Principles, Practices, and Challenges for Green Infrastructure Projects in Latin America

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DISCUSSION PAPER

No. IDB - DP - 250

November 2012

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2012

http://www.iadb.org

This discussion paper was prepared under the direction of the Environmental and Social Safeguards Unit (VPS/ESG) of the Inter-American Development Bank (IDB). ESG works to promote the environmental and social sustainability of Bank operations. It collaborates with project teams to execute the IDB's commitment of ensuring that each project is assessed, approved and monitored with due regard to environmental, social, health and safety aspects, and that all project – related impacts and risks are adequately mitigated or controlled. ESG also helps the Bank respond to emerging sustainability issues and opportunities.

This paper proposes a concept of green infrastructure, centered on a multi-level approach to infrastructure development that addresses these impacts. The paper argues that only multi-level solutions, encompassing national policy, sector planning, and sound project engineering, will be able to effectively minimize the impacts of infrastructure development on natural habitats by overcoming major limitations of the traditional project-by-project approach, thereby addressing the long-term impacts of infrastructure development in a more systematic manner.

This document was prepared under the supervision of Janine Ferretti, Chief of the Environmental and Social Safeguards Unit (VPS/ESG). The author was Juan David Quintero, consultant. Insightful inputs were provided by Graham Watkins, Environment Lead Specialist of the IDB. Editorial support was supervised and provided by Gabriela Infante.

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I. PROTECTING NATURAL HABITATS IN INFRASTRUCTURE PROJECTS

1. Background

The development of infrastructure projects can cause major direct, indirect, and cumulative impacts on natural habitats. Habitat fragmentation, increased poaching, land-use changes, and many other disturbances likely to result from infrastructure, especially road development, exert significant pressure on natural habitats (Davenport & Davenport, 2006; Seiler, 2001) and lead to impairment or loss of ecosystem functions.

While there is no shortage of attempts in infrastructure projects worldwide to ease the conflicts between development and habitat conservation, the fact remains that the loss of natural habitats due to infrastructure development has been increasing over the years. To date, traditional project-based mitigation approaches, which have been a common practice, addressing—often unsuccessfully—only direct impacts associated with individual projects, have proven insufficient to halt the long-term impacts of habitat fragmentation and biodiversity loss.

Based on an extensive review of infrastructure projects in Latin America spanning the past two decades, this paper proposes a concept of green infrastructure, centered on a multi-level approach to infrastructure development that addresses these impacts. The paper argues that only multi-level solutions, encompassing national policy, sector planning, and sound project engineering, will be able to effectively minimize the impacts of infrastructure development on natural habitats by overcoming major limitations of the traditional project-by-project approach, thereby addressing the long-term impacts of infrastructure development in a more systematic manner.

The impacts of infrastructure, especially roads, in various countries in Latin America illustrate the damage to natural habitats and biodiversity generated by these projects. The national road agency in Ecuador built a road in the Eastern region of the country which resulted in millions of deforested hectares in the Amazon region. In Brazil, roads forged through the Amazon are responsible for major deforestation and loss of biodiversity. Peru's Pacific region has also suffered from major erosion, deforestation, biodiversity loss, and the degradation of pre-Columbian archeological treasures due to the effects of road construction. A series of roads built in the 1960s through the Salamanca National Park on the Caribbean coast of Colombia interrupted natural drainage patterns between freshwater wetlands and the sea. This was exacerbated by intensive water use in the wetland watershed, resulting in the destruction of over 100,000 hectares of mangrove ecosystems within the Park.

This paper provides a menu of instruments for habitat conservation that have been put into practice in Latin American countries and proven to be effective, from government (international, national, sector plans and policies) to private/corporate initiatives (voluntary measures, financing, and project design and operations). At the national level, various regulatory policies, fiscal policies, and incentive programs can be applied to promote biodiversity-friendly infrastructure development. At the sector level, considerations for habitat conservation need to be explicitly included in infrastructure sector plans through biodiversity-inclusive strategic environmental assessments, in addition to effective stakeholder engagement, environmental management, and biodiversity offsets. Lastly, at the project level, there are a number of options in engineering design available to ensure that fragmentation, habitat loss, and other induced impacts are minimized. Implementing this framework will require strengthening the capacity of sector agencies to address natural habitat issues.

Finally, several common cross-cutting issues that are at the center of ensuring the implementation of this multi-level approach in Latin American countries are discussed. Project experiences shows that, because of the lack of political willingness or client capacity or both, mechanisms to ensure the inclusion of biodiversity concerns at all stages of lending operations are essential. These could include strong requirements in lending policies, and dedication of a sufficient budget to cover project cost and provide the supervision necessary to ensure that the steps are undertaken correctly. Through these measures, infrastructure development could be turned into opportunities for strategic conservation of natural habitats in Latin America.

2. Impacts of Infrastructure Projects on Natural Habitats

Direct and long-term impacts of infrastructure projects occur easily if habitat conservation activities are not undertaken systematically and strategically. This section begins with an overview of the direct and long-term impacts of infrastructure projects, with a focus on linear infrastructure. More often than not, these impacts are unsuccessfully addressed at the project level.

2.1 Direct Impacts

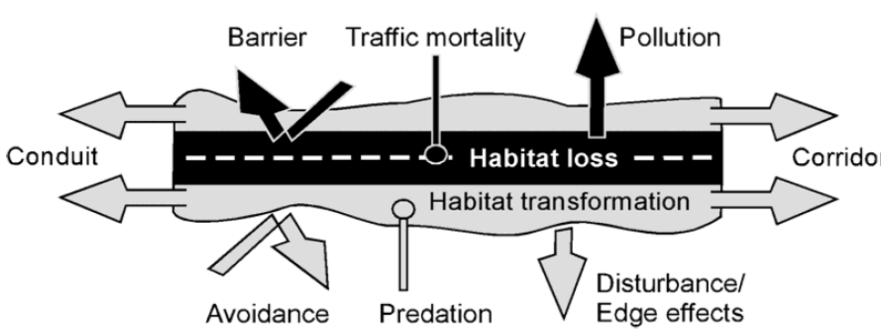
Direct impacts of infrastructure development pertain to the effects of the projects themselves and their associated infrastructure on natural habitats or species of conservation concern (Ledec & Posas, 2003). For instance, linear transportation infrastructures connect places and also act as barriers between adjacent spaces, splitting ecosystems into discrete and isolated patches and leading to habitat fragmentation, one of the major direct impacts of greenfield infrastructure development (Bekker & Iuell, 2004; Watson, 2005; Piepers et al., 2006). Dams and other water infrastructure create barriers to movement of aquatic species, while the damming itself floods terrestrial habitat by destroying a large area of habitat and killing everything that was there. Dams also bring about upstream and downstream hydrological changes, with potential significant impacts on fish and fisheries in the entire watershed through alteration of fish communities. In addition, road infrastructure associated with dam and mining development can also create barriers over an area larger than that occupied by the physical infrastructure itself, owing largely to disturbance and edge effects (Seiler, 2003).

In both the construction and operational phases, infrastructure projects cause a series of physical and chemical disturbances. These include: water quality and quantity changes in hydroelectric projects; erosion and siltation of streams, soil and water pollution in mining projects; and noise, vehicle movement, traffic lighting, sedimentation, soil erosion as well as environmental contamination by petroleum and other substances which trigger various physical and biotic changes on the verges of roads (Seiler, 2003). Opening up new corridors, exacerbated by poorly planned re-vegetation in affected areas along the right-of-ways can also introduce invasive species (Davenport & Davenport, 2006). These disturbances collectively result in biotope degradation along linear infrastructures (Seiler & Folkeson, 2006).

Impacts on natural habitats from road development are significant. The barrier effects of roads impair the connectivity between habitat patches and restrict faunal movements across landscapes, resulting in population fragmentation. Fragmentation can reduce the gene flow between members of a once contiguous population for both fauna and flora (e.g., migration for breeding, pollination) (Frankham et al., 2002). In extreme cases this can lead to local extinctions because populations become so subdivided they are unable to survive.

Population dispersal and genetic exchange of local fauna can be directly disrupted by: (a) road avoidance, and (b) animal-vehicle collision (Trombulak & Frissell, 2000). In the first case, some species avoid areas adjacent to roads due to the aforementioned biological, physical, and chemical disturbances (Jackson & Griffin, 2000; McGregor et al., 2008). Animal-vehicle collisions, which are also a traffic safety issue, occur frequently when the configuration of a road network blocks animals' migration routes or access to food or water. Collisions are another major direct human cause of fauna casualties in addition to hunting (Fahrig & Rytwinski, 2009; Forman & Alexander, 1998). The verges of roads can often serve a positive function, as they represent a new habitat type that acts as a corridor for wildlife (Iuell et al., 2003; Trocmé et al., 2003). These effects are illustrated in Figure 1. However, the same verges can also act as corridors for the movement of introduced species.

