibly conflicting factors. Conclusions from the workshops and expert knowledge were taken into account in the identification of values and costs used in the analysis.

8.6 Holistic analysis

The Holistic analysis will focus on the importance of biodiversity and ecosystem services and the potential of complementing or adding value to conservation practices. The question that needs answering is how the factors overlap for a more cost efficient conservation strategy. In the case of Monquentiva aside from biodiversity a number of ecosystem services were chosen.

\(^2\) A SWOT analysis is an analytic tool mainly for organizations and their environment. It is the first stage of planning and helps to set the focus on key issues. SWOT stands for strengths, weaknesses, opportunities, and threats. Strengths and weaknesses are internal factors. Opportunities and threats are external factors (http://www.marketingteacher.com/lesson-store/lesson-swot.html visited 2012-02-19)
Described by the MA as the “life on earth” (Conceptual framework 2005 p. 29) biodiversity is a provider of many ecosystem services both directly and indirectly. It is also of importance to state the intrinsic value of living species that sets above the general anthropocentric values. For the analysis, the biodiversity factor is a collection of a number of attributes. It is a combination of species distribution considering both geographic and specific division. Three distribution groups were identified according to an initial assessment of the entire conservation corridor and consist of species endemic to the area, rare species and the overall richness of species in the area.

The second part of the analysis is the one incorporating ecosystem services. As mentioned earlier there are many different services connected to ecosystems, such as provisioning, regulating, supporting and cultural services (MA Conceptual framework 2005) and considering the area of Monquentiva a number of important services can be identified. The location of the area and the different types of habitats such as páramos, forest and shrub lands are highly important contributors to the regulation and generation of freshwater for both local and regional needs as provisioning and regulating services. Thus, factors such as hydrology, geology and drainage are important to consider for the analysis. Looking at the geology of Monquentiva, another aspect of importance are areas with sensitive bedrock and soils that are prone to erosion. In order to avoid future natural disasters, such as landslides, it is evident that measures need to be taken in high risk areas with erosion sensitive soils and extensive land use activities conserving regulating services such as disaster prevention. Another important factor to the study area and the notion about human-well-being are cultural values or services. There are large parts of natural habitat in the area and one could predict a possible interest from a tourism perspective. The area also has a rich history with legends and a wide indigenous heritage. Well managed eco-tourism could be a way of development for Monquentiva in the future. Aspects in need of consideration are the willingness of stakeholders in the area to open up for tourism and the accessibility of the area in terms of infrastructure such as roads and transportation.

8.6.1 Values and Assessment

A number of ecosystem services with connecting attributes were chosen for the holistic analysis. They are considered important for the area in question. The analysis will evaluate the services chosen and the importance of each attribute to enhance decision making for future conservation management of Monquentiva. Each attribute will be given weights of importance. With the relatively scarce knowledge of certain aspects there will have to be an amount of speculation included in the analysis. In order to validate these weights a paradigm assessment will be conducted over the attributes connected to biodiversity and the ecosystem services included. The assessment will include both general conclusions and direct reflections considering the area of study. The attended workshops will be used as guides of expert knowledge and interest of local stakeholders in the case of Monquentiva.

8.6.2 Objective

The objective of the assessment is to bring understanding and validation of the weights connected to the attributes in the GIS analysis. The attributes are intended to show sites that are important for the conservation values chosen for the study. The main conservation values are ecosystem services and biodiversity in the Monquentiva study area.

8.6.3 Water resources

There are important ecosystems for water regulation and supply in Monquentiva. Páramos and Andean forests contribute to the steady flow of freshwater and are important climate regulators with drought resistant attributes as they retain water. The area has a large proportion of natural habitats (75%), with a relatively high precipitation range, 500 mm in the north to 2000 mm in the south. The evapotranspiration is between 900 and 1000 mm/ year (Alvarado Camacho unpublished). The three factors chosen for the analysis are necessary for a clear understanding of the water regulation of the area. Hydrology as a factor brings information about the general movement, distribution and quality of water while geology and drainage are important for the soil properties and resilience towards dry periods and retained water flow. Equal importance has been placed on the different factors as it is highly complicated to determine which of them that could possibly have a greater impact on the service. However, they are all important for the analysis. The weightings were decided after discussions with personnel who had insights in the project.

As an anthropocentric value it is clear that water resources are of great importance for human welfare and contributes largely to the well-being and future development of the area in question. Considering the general state of the area with illegal water collecting, non-sustainable usage and underdeveloped collecting systems there
is a need for better management and protective measures of the regulating service, especially in the light of drivers such as climate change and the possibility of longer periods of drought or heavy rainfall.