Figure 1. Primary Ecological Effects of Roads



Source: Seiler, 2001.

The range of adverse impacts on natural habitats that can result from hydroelectric dams is remarkably diverse. While some impacts occur only during construction, the most important impacts are usually due to the long-term existence and operation of the dam and reservoir. Other significant impacts on natural habitats can result from complementary public works such as access roads, power transmission lines, and quarries and borrow pits. Some reservoirs permanently flood extensive natural habitats, with local and even global extinctions of animal and plant species. Very large hydroelectric reservoirs in the tropics are especially likely to cause species extinctions (although such losses are only infrequently documented due to the lack of scientific data). Particularly hard-hit are riverine forests and other riparian ecosystems, which naturally occur only along rivers and streams. From a biodiversity conservation standpoint, terrestrial natural habitats lost to flooding are usually much more valuable than aquatic habitats created by the reservoir. The loss of terrestrial wildlife to drowning during reservoir filling is an inherent consequence of the flooding of terrestrial natural habitats.

Major downriver hydrological changes brought about by dams can destroy riparian ecosystems dependent on periodic natural flooding, exacerbate water pollution during low flow periods, and increase saltwater intrusion near river mouths. Reduced sediment and nutrient loads downriver of dams can increase river-edge and coastal erosion and damage the biological and economic productivity of rivers and estuaries. Induced desiccation of rivers below dams (when the water is diverted to another portion of the river or to a different river) kills fish and other fauna and flora dependent on the river; it can also damage agriculture and human water supplies. Hydroelectric projects often have major effects on fish and other aquatic life. Reservoirs positively affect certain fish species (and fisheries) by increasing the area of available aquatic habitat. However, the net impacts are often negative because (a) the dam blocks upriver fish migrations, while downriver passage through turbines or over spillways is often unsuccessful; (b) many river-adapted fish and other aquatic species cannot survive in artificial lakes; (c) changes in downriver flow patterns adversely affect many species; and (d) water quality deterioration in or below reservoirs (usually low oxygen levels; sometimes gas super-saturation) kills fish and damages aquatic habitats. Freshwater mollusks, crustaceans, and other benthic organisms are even more sensitive to these changes than most fish species, due to their limited mobility (Quintero & Ledec, 2003).

Renewable energy projects can also pose significant threats to natural habitats and biodiversity. Although wind power plants are generally considered more environmentally benign than hydropower developments, some environmental issues related to wind power projects could be of concern:

- The opening of new access roads, which can lead to increased deforestation, soil erosion, and illegal hunting around the project area;

- Increase in noise pollution, depending on the number and model of the turbines and the distance between them, as well as the location of the power plant in relation to existing housing;
- Bird deaths from rotating arms; the negative impact can be especially serious if windmills are located in the path of migratory birds.
- Impacts on native vegetation and archeological sites as a result of construction activities for windmill towers, transformers, and access roads; and,
- Impacts on the scenic value of the area since wind-power plants are usually located on hilltops or open land, both of which make them visible from far away.

Impacts from mining projects can also be significant. Open pit mines can devastate entire landscapes, cause erosion and silting of streams and lakes, and pollute watercourses. The presence of a large workforce in remote areas increases pressure on natural resources and biodiversity. The influx of workers can bring about population changes and the creation of boom towns. Access roads can exert all the impacts of roads described above.

2.2 Induced and Cumulative Impacts

Infrastructure projects bring induced impacts and, ultimately, cumulative impacts, which grow over time. Induced impacts are usually associated with human activities associated with infrastructure construction or improvement. They tend to be both more serious and more difficult to control than direct impacts (Ledec & Posas, 2003). The three major induced impacts of poorly planned and managed infrastructure projects in green fields are increased illegal collection of natural resources (e.g., through the infrastructure under construction, access roads, or expanded cleared land area), downstream hydrological effects, and land-use change which may lead to habitat degradation or even destruction. These induced impacts are cumulative and can be considerable when interactions with other projects and the configuration of networks of linear infrastructures, their surrounding habitats, and different types of impacts are taken into account (Forman et al., 2003).

Illegal collection of natural resources (e.g., wildlife, forest products) is one destructive disturbance to natural habitats that may cause species extinction, habitat degradation, and deforestation (Song, 2003; Casson & Obidzinski, 2002). It is likely to increase in all infrastructure sectors along with the enhanced availability of transport infrastructures in and around natural habitats if there is no effective implementation of strict restrictions on human access to these areas. Infrastructures and ancillary roads built during construction of dams and mining projects, or oil and gas exploration open up intact habitats, increasing the opportunities for poachers and collectors of other forest products to access remote protected areas and transport their goods to outside markets. In some countries, benefitting from convenient transport, market networks of illegal trading of natural resources are actually located along roads (Song, 2003; Casson & Obidzinski, 2002).

Further, activities associated with the construction and maintenance of infrastructure projects can alter downstream hydrological processes and geomorphologic conditions and ultimately cause degradation of aquatic ecosystems (Keller & Sherar, 2003). In road projects, for example, because their construction involves channel relocation, obstruction of wetland water system for flood prevention, building of embankments, drains, cuts, and fills, the construction activities often negatively influence local hydrology. Moreover, the surrounding hydrological system can also be severely affected by high erosion rates and sedimentation caused by improper road siting, construction, maintenance, or heavy traffic (Keller & Sherar, 2003; Rajvanshi et al., 2001). Roads can also be constant sources of sediments to streams as they accelerate runoff, and their construction, maintenance, and operation activities increase the volume of loose material (Ziegler et al., 2004). In addition, erosion impacts of roads facilitate gully development below their drainage structures (e.g., culverts, water bars, rolling dips) and eventually lead to channel extension, diversion of existing stream channels, and the increase of drainage density (Coe, 2004). These impacts cumulatively damage the conditions required by aquatic species for reproduction, can shorten the life of downstream infrastructure (e.g., reservoirs, bridges), and change water supply systems relying on ecosystems of natural habitats (Elliot et al., 1997).

Dam construction and operation can also exert significant indirect and cumulative impacts on natural habitats. Hydroelectric dams often make possible new development projects with major environmental impacts, including irrigation, urban expansion, and industrial facilities (due to new water supplies). The presence of large workforces in remote areas increases pressure on fragile ecosystems. Access roads for dam construction bring about the impacts discussed above for standalone road projects. The retention of sediments can alter the productivity of the flood plains or estuaries downstream from the dam. The variations of flows downstream can alter fish population and fisheries. Multiple dam development on the same watershed can alter flow patterns and eliminate the possibility for any fish migration.

Mining projects can also exert important induced and cumulative impacts: rapid growth of urban areas and boom towns, additional demand for services (water and electricity) and expansion of the agricultural frontier, and new industrial developments associated with the mining industry.

In the long run, infrastructure projects often accelerate land-use change, which often results in permanent habitat loss (Nelson & Hellerstein, 1997). Natural habitats may be transformed into areas for agriculture, aquaculture, human settlement, and other industrial purposes as projects and their associated roads improve opportunities for economic exploitation of resources in these areas (Richards, 1990). For instance, new roads, either on their own or associated with dams and mining projects, in previously intact habitats are often followed by clusters of roadside settlements and construction of more community roads that extend from the original ones. These areas ultimately grow into zones of urbanization (Rajvanshi et al., 2001) that often become nuclei for invasive species introductions. Land-use changes, together with other human colonization-induced impacts, can considerably affect native terrestrial and aquatic ecosystems (Trombulak & Frissell, 2000).

3. An Approach to Green Infrastructure

Green infrastructure means natural habitat and biodiversity-friendly infrastructure development.[1] At the core of the concept of green infrastructure is the "mitigation hierarchy," namely, avoid, mitigate, restore, compensate, and offset. Green infrastructure requires infrastructure project to embed this hierarchy in its planning, design, and construction—in other words, the whole infrastructure development life cycle.

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[1] Green infrastructure is also used in other contexts such as energy efficient infrastructure, artificial wetlands for managing runoff, energy efficient buildings.

3.1 Limitations of a Project-by-Project Approach

To understand the principles of green infrastructure, it is important to start with the major shortfalls of a project-by-project approach to habitat conservation. New infrastructure projects will continue in response to the changing land uses and the growing economy around the world. The conflict faced by habitat conservation in infrastructure development calls for reconsideration of whether habitat loss can be resolved at a single decision-making level.

There is no dearth of effort to mitigate impacts on natural habitats in many individual infrastructure projects, by building overpasses and underpasses in highway projects to enhance fauna mobility, restoring or creating conservation corridors to connect habitat patches, fish passages in hydroelectric projects, strengthening construction management and maintenance, or adopting good siting criteria (Jaeger et al., 2006, Quintero & Ledec, 2003). However, these techniques often focus on environmental management at the project scale, and not all of them can demonstrate significant effectiveness (Bacher-Gresock & Schwarzer, 2009). In fact, a project-by-project approach appears, and in many cases undeniably is, insufficient to halt habitat or species loss (Quintero et al., 2010). In particular, the traditional project-based approach shows limitations in (a) addressing long-term impacts of infrastructure projects, (b) restoring habitat connectivity, and (c) lowering human and monetary costs of conservation activities. This approach is often executed by a deficient analysis of project alternatives, which leads to a failure to apply avoidance principles in the mitigation hierarchy.

Disregarding Cumulative Impacts. It is often beyond the scope of a single project proponent (especially in private sector projects) to address induced and cumulative impacts. While the impacts of an individual project may fall below the defined critical thresholds, the totality of the incremental contribution of each project over a period of time can be disastrous to natural habitats (MacDonald, 2000). More often than not, even in sector programs or projects of regional importance, the project-level Environmental Impact Assessment does not address cumulative impacts, or the quality of the analysis of cumulative impacts is deficient. Furthermore, cumulative impact assessment is generally not required by Environmental Assessment regulations in many developing nations. The failure to address cumulative impacts in the road, hydroelectric, and mining sectors is a major deficiency in many countries around the world, especially in Latin America.

Induced and cumulative impacts from infrastructure projects usually extend beyond the temporal and spatial scale of the project per se (Bekker & Iuell, 2004).The spatial scale and the horizon of infrastructure development need to be expanded in order to address the impacts of multiple projects, including additive and cumulative impacts, as they can only be discussed in the context of broader development plans (Rajvanshi et al., 2001). Long-term impacts of infrastructure development, with their wide areas of influence and time horizons, therefore can usually only be adequately tackled with actions at the program and policy level (André et al., 2004).

Not restoring full connectivity. Mitigation measures at the project level to counter the adverse effects of fragmentation cannot fully restore connectivity because species respond to it in different ways. Mitigating connectivity impacts in one single road segment of a network does not necessarily resolve connectivity issues for a given species across the entire landscape. The spatial arrangement and the movement of organisms among habitat patches determine the connectivity of habitats, which is a vital element of landscape structure (Forman, 1995). Connectivity is indicated by the degree to which the landscape facilitates or impedes individual movements among habitat patches to acquire resources (Taylor et al., 1993), and the level of habitat connectivity is species-specific. In linear projects, various structures are designed to reduce the isolation effects: wildlife culverts, tunnels, underpasses, overpasses, and fences are built to facilitate animal mobility across road structures; expanded bridges, tunnels and viaducts are chosen for road sections which have to cross sensitive habitats. However, species do not adapt to these man-made structures in the same way and for some they may be totally inappropriate as they have different responses to the conditions provided by these structures, such as their placement, size, substrate, and noise, temperature, light and moisture levels (Jackson & Griffin, 2000). Trying to find the right type of structure for the full variety of species in the vicinity of a single project would be impractical, as much as it would be a misguided proposal for restoring habitat connectivity.

The mitigation of barrier effects of dams and other water infrastructures is more difficult to attain. More often than not, fish passages and other mitigation measures cannot fully restore migration patterns in a river. At best, they might serve as a source of restocking genetic material in the reservoir and upstream. Frequently, distinct migratory patterns are established upstream and downstream of the dam regardless of the existence of these passages. Run-of-river hydroelectric projects often lead to wet-dry-wet segments of rivers, with rarely studied effects on local ecosystems. Maintaining adequate environmental flow conditions downstream of dams is of particular importance for aquatic ecosystems. The term *environmental flow* refers to a variable water flow regime that has been designed and implemented—such as through intentional releases of water from a dam into a downstream reach of a river—in an effort to support desired ecological conditions and ecosystem services. In this manner, environmental flows are an important tool in managing the impacts of hydropower dams on aquatic habitats.

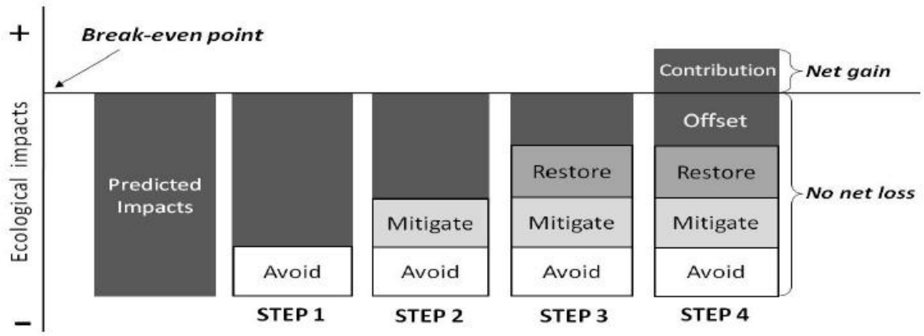
High human and monetary costs. The application of restoration and mitigation techniques can be too expensive and ineffective to be attractive to individual projects if strategic planning and allocation of resources in the infrastructure sector are not in place. From an administrative perspective, conservation efforts undertaken in an uncoordinated, piecemeal manner are likely to cause delay in project delivery. Furthermore, they might not provide the best environmental outcome. Permit-granting agencies have to individually review multiple mitigation proposals and projects within areas that are ecologically connected, many of which should ideally be put under the same conservation plan (Thorne et al., 2009). From an economic perspective, many of the most effective structures for habitat conservation in infrastructure projects are costly, with price tags in the thousands and millions of dollars (Abson & Lawrence, 2003; Huijser et al., 2007; Quintero et al., 2010). Moreover, field surveys and monitoring to determine the right type of measures to reestablish connectivity in several small projects can be not only very expensive but also time consuming (White & Ernst, 2003). It is a better solution to conduct them for multiple infrastructure projects if they are planned in ecologically connected areas, rather than carrying them out separately for each project. In this manner, a more holistic vision of impacts on natural habitats can be obtained. This is important because sometimes conservation of particular species may be of lesser concern than maintaining overall habitat connectivity, or sometimes it is more worthwhile to conserve fragments that are still linked by a corridor of habitat rather than isolated ones of similar size (Diamond, 1975). Therefore, an economic strategy is to reserve these costly measures for the maintenance of connectivity between habitats of the greatest ecological value (Jackson, 1999; Betsch et al., 2009). Additionally, incentives should be provided for implementing sound engineering practices in infrastructure projects, and sector or even national level planning is needed to identify the natural habitats of high conservation priority.

3.2 A Multilevel Approach to Habitat Conservation in Infrastructure Development

Critical habitats and connectivity zones need to be avoided in infrastructure development in order to effectively sidestep the issue of fragmentation. In order to achieve this, conservation actions have to look beyond project engineering into sector planning and national policy making. Current conservation practices, mostly mitigation and restoration activities, focus inordinately on reducing impacts of infrastructure projects on local natural populations without understanding the ongoing degradation of meta-population dynamics and wider ecological processes from a landscape perspective (Hanski, 1999; Moilanen & Hanski, 1998). Ideally, according to the "mitigation hierarchy" (see Figure 2), infrastructure projects should first avoid, then minimize, then restore, and finally, when the previous options are exhausted, offset its ecological impacts (BBOP, 2009; Prince Waterhouse Coopers, 2010).

Framing them around this hierarchy, there are four types of measures that can be undertaken to conserve habitats, including expanding protected areas, enhancing the quality of existing habitats, minimizing impacts from surrounding land use, and providing connectivity within fragmented landscapes (Bennet, 2003). Avoidance, by keeping critical natural habitats and their connectivity zones intact, is the fundamental and essential basis for nature conservation (Sanderson et al., 2010). It is not only a matter of project siting, but indeed an imperative for both land-use planners and infrastructure planners. Many infrastructure projects have gone beyond the no-net-loss concept and have contributed to a net gain for biodiversity, providing win-win conditions for conservation and infrastructure development (Quintero, 2007).

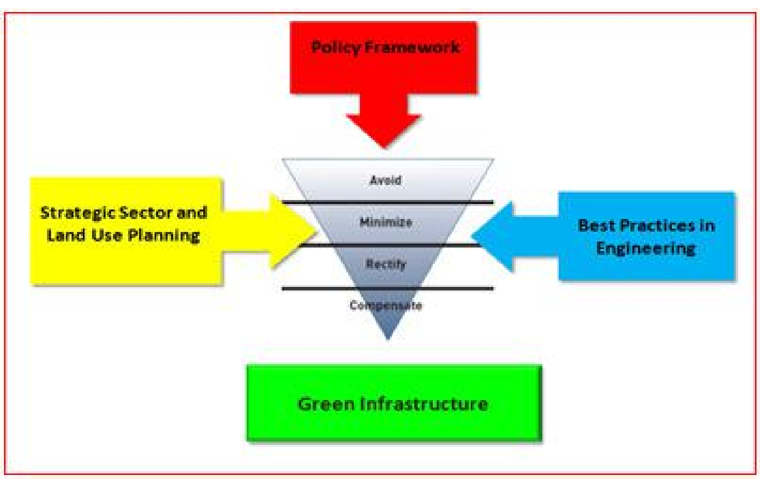
Figure 2. Mitigation Hierarchy



Source: Adapted from BBOP, 2009.