8.6.4 Biodiversity and species distribution

The new holistic ethics of sustainable development discussed by Stenmark (2007) seem to have been well adopted by the MA in sharing the idea that human well-being is the goal of development, and environmental policies. However, the notion that ecosystems and biodiversity are recognized as having intrinsic value has been clarified, perhaps since the assessment is mostly directed towards environmental issues. It stretches further than the practical notion of the anthropocentric values of the much appreciated services that are given from the two concepts of “holistic ethics” and “intrinsic value”. Merely considering intrinsic value as grounds for biodiversity conservation seems to be inadequate in some cases. Thus, other factors need to be considered, such as direct values or a combination of biodiversity conservation and the conservation of marketed resources as in this case, hopefully increasing the willingness to pay for such management. As opposed to the other attributes in the analysis where information produced especially for the area of Monquentiva was used, the factor of biodiversity was given from the main information produced for the entire corridor Chingaza – Sumapaz – Cerros Orientales – Páramo de Guerrero. However, this is simply in respect to the actual map produced and not the background information for discussion since further studies have been performed in the area (Cantillo et al. unpublished).

For the analysis, the factor of biodiversity is a collection of a number of attributes. It is a combination of species distribution considering both geographic and specific division. Three distribution groups were identified according to an initial assessment of the entire conservation corridor and consist of species endemic to the area, rare species and the overall richness of species in the area. The valuation of the attributes was made from the perspective of importance and resilience towards extinction. Therefore a higher value was given to endemic and rare species in comparison to the overall richness. One could of course debate over the importance of richness to ecosystem function or equal intrinsic value for all species but in this case the factor and attributes were determined through discussions with personnel who had insights in the project.

Considering the area of Monquentiva and the general state of biodiversity there are many positive opportunities to act upon with well preserved habitats and general species richness including species registered as threatened on the IUCN redlist, but perhaps the most important aspect is an increased knowledge and interest by the local communities in preserving the surrounding environment for future generations (Cantillo et al. unpublished).

8.6.5 Disaster prevention

The large areas of natural vegetation represent a stable resource considering disaster prevention, but as previously described there are areas prone to erosion and landslides in Monquentiva. Such disaster events are foremost linked to lithology, general climate conditions and slope, although there are also other factors that contribute to soil instability. Just as with water resources, the climate is one of the strongest factors driving soil related disasters. The intensity of rainfall and temperature differences may strongly affect natural processes. Together with land use factors including agricultural management and other practices that lead to structural land and soil changes, climate factors may lead to increased erosion and instability. (Alvarado Camacho unpublished) The attributes of landslide sensitivity and land use were chosen for the analysis with the guidance of responsible and knowledgeable experts. With the same reasons as with the attributes of water resources, an equal valuation was given to the two factors.

As a general public interest and regulating service according to the MA (Conceptual framework 2005), disaster prevention is an important part of the holistic analysis. As a means of security management, care should be taken in areas especially prone to erosion, especially considering the current expansions of agriculture and dairy production. Regeneration of degraded land may reduce some risk factors; however, such actions should be carefully planned and analyzed on long-term basis. The current forest plantations in the area of Monquentiva show possible implications of poorly managed arrangements.

8.6.6 Aesthetic services – Eco tourism and natural areas

The non-material benefits that are given through ecosystems are defined by the MA (Conceptual framework 2005) as cultural services. Aesthetic values are considered ever so important for human and social well-being. Due to the large parts of native vegetation and preserved habitat in the study area there are obvious values of aesthetic appreciation and recreation. As mentioned earlier there are possibilities of contemplation and eco-tourism that could bring positive opportunities for the departments. Rodriguez (unpublished) brings forward the
need of careful management and control to avoid damages to the environment and cultural traditions. Special areas of importance are natural areas in the sub-department of Juiquin with rivers and watersheds with scenery and waterfalls that could offer possibilities of contemplation and eco-tourism. In the sub-department of Monquentiva there is also the area of “Pantano de Martos”, a large marsh with considerable recuperation that may also be a suitable place for eco-tourism since there are observation points and roads connecting to the area. The mountain area surrounding the marsh is well preserved with high Andean forest patches (Rodriguez unpublished). Apart from the value of natural habitat in the area there are historical aspects of prehispanic and colonial periods such as trade-routes, sites for religious activities and rituals performed by the Muiscas connected to natural elements in the area (Sguerra et al. unpublished).

Expanding the notion of tourism in the study area is not done easily and there need to be an overall willingness from the people living in the area. During the second workshop, concerns were brought forward whether it could become a disturbance in their day to day work and bring substantial changes to their livelihoods, positive as much as negative. Other aspects are the accessibility and transportation means of the area. For a sustainable tourism to take place the location of the area is relatively important. However, with the absence of suitable data, aesthetic and cultural services could not be directly included in the model. As it is still an important factor for the area, a separate map will show the distribution of important areas for culture and accessibility in the area of Monquentiva (See fig. 1).