As demonstrated above, conventional project-based conservation activities need to be combined with supporting national policies and sound planning in the infrastructure sectors. Green infrastructure emphasizes the importance of combining habitat conservation options at all levels from policies and sector planning to engineering designs and construction and operation practices. As approach lies the mitigation hierarchy, which needs to be mainstreamed at all level of decision making: national policy level, sector planning, and project levels (Figure 3).

Figure 3. A Multilevel Framework for Natural Habitat Conservation



3.3 Options at the National/Policy Level

At the national policy level, there are three main considerations: (a) mainstreaming natural habitat conservation in land-use policies/frameworks/strategies; (b) providing financial incentives to infrastructure projects and sector plans to proactively reduce their adverse impacts on natural habitats; and (c) using biodiversity offsets to make sure that infrastructure projects do not cause net loss of habitats.

Mainstreaming natural habitat conservation. The first option to be introduced is setting aside critical habitats and their vital linkages from intensive infrastructure development in national land-use policies, frameworks, or strategies. The national level is the most appropriate level of decision-making to practice "avoidance" in the mitigation hierarchy. Land-use policies should ensure that core ecological networks of natural habitats are designated as "no-go" areas. Subsequently, as land-use policies are modified, adding habitats, buffer zones, or connectivity corridors in national nature reserves might be needed in order to conserve habitat networks, as well as the ecological processes they support (e.g., long-distance migration) (Berger, 2004; Leitão & Ahem, 2002). Besides mapping out a new national land-use plan, other planning tools can also be adopted to supplement the existing land-use plan, including landscape planning, ecological planning, ecosystem management planning, and habitat conservation planning (Sanderson et al., 2002; Steiner, 2000). Land-use planning, at the national and regional levels, plays an important role in managing the risks of infrastructure projects by guaranteeing an upstream implementation of the avoidance principle and providing a framework for mitigation and compensation. Restrictions imposed by land-use planning should be taken into consideration at the screening stages of the project cycle. Making these restrictions easily available to infrastructure planners (using screening tools like Tremarctos in Colombia, which will be discussed later) can facilitate the mainstreaming of natural habitat conservation.

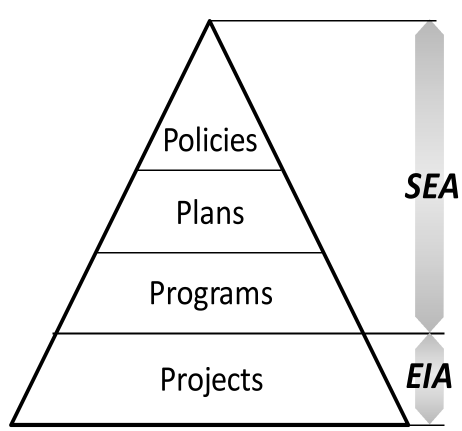
Financial incentives. The second measure is using incentive mechanisms to promote habitat conservation activities in infrastructure plans and projects. These incentives can be in the form of national conservation programs/initiatives, tax benefits, funding sources for habitat protection, or direct cash subsidies (White et al., 2007). Leveraging funds from infrastructure projects can be highly effective in benefiting conservation efforts.

Biodiversity offsets. The third measure that can be considered by national governments is establishing channels to transfer a portion of infrastructure project profits to financially support habitat conservation through biodiversity offsets. Biodiversity offsets are measureable conservation actions designed to compensate for residual and unavoidable harm to habitat caused by infrastructure development, after prevention and mitigation measures have been taken (ICMM, 2005). Before applying biodiversity offsets, supportive policy/regulatory/legislative frameworks need to be established.

3.4 Options at the Sector Level

A very important option for policy makers is the establishment of a national Environmental Assessment (EA) system. Typically, an EA system comprises two main instruments: Environmental Impact Assessment (EIA) and Strategic Environmental Assessment (SEA). In addition to being an input to decision making, the EIA is used to analyze the effects of development projects, while the SEA is applied to assess the impacts of policies, plans, and programs (see Figure 4). Currently, nearly all countries have some experience with EIA, and many have been actively testing SEA over a much broader range of decision making (Dalal-Clayton & Sadler, 2004). A sound EA mechanism, effectively implemented, sets the groundwork for acting on concerns about habitat loss during planning and design (World Road Association, 2007). In addition, the three national-level options can be embedded in the EA process (IAIA, 2005). For instance, SEA can initiate an integrated process to link traditional infrastructure planning, land-use planning, and ecological planning. It also helps to address the cumulative impacts of multiple projects (Fischer, 2002). This is perhaps the most important use of SEAs.

Figure 4. A Tiered EA System



Options for habitat conservation at the sector level include seeking interagency coordination in network planning for linear infrastructures or hydroelectric development in watersheds, expediting approval for habitat-friendly projects; and strengthening environmental management and supervision in infrastructure projects.

Biodiversity-inclusive EIA and SEA. Infrastructure sectors should implement biodiversity-inclusive SEA and EIA to mainstream habitat and biodiversity conservation in mapping out development plans (Slootweg et al., 2006). Two concepts regarding biodiversity-inclusive SEA and EIA are emphasized here: (a) linking SEA and EIA, and (b) using them as platforms for cross-agency coordination and communication among different social groups. The concept of linking SEA and EIA, which is called "tiering" in academia, refers to the application of a sequence of EAs at different decision-making levels (again, indicated in Figure 4) and linking them (Arts et al., 2005; OECD, 2006). Implementing tiering is important because it helps to trickle down habitat conservation concerns from broad-brush narratives at the policy level to concrete actions in infrastructure projects (BBOP, 2009). A tiering system for the infrastructure sectors should avoid the creation of parallel SEA and EIA systems. For instance, a tiered SEA-EIA system for the hydroelectric sector must necessarily influence the way EIAs for specific projects are carried out in the country, and hence it must also have some inherence on the way the environmental licenses are issued. A tiered system should promote SEAs for policies and expansion programs, cumulative impact assessments at the watershed level, and EIA at the project level.

At the sector level, biodiversity-inclusive SEAs should address the most limiting aspect of the project specific approaches, that is, the cumulative impacts of sector plans. For the road sector, strategic assessment of road plans should address the issue of habitat fragmentation. For hydroelectric developments in the same watersheds, SEAs (or simply cumulative impact assessments) should address aquatic connectivity issues, fish migration, the need for ecological flows, and the cumulative impact on terrestrial ecosystems from reservoirs, access roads and transmission lines. Strategic assessments at the sector level should also address issues like evaluation of ecosystem services and regional monitoring programs.

The concept of using biodiversity-inclusive SEAs as platforms for coordination and communication is important for habitat and biodiversity conservation. The broadness breadth and complexity of biodiversity issues requires a participatory mechanism. Very often, biodiversity offsets are designed on the basis of valuation of ecosystem services (Slootweg & Beukering, 2008). Quantifying an area's ecosystem services requires extensive stakeholder participation, because ecosystem services (provisioning, regulating, cultural, and supporting) encompass various functions, ranging from food and fuel provision, carbon sequestration, and nutrient cycling to recreational and aesthetic uses (Millennium Ecosystem Assessment, 2005; OECD, 2008). By undertaking public participation, one of SEA's process components, biodiversity-inclusive EA can facilitate the integration of as much local knowledge as possible and transparent decision-making for ecosystem service evaluation.

3.5 Options at the Project Level

Sound engineering design ensures that adverse impacts on natural habitats are mitigated. At the project level, engineering practices will have to be based on scientific information about the conservation target (species), strategic planning, and management from national and sector levels. Besides these, two additional good practices are worth mentioning. The first one is infrastructure siting. Siting is perhaps the most important measure for a project to reduce disturbances to natural habitats in hydroelectric projects (Quintero & Ledec, 2003). Siting criteria that take habitat conservation into consideration can in fact help reduce the construction cost of infrastructure projects (Keller & Sherar, 2003; O'Brien, 2006; Grimsö Wildlife Research Station Roads & Wildlife, 2011). The second good practice is using physical structures to restore and conserve habitat connectivity. Experience has demonstrated that there are considerable possibilities for man-made facilities to substantially ease habitat fragmentation in a landscape. For roads, some of the principal types of structures that maintain wildlife mobility include long tunnels/bridges, boulders in the right-of-way, fencing, viaducts, elevated roads, river crossings, culverts, overpasses, and underpasses. The use of fish passages in hydroelectric projects is quite common in many countries albeit with varying degrees of success.

While options are abundant, projects need to include their own solutions to several issues.

First, as discussed before, habitat preferences of different species are often at odds with one another. Local ecology should be deliberately assessed before determining the best combination of structures. Second, monitoring is needed to evaluate the effectiveness of installed structures and to provide knowledge for improving the design of structures in future projects or maintenance efforts.

4. Advantages of the Multi-Level Approach for Habitat Conservation

The advantages of this multilevel approach for green infrastructure are:

- It provides a comprehensive basis for improved decision making in infrastructure development. This approach helps to mainstream biodiversity conservation and the mitigation hierarchy at all levels so that it receives proactive attention rather than reluctant inclusion.
- It promotes the early integration of conservation considerations within infrastructure sector decision making to solve habitat loss systematically. Traditional conservation activities are usually undertaken in a late stage in the life cycle of infrastructure development, which spans project siting, design, construction, and operation. Practices introduced at late stages tend to make only small contributions to the reduction of impacts, because usually few decisions are still open to change at the project level.
- In addition, preparing individual conservation plans for each infrastructure project often causes delays in project development, as these conservation plans have to be reviewed on a project-by-project basis, even if the projects affect more or less the same habitats. In order to overcome such deficiencies of conventional conservation practices, the multi-level approach emphasizes systematic planning by suggesting that land-use/ecological/landscape plans be linked with infrastructure plans.
- The multi-level approach addresses cumulative impacts of infrastructure projects in a more effective manner by advocating strategic planning of both infrastructure sectors and conservation activities. Ignoring cumulative impacts occurs easily in the project-by-project approach. Because infrastructures and their zones of influence usually cross different jurisdictions, there is a great need to enhance inter-sectoral and

inter-administration cooperation so as to tackle cumulative impacts with large temporal and spatial scales. Therefore, implementing the multi-level approach, which comprises actions that need to be taken at national and sector levels, presents numerous opportunities for improving collaboration among government agencies. As mentioned before, cumulative impact assessment should preferably be carried out at the sector level, but there are still many opportunities and benefits from this type of assessment at the project level.

- A multi-level approach reduces the high cost of habitat conservation. Project-by-project conservation practices often have high cost, which still does not guarantee that ecological processes will be conserved or restored. Generally, as conservation actions are taken later in the lifecycle of infrastructure development and go down along the mitigation hierarchy (from avoidance, mitigation, restoration to offset), the cost of environmental protection goes higher. Avoidance at early stages of decision-making in infrastructure development (e.g. Avoid "no-go" areas defined inland-use plans/watershed plans) is the cheapest and probably the most effective action to conserve habitats.
- The multi-level approach—which advocates the early integration of conservation considerations following the mitigation hierarchy—offers a clear picture of how to reduce infrastructure developers' costs in relation to habitat conservation.

II. GREEN INFRASTRUCTURE IN LATIN AMERICA

1. Introduction

Experience from Latin America has shown that integrating consideration for natural habitats into the design and operation of infrastructure projects can not only substantially reduce the associated environmental costs, but also create a win-win situation for habitat conservation and development. Specifically, infrastructure projects can provide and/or leverage important resources that might not be available for strictly "green" projects, resulting in a significant conservation gain. Annex 2 includes 12 brief case studies of Latin American experiences in addressing natural habitats issues in infrastructure projects. Quintero, 2007 includes eight case studies from Latin America from the late 1990s to early 2000s.

There are many examples in Latin America that illustrate the application, albeit not in a systematic manner, of the multi-level green infrastructure approaches. Breaking common perceptions, green infrastructures redefine the role of infrastructure development with regard to conservation. In Latin America, good planning, as well as innovative engineering construction and operational techniques, were devised specifically to avoid natural habitats, reduce the area of the disturbed sites, minimize the magnitude and extent of unavoidable impacts, and mitigate all remaining impacts. Project resources in Latin America were mobilized to carry out restoration projects, endangered species conservation action plans, environmental education and awareness programs, identification of non-catalogued sensitive areas, establishment of new protected areas along with the provision of their management plans, co-management agreements, recurrent costs, financing, personnel training, and provision of initial funds. In many cases these actions were embedded within more profound changes that involved raising institutional environmental standards, revising legal frameworks, and creating new divisions to address environmental issues.

Successful strategies used by the single projects included in Quintero (2007) can be summarized as follows:

- Promoting development through well-designed infrastructure projects can freeze and even reverse degradation of natural habitats and the loss of biodiversity;

- Thorough Environmental Assessments are the foundation of successful environmental outcomes;
- Early involvement of stakeholders improves project design, operation, and management;
- Timing is crucial: the nature of key actions may be ineffective if they are not carried out at given times during the project;
- Compensation and restoration measures with successful outcomes can be achieved even when impacts are identified during project implementation;
- Efforts to establish new protected areas need to be started during project preparation;
- Large-scale projects facilitate institutional strengthening and restructuring; and
- Well-sited projects enable more in-depth, site-specific actions.

Despite successes in individual projects, there is no evidence of a systematic approach for natural habitats in infrastructure projects in Latin America. Following the principles of green infrastructure, the sections below summarize the application of green infrastructure options and mitigation hierarchy principles, in infrastructure development in Latin America.

2. Application of Options at the Policy/National Level in Latin America

The following is a summary of the types of mechanisms that have been applied in some Latin American countries.

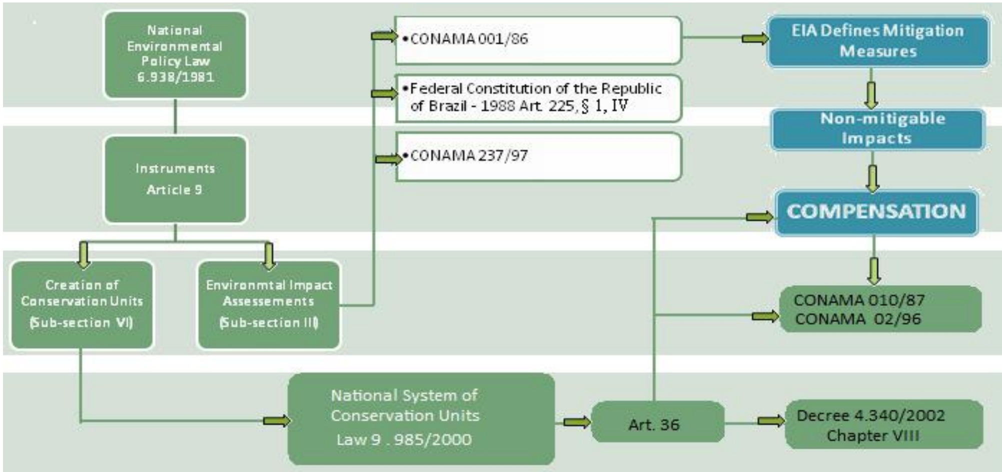
Policies and financial mechanisms. Few countries in Latin America have introduced green infrastructure principles at the policy level. Two notable exceptions are Brazil and Colombia. In Brazil, a law requires a percentage of the total cost of an infrastructure project be transferred to support the creation or maintenance of priority conservation units (see Box 1). The exact percentage is determined by various factors and increases with environmental sensitivity, thus acting as an incentive to developers to offset harm and/or avoid ecologically sensitive areas.

A more recent example of the introduction of a policy on ecological compensation is in Colombia. Decree 2820 of 2010 defines compensation measures as *"…actions to compensate and indemnify communities, regions, local sites, and the natural environment for negative impacts caused by a given project or activity that cannot be avoided, restored, mitigated, or* *substituted.*" Although it is too early to assess the effectiveness of this decree, the example set by Colombia may provide guidance to other countries to introduce this basic principle of the mitigation hierarchy in their environmental regulatory framework.

Another good example at the policy level is the recently passed regulation on ecological flows in Mexico. Mexican Norm NMX-AA-159-SCFI of 2012 establishes the procedures for environmental flow determination in hydrological basins. It defines ecological flow as the quality, quantity and flow regime or variation of water levels that are required to maintain the components, functions, and processes of aquatic ecosystems. This type of regulations is much needed in many countries in the region.

New financial mechanisms for natural habitat conservation are being used in Latin America. The Costa Rican Payments for Environmental Services (PES) case illustrates that by instituting appropriate forestry management schemes, all stakeholders can benefit from the environmental services provided. PES programs are mainly targeted to NGOs and landowners, but the mechanism also offers business a clear opportunity to participate. Countries interested in preserving natural habitats could customize and implement a flexible PES scheme by including national and regional governments, NGOs, landowners, resource users, hydropower, mining, water, gas, and ecotourism companies in the PES scheme.

Box 1. Integrating Biodiversity Compensation Requirements into Environmental Laws and Regulations
The Brazilian experience with biodiversity offsets illustrates that biodiversity offsets not only constitute an excellent financial instrument for consolidation of protected areas but also address the full impact of infrastructure projects on biodiversity at the landscape scale. Environmental compensation was first used in Brazil in 1987. Brazilian law requires that every development project, private or public, that may have significant environmental impacts must be licensed before its inception by the federal or state environmental agency responsible for the location of the development. In July 2000, the Congress amended the law to include that, as a condition of licensing, the enterprise carrying out the project is required to financially support the establishment and/or maintenance of a strict conservation unit.



The compensation mechanism was fully imbedded in the EIA Licensing System and is based on the identification of immitigable impacts.

According to Art. 33 of the SNUC Decree, regulating Art. 36 of the SNUC Act, the money from compensation may be spent on existing or newly created conservation units for the following purposes (in order of priority): (i) land tenure regularization and land demarcation; (ii) elaboration, revision, or implementation of a management plan; (iii) acquisition of the goods and services necessary to establish, manage, monitor, and protect the conservation unit, including its buffer zone; (iv) studies necessary for the creation of a new conservation unit; and (v) development of the research necessary to manage the conservation unit and its buffer zone.

The destination of the compensation payments is a general point of contention aimed at the project developers offset. To ensure the implementation of the "no net loss principle," compensation must aim to improve environmental quality in order to counterbalance impacts. Mere conservation actions cannot achieve this goal. The fact that developers are not required to be directly involved in conservation and compensation measures may give the wrong impression that mere payments can resolve environmental obligations, with no need to commit businesses to environmental priorities. Another challenge of the Brazilian compensation approaches is that compensation measures are designed on a case-by-case basis and that no general, predefined, comparable, and transparent criteria are available.

Payments for Environmental Services can be defined as "a voluntary, negotiated framework where a well-defined ES, or a land use likely to secure that service, is being 'bought' by at least one ES buyer from at least one ES provider, if and only if the ES provider secures ES provision (conditionality)"[i] The central element of PES is that external ES beneficiaries make direct contractual and conditional payments to both local landholders and users in return for adopting practices that secure ecosystem conservation and restoration.

The Kyoto Protocol and the Clean Development Mechanism (CDM) are important mechanisms for addressing the impacts of climate change. However, what is less well understood is their potential for financing the protection of wild populations of critical biodiversity importance. By linking carbon revenues to local social and environmental indicators, these resources would be responding to the spirit of the CDM and contribute to the protection of natural habitats. The Amoyá Hydroelectric Project is located in the central range of the Colombian Andes above 3,500 m in the municipality of Chaparral. The region harbors the largest stretch of moorland habitat on Earth. Here, the most humid moorland (Páramo Las Hermosas) is rich in endemic species. Amoyá will have a capacity of 80 MW, generating 510 GWh/year. This run-of-river (kinetic energy, no reservoir) hydropower generation unit is currently being built by ISAGEN using the stream of the Amoyá that is fed by the moorlands of Las Hermosas.

By linking carbon revenues to the conservation of the Páramo ecosystem, which in turn provides the water for power generation, the project has a positive sustainability cycle. Clean power generation results in the displacement of current and future thermal capacity, which can be purchased under the CDM. Some of these revenues could be invested in conserving the moorlands, which would contribute to maintaining a sustainable water cycle, currently threatened by global climate change and other anthropogenic impacts.

Similarly, Reducing Emissions from Deforestation and Forest Degradation (REDD) schemes, when conducted properly and with the right pre-conditions, can provide significant funding for habitat conservation. A good case is the Brazil Noel Kempff Climate Action Project. The project was launched in 1996 with the 831,689 ha expansion of the Noel Kempff Mercado National Park, which more than doubled the size of the park from 750,633 ha to 1,582,322 ha. Using funds from the private sector, public sector and non-profit sector, the project bought and retired three timber concessions totaling more than 575,000 ha. Furthermore, funds were also used to assist local communities, establish new park facilities and staff. Financing of NKCAP was provided by three energy companies (American Electric Power Company (AEP), BP America, and PacifiCorp), a non-profit (The Nature Conservancy, TNC), and the government of Bolivia (who contributed in the form of closing the timber licenses and expanding the park). In return, the companies were provided with 51% of the future 3rd-party certified carbon offsets created over the 30-year lifetime of the project while the government received the remaining 49%.

Biodiversity offsets. Generally, there are two ways that biodiversity offsets can be applied. First, offsets can be used as actions undertaken by individual projects. This means that a project needs to develop an offset proposal and compensate impacts though its own action. The implementation of the offset proposal, which is essentially a mitigation plan, can be guaranteed by project licensing requirements. Second, offsets are transferred in the form of “credits” in a market involving developers, locals, and bankers: developers can fulfill their mitigation obligations by implementing their own mitigation initiatives or purchasing from bankers, while bankers can create or restore a conservation area to earn credits and sell them at market rates to recapture their investments. Through trading offset credits, stakeholders receive financial gains from protecting habitats (Fox & Nino-Murcia, 2005), as is envisioned in the emerging financial mechanism to reduce emissions from deforestation and forest degradation (REDD) (Miles & Kapos, 2008; Angelsen et al., 2009; Madsen et al., 2010) at the local, national, and international levels.

Perhaps the most common biodiversity offset mechanism in Latin America has been the creation and strengthening of protected areas. Quintero (2007) presents examples of this type of offset in hydroelectric projects, road development, water and sanitation, and gas projects. These projects secured legal protection for conservation priority areas that were either not previously catalogued or recognized.

New protected areas. They include:

- Road project in Aguan Valley in Honduras: A conservation action plan was formulated to conserve critical thorn forest habitat for the endemic endangered Honduran Emerald hummingbird, *Amazilia luciae*, as well as 11 endemic plant species. To date, some 1,200 hectares of natural vegetation (of which 600 ha comprise Honduran Emerald habitat) are under permanent protection within the Poligono Habitat Management Area established in 2005.

- Storm Water Drainage Project around Gra-Gra Lagoon in Belize: 484 ha were protected by establishing the Gra-Gra Lagoon National Park, which aims at the conservation of the lagoon and neighboring mangrove areas.
- Yacyretá Hydroelectric Project Protected Areas Network in Argentina-Paraguay: Legal protection has been secured for 155.000 ha in 11 protected sites. The habitats include river islands and riparian habitats similar to those lost after flooding. These lands neighboring the dam harbor threatened and/or endemic species. In order to improve water quality near urban areas, urban reserves, mainly artificial wetlands, have been created in urban creeks and streams.
- Road Sector Program in Tocantins, Brazil: Six of 11 identified conservation areas will be established as part of the project. The 11 areas amount to 917,000 ha, six of them encompassing a minimum of 214,000 ha up to a maximum of 762,000 ha. The conservation units are part of the state's goal to secure 10 percent of its total area for conservation purposes.
- Cartagena Water and Sanitation Project: the freshwater lagoon Ciénaga de la Virgen had been long neglected in spite of being widely recognized as an important area for endangered species and of great esthetic value for Cartagena. The Ciénaga de la Virgen was legally established as a protected area. The accompanying Recovery, Conservation, and Environmental Management Plan (RCEMP), included in the project, was implemented through an arrangement with the regional environmental agency and Conservation International.

Strengthening existing protected areas. Where protected areas were already in place or had long been recognized, strengthening established ones has been a common viable option. This was the case for Bolivia-Brazil Gas Pipeline, where 12 conservation units, mostly national parks and biological reserves covering over 218,000 ha, were chosen throughout the five provinces affected by the project and supported financially by the Brazilian ecological compensation law. The areas benefited include: 1) Parque Nacional da Serra da Bodoquena; 2) Floresta Nacional de Ipanema; 3) Centro de Manejo, Reabilitação e Triagem de Animais Silvestres do Parque Estadual Alberto Loefgreen; 4) Parque Nacional Superagüi; 5) Parque

Estadual do Cerrado; 6) Parque Estadual de Guartelá; 7) Parque Estadual de Campinhos; 8) Parque Estadual da Serra do Tabuleiro (Figure 8); 9) Parque Botânico de Morro Baú; 10) Parque Nacional de São Joaquim; 11) Parque Nacional Aparados da Serra; and 12) Reserva Biológica Estadual Mata Paludosa.

More comprehensive and innovative offset and biodiversity protection programs have been recently designed in the Reventazón Hydroelectric Project I Costa Rica, financed by the Inter-American Development Bank which required a more strategic approach to cumulative impacts (See Box 2).

Box 2. Biodiversity Offsets in the Reventazón Hydroelectric Project in Costa Rica
The Reventazón Hydroelectric Project (PHR) is the fourth large hydroelectric dam project of the Instituto Costarricense de Electricidad (ICE) on the Reventazón River and will be the hydroelectric project with the highest energy production in the country. The dam will be located in the lower basin of the river near the town of Florida. The water level will reach about 265 meters and will flood an area of approximately 650 km^2 along an 8 km stretch of the river. **Importance of the Area:** The PHR is located within the Volcánica Central Talamanca Biological Corridor (CBVC-T), one of the most important areas for ecological connectivity in Mesoamerica within the larger, regional framework of the internationally recognized Mesoamerican Biological Corridor project. The CBVC-T (biological corridor) connects two large expanses of protected areas, the Cordillera Volcánica Central Forest Reserve and the Siquirres River Watershed Protection Zone/Pacuare River Forest Reserve. Within the CBVC-T lies the Barbilla Destierro Biological Sub-Corridor-Path of the Jaguar (SBBD), designated by the NGO Panthera and others as an important corridor for movement and genetic flow of jaguar between the protected areas. The CBVC-T, which includes the SBBT, is recognized as one of the official corridors of the country by the Biological Corridors National Program of the Ministry of Environment, Energy, and Telecommunications (MINAET). <u>Two biodiversity offsets: a fluvial offset based on the intact river concept, and a terrestrial connectivity program to ensure jaguar connectivity.</u> Objectives of the Fluvial Offset Project: To maintain in perpetuity a river ecosystem ecologically similar to the ecosystem of the Reventazón River (i) ensuring the functionality of the ecosystem and the services it provides, and (ii) maintaining a commitment to avoid barriers (in the system). **Consolidation of the Barbilla-Destierro Biological Corridor (SBBD)** • Design and implement habitat restoration measures within the SBBD along the southern end of the reservoir, including land to the east and west of the reservoir. This corridor will be designed using the Habitat Hectare approach of BBOP and recommendations put forth by Panthera.

3. Application of Options at the Sector Level in Latin America

Although EIA systems have been established in all countries in Latin America, the use of strategic environmental assessment for sector planning or even at project level is very limited. Furthermore, the use of biodiversity tools in EIA is still scarce and practically non-existing in SEAs.

3.1 Main Drivers and Limitations for SEA in Latin America

There is no strong legal driver for SEA in the region, since few countries have taken SEA into consideration in their legislation as a requirement for policy changes or the establishment of sector plans or large-scale infrastructure. These include the Dominican Republic, Panama, Guatemala, and more recently Peru. The development banks, including the Inter-American Development Bank (IDB), have supported much of the work in addition to other bilateral and multilateral development partners. Clear evidence of the lack of mainstreaming in the region is seen in most guidance documents developed for the region that primarily reference the EU directive in regard to methodological approaches (IIRSA 2009, CEPAL 2009, World Bank 2011, World Bank 2005) rather than national approaches. The IDB, and to a certain degree the World Bank, are the main promoters of SEA in the region.

3.2 Strategic Assessments in the Road Sector in Latin America

Roads will continue to pose the greatest challenge for habitat conservation in Latin America. More and more roads are being built in frontier areas with sensitive natural habitats. It is not surprising that the development of strategic approaches to infrastructure projects and natural habitats is more advanced in the road sector than the hydroelectric or mining sectors. Strategic approaches to road infrastructure projects can be found in the following IDB-financed projects (taken from unpublished IDB documents):

Improvement of BR-364 in Acre, Brazil. The IDB has been involved in managing the environmental and social impacts of major rural (or inter-urban) highway improvement projects in the western Brazilian Amazon region, and more specifically in the state of Acre, almost continuously since the mid-1980s. Bank experience with two subsequent and generally successful operations in this regard provides a valuable learning opportunity with respect to how such impacts can best be identified, assessed, and addressed in large ecologically sensitive and socio-culturally diverse areas such as the Amazon. A key lesson that emerges from this experience is the critical importance of the up-front identification and assessment of potential direct and indirect environmental and social impacts in the project's broader area of influence. A second IDB loan for the follow-on Acre Sustainable Development Project applied the concept of environmental sustainability in all of the actions of the program, with the participation of all affected stakeholders. These projects have demonstrated that, even in the Amazon region, it is possible to invest in transport infrastructure without increasing deforestation.

The Interoceánica/IIRSA Sur and IIRSA Norte Highway. The IIRSA Sur or "Interoceánica" Highway connects the Atlantic coast of Brazil with the Pacific coast of Peru, with border crossing improvements at Iñapari between Brazil and Peru. Launched in 2000, the IDB has been, and appears likely to continue to be, one of three regional multilateral agencies responsible for assisting with the technical coordination and financing of IIRSA projects, which are mainly for large infrastructure. It has been involved in improving sections of the IIRSA Sur highway system through several national road upgrading projects that include interventions in other parts of the country as well. It is also attempting to help promote biodiversity conservation and sustainable development along a critical section of the Interoceánica even though it is not involved in financing the road construction work per se. Attempts have been made to address induced and cumulative impacts on natural ecosystems in a more holistic way. Addressing these impacts, as the SEA for IIRSA Norte clearly indicates, will require a broad range of socioeconomic, environmental, and other measures (e.g., territorial and land-use planning, institutional capacity building, etc.,) in the projects' direct and indirect areas of influence over the short, medium, and longer terms in the form of multi-sectoral and multi-institutional regional sustainable development programs.

The Darién Sustainable Development Program. This program included the pavement of a 134-kilometer section of the existing Pan-American Highway and rehabilitation of other section of this and other local roads. Darien province has three different ecosystems: (a) an estuary around the Gulf of San Miguel, which provides conditions suitable for mangrove ecosystems, acacia forests and a rich diversity of fish life; (b) three mountain ranges, which are home to most of the region's unique flora and fauna; and (c) the Central Valley, in the basin of the Chucunque River (through which the Pan-American Highway was built), and a number of smaller valleys that constitute the region's modest agricultural potential. Given the specific characteristics of the road's area of influence, the Bank decided to embed these investments in a broader sustainable regional development program and require that certain environmental and social protection measures be taken prior to initiating the planned road improvements.

The project includes support to land-use plans: (a) management plans for three proposed zones: (i) the National Park and the Serranía de Darién, approximately 560,000 ha, including a plan for coastal management; (ii) Valle del Chucunque, roughly 600,000 ha; (iii) estuary of the Gulf of San Miguel, approximately 400,000 ha; and (b) other areas, specifically: (i) the Hydrological Reserve and the Forest of the Serranía de Cañazas and del Tallo. The project also includes an innovative pilot system of transfers for conservation and protection services. A scheme would be developed to provide incentives or direct grants to small farmers (some 200 families, with an average of 10 ha/family) located in critical areas, to compensate them for the opportunity cost of conserving and protecting the forest (i.e. payment for environmental services).

The Mocoa-Puerto Asis By-pass Road in Colombia. Some regional planning efforts that included protected areas and biodiversity corridors based on SEAs were introduced in the project design. This 46.5 km road, located in the southern region of Putumayo, cuts through sensitive natural habitats in a geologically unstable area. The project proposes to: (i) expand a forest reserve; (ii) create a biodiversity corridor based on landscape and territorial planning; and (iii) support biodiversity conservation programs. As the project is still in its early stage of implementation, it may be too early to assess the benefits of this approach. Complex inter-institutional arrangements will require political will to be successful. However, the use of strategic planning and a regional biodiversity conservation approach in this project are considered to be an important step to a more biodiversity-friendly road infrastructure development in Colombia. This example, reinforced by the introduction of the compensation requirements in Colombia in 2012, should facilitate these efforts.

Other projects in which SEAs (regional, cumulative impacts) have been supported by multilateral investment banks include: The Santa Cruz-Puerto Suarez highway in Bolivia; the Bolivia-Brazil Gas pipeline; and the Reventazón Hydroelectric Project in Costa Rica.

4. Application of Options at the Project Level in Latin America

Good engineering practices for natural habitat conservation in infrastructure projects are common in Latin America. Good engineering practices were introduced in the Bolivia-Brazil Gas Pipeline. Although this project was completed over a decade ago, it still illustrates the need for the application of avoidance and good engineering as tools for habitat conservation (see Box 3).

Restoration of affected ecosystems can also be included in the engineering design of projects. There are many cases in Latin America in which urban wetlands were restored as project engineering (Quintero, 2007). The wetlands at both Cartagena and Bogotá, Colombia, were at varying degrees of degradation prior to the initiation of water and sanitation projects. In Bogotá, this happened despite their protected status. The main problems affecting the wetlands around Cartagena and Bogotá involved: 1) illegal occupation of urban spaces, 2) loss of biodiversity, 3) destruction of mangroves, 4) filling of wetland ecosystems, and 5) public health issues. Both for Cartagena and Bogotá, a wetland restoration program was implemented as part of the project. The public works themselves helped stop and reverse some of the damage because they: 1) ceased disposal of effluents directly into the wetlands; 2) improved or re-established flow among water bodies and waterways, thus avoiding the isolation of particular areas and restoring previously fragmented habitats; and 3) constitute physical barriers that will prevent future urban sprawl into the wetlands.

In Bogotá, 600 ha of wetlands were physically, hydraulically, and ecologically restored as part of the project. Wetlands and storm water drainage systems were demarcated by bordering these areas with linear parks. Bike routes, walking trails, and passive recreational areas run along rivers and canals, serving multiple functions. The canals and paths serve as physical barriers that prevent encroachment into the wetlands and serve as urban spaces where the public can enjoy the aesthetic values of the landscape.

Long-term restoration is quite important in mining projects with large footprints over a long time span. A notable case is the Cerrejón Mining Project in Colombia (see Box 4). For small mining, Oro Verde Gold Mining is an example of an alternative form of artisanal mining development that is sensitive to biodiversity needs, while also benefiting social and economic criteria. Located in Colombia and founded in 1999, the Oro Verde has been in operation since 2001, mining both gold and platinum. The Chocó region is a biodiversity hotspot which not only contains a diversity of habitats from tropical rainforests to alpine tundra, but is also home to an array of endemic species. The area had been subject to considerable environmental degradation due to mining, logging, and agricultural land conversion (palm oil and illegal coca) and is also very poor in comparison to other parts of Colombia and the rest of the world. In fact, the Afro-Caribbean communities that inhabit the Chocó are descended from the African slaves brought into the region by the Spanish conquistadors to extract gold centuries ago.

Box 3. GASBOL Pipeline: Engineering Solutions to Minimize Impacts on Natural Habitat

The case of the GASBOL Pipeline demonstrates how to integrate biodiversity conservation into infrastructure planning to avoid critical natural habitats while also engaging local communities. Furthermore, the infrastructure can in fact help drive biodiversity conservation through fund generation and insights from EIAs. Extending over 3,000 km through largely unpopulated areas between Bolivia and Brazil, GASBOL is among the largest gas pipelines in South America. This area covers a range of diverse habitats from mountainous areas to wetlands and tropical forests. Despite its extension, and overcoming differences between the countries' infrastructure networks, legal structures, and stakeholder agreements, the project's overall footprint is minimal. The alignment of the pipeline was designed with three criteria: avoiding sensitive ecosystems when possible, reducing the size of impacted areas, and devising techniques that caused minimal disturbances to the landscape and ecosystem functions. Highlights include:

- The pipeline was re-routed to avoid sensitive ecosystems and the width of the right of way (ROW) was reduced in many transects, again avoiding habitat impacts (avoid);
- 13 rivers were crossed by drilling under the river beds. This employed horizontal drilling techniques to minimize disturbance to riparian vegetation;
- Steep terrains were avoided by tunneling, thereby avoiding erosion, sediment accumulation, slope instability, and landscape alterations;
- Wetlands were crossed using a pushing and pulling method during the rainy season. This method floated sections of pipe into position thereby requiring less habitat clearing than conventional methods;
- A 13-meter wide strip along the ROW of the pipeline underwent extensive revegetation. 2007 surveys of the 3,150 km pipeline indicate little or no trace of ecological footprints from construction activities;

- Funds were provided by a comprehensive ecological compensation plan to support a total of 13 protected areas (described elsewhere in this paper)

The GASBOL Pipeline Project generated several lessons:

(a) Careful and considered design around the location of the pipeline was a primary concern. The pipeline was re-routed in several areas, be it horizontally or vertically, to avoid impacts to the landscape.

(b) Large infrastructure projects can drive both in situ and ex situ conservation. Whether through political influence, conservation project funding transfer mechanisms, or changes in legal and regulatory frameworks, large-scale infrastructure projects are significant opportunities to enact change beyond the project site itself.

Environmental supervision during construction is essential to guarantee implementation of agreed environmental management plans.

Box 4. Long-term Restoration: the Cerrejón Mine – Colombia

Cerrejón is an open-pit mining operation dedicated to the exploration, extraction, transport, shipping, and export of thermal coal. It is located in the northeast of Colombia, on La Guajira peninsula (Figure A). The mining operation uses the truck-and-shovel method and currently has a production capacity of 32 m metric tons of coal per year. Cerrejon's open-cut mines represent one of the biggest earthmoving operations worldwide. Cerrejón has developed a Wildlife Management Plan that includes four specific programs (Conservation International – Cerrejon, 2012):

Biodiversity Conservation Initiatives: Cerrejón participates in various biodiversity conservation initiatives, engaging with public and private organizations. Cerrejón also supports programs advocating the establishment of new regional and national conservation areas. One example is Cerrejón's initiative for recovery and conservation of endangered species in Alta Guajira. The company performed a population census of the American crocodile (*Crocodylus acutus*), hawksbill turtle, loggerhead sea turtle, leatherback turtle, and green turtle (*Chelonia mydas, Dermochelys coriacea, Eretmochelys imbricata, and Caretta carett*a). In 2007, Cerrejón developed a five-stage program to conserve these species).

Fauna Rescue and Rehabilitation: Prior to deforestation of areas required for mining, a process of locating and identifying low-mobility animals to allow relocation later to areas that are not affected or have been reclaimed was implemented. This initiative is known as the Wildlife Rescue Program for Mining Areas. After fauna are released, they are monitored to track their condition and to ensure they are adapting to their new habitat. Approximately 26,000 animals (including mammals, fish, amphibians, and reptiles) have been rescued and relocated to safe areas that offer habitats and food sources similar to their original location. In addition, other activities, such as acquiring nearby land and core habitat for the local species and prohibition of commercial hunting and fishing along with protection of key habitats, are implemented in order to guarantee the relocation and survival of the species (Cerrejón, 2012).

Land Rehabilitation Plan: As part of the ecological restoration program, a land rehabilitation plan focused on those areas intervened by mining operations and has recuperated 2,652 has. (25 percent of the total area intervened during 26 years of operation).

Fauna Rehabilitation Center and Education Program: The Cerrejón Fauna Rehabilitation Center (CRFC—its Spanish acronym) was created in 2007 for the veterinary care of wildlife. The center's staff comprises a biologist, a veterinarian, and several field assistants who serve as local experts. The team manages fauna recovery processes. The CRFC also treats animals from outside the mine's immediate area of influence. To date, more than 1,600 animals have been treated at the center, including fish, birds, mammals, and reptiles.

Monitoring: A monitoring team analyzes the species composition, abundance, diversity, and spatial-temporal distribution of populations of amphibians, reptiles, birds, and mammals in the area of the mine. The monitoring program generates data necessary to continuously improve environmental management plans to ensure that wildlife is not affected by mining operations (ICMM, 2010). Currently, Cerrejón's biological databases complement national databases on biodiversity compiled by the Alexander von Humboldt Institute. Ongoing monitoring has shown a threefold increase in the number of species recorded in the zone since the baseline studies in 1982.

Oro Verde aims to address these deeply rooted economic, social, and environmental inequities through so-called responsible mining standards that the miners must meet to maintain their certification under the program: (a) There is no massive ecological destruction that generates changes to the ecosystem of such scope that make impossible the restoration of the area in the medium term; (b) Toxic chemicals as mercury, cyanide and other important contaminators are not used in the process of extraction and benefiting; and (c) The exploited areas will achieve ecological stability in the following three years (http://www.greengold-oroverde.org).

There are also good examples of addressing natural habitat issues in the growing field of wind power in the region. In the Yucatan Peninsula in Mexico, some wind farms (La Ventosa, Equus) area carrying out extensive avifauna surveys and monitoring of bird collisions during operation. More importantly, some farms have included bird kill indicators to define thresholds to modify operating rules or complete shutdown of operations.

5. Moving Forward: Improving Natural Habitat Practices in Latin America

Many innovative strategies for natural habitat conservation and protection in infrastructure projects have been applied in Latin America. Key elements of this success include a strong legal and regulatory national framework for environmental impact assessment and clear mandates on habitat conservation in policies for lending operations from multilateral agencies. International development agencies, such as the IDB, should maintain an active dialogue with governments on improving their environmental assessment system to mainstream and upstream the protection of natural habitats. This dialogue can be complemented with initiatives and alliances with NGOs.

The principles of green infrastructure have not, however, been fully mainstreamed in Latin American countries. Most of the attention to natural habitat issues is concentrated at the project level, with limited attention at the sector and policy levels:

- Few countries in Latin America have introduced green infrastructure principles at the policy level. Financial mechanisms to transfer funds from infrastructure to biodiversity conservation are generally lacking. Compensation requirements are not explicitly included in environmental legislation.

- There is no strong legal driver for SEA in the region since few countries in the region have taken SEA into consideration in their legislation as a requirement for policy changes, established sector plans, or large-scale infrastructure. Cumulative impact assessment