8.6.7 Results

By combining the different factors of ecosystem services and biodiversity one may predict areas of special and integral importance for a holistic view of the conservation values of Monquentiva (See fig. 1 and 2). The area of Monquentiva is shown in a grey scale where the lighter color represents high importance. In the lighter areas all of the above mentioned ecosystem services as well as biodiversity and species distribution have a high importance. These lighter areas are mostly found on higher plateaus and areas that are fairly unexploited. Darker areas on the other hand have a higher rate of exploitation and contribute with less ecosystem services. One could also imagine a lower species diversity and distribution in the darker areas.

The attributes used for the analysis are connected to the four different conservation values and further divided into ten variable groups as shown in table 1 in Appendix 1. All the variables are represented as layers of geographical data within each conservation value. The weights of importance given to each attribute in the holistic analysis created a basis for the geographical analysis. The conservation values were all given the same weighted value while the connecting variables were weighted differently to fit local conditions. The weightings were all based on the paradigm assessment, local knowledge and responsible and knowledgeable experts.

The most cost efficient and effective conservation measures could be directed towards the areas where the conservation values coincide, i.e. the areas of greatest importance. The produced maps should be seen and used as guidance in the planning process towards a protected area and not as a definite answer. As previously stated maps may cause bias towards the factors chosen to be shown. The correctness of the map will greatly depend on the information the analysis is based on.
Figure 1. Holistic analysis of Monquentiva showing cultural values and accessibility to natural areas of aesthetic importance. Boberg, C. 2012. Department of Earth Sciences, Uppsala University. With courtesy of Conservation International considering the data for the cultural values.

Figure 2. Holistic analysis of Monquentiva showing coinciding conservation values with light colors representing high coincidence (Legend scale in percentage). Boberg, C. 2012. Department of Earth Sciences, Uppsala University.
9 Discussion and conclusion

Looking into the future and considering the importance of ecosystems and what would be the possible implications of further degradation of the Andean natural forests and páramos, there is a need for action. With their role as climate regulators and supporters of ecosystem services necessary for the region there could be drastic consequences if care is not taken and suitable management is not implemented. I believe that the Millennium Ecosystem Assessment poses important questions and bring clarity in many aspects considering ecosystems and human well being. It puts emphasis on the most pressing matters such as biodiversity loss, degradation of ecosystems and their services and growing influence of many direct drivers such as climate change and land use changes. The indirect drivers such as sociopolitical and cultural drivers are highly relevant for the area of Monquentiva and for Colombia as a whole. Positive and cooperative stakeholders and decision makers could make all the difference.

For sustainable development as a concept to permeate all stages of problem formulation, working process, decision making and management, a shift is needed in the way we perceive our living environment and its surroundings. The new ethics of sustainable development including nature, intrinsic value and future generations is important for this shift and understanding of the systems that we are an integrated part of. Despite the acknowledgement of intrinsic value the focus is primarily on humans and their well being, and the goal of reaching this basic need is also supposed to include the protection and conservation of the environment. Hopefully the goal will be pursued and the prediction correct.

By including ecosystem services into conservation management there has been an increased focus on the economical benefits of preserving the environment. This seems like a positive development as more areas might be considered for protection as the environment is more tightly connected to the markets and the economic system that is dependent on its resources. However, the intrinsic value of nature and cultural and aesthetic values cannot be forgotten in the process. The network of protected areas is growing larger and larger but the question of effectiveness and management remains as a problem for future conservation practices. The protection of important conservation values need to be improved and strengthened as long as it does not develop in a way that could interfere with human rights and basic well being. In the case of Monquentiva there is good potential of the protection of conservation values as there are large parts of preserved natural habitat and areas in recuperation. The willingness of the landowners to contribute with available means seem promising and the final part of the process now lies in the hands of the decision making authorities. If declared as a protected area the páramo of Monquentiva could help to improve the connectivity in the corridor Chingaza – Sumapaz – Cerros Orientales – Páramo de Guerrero with decreased fragmentation as a result.

A combination of biodiversity and ecosystem services for more cost efficient conservation strategies is desired but there are negative aspects to consider when important biodiversity values and ecosystem services do not coincide. Here intrinsic value and cultural and aesthetic values could be complementing if there otherwise is a lack of willingness to preserve. The implementation of the precautionary principle in decision making processes needs to improve in the light of the sensitivity of ecosystems. It is becoming more and more apparent that failing to protect our ecosystems could become more expensive than the actual costs of protection. This understanding brings hope to the conservation for the future and the generations to come.

Acknowledgements

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**APPENDIX 1.**

Table 1. Holistic analysis with specification of conservation factors, variables and attributes. Boberg, C. 2012. Department of Earth Sciences, Uppsala University.

<table>
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Recreation, culture (easy access)

With an absence of suitable data, aesthetic services could not be directly included in the model. As it is still an important factor for the area, separate maps will show the distribution and accessibility.

Natural landscapes (attractive spots for bird watching, views etc.)
APPENDIX 2

Figure 3. Overview of the conservation corridor Chingaza – Sumapaz – Cerros Orientales – Páramo de Guerrero and the position of the study area of Monquentiva. With courtesy of Conservation International, Alvarado Camacho Unpublished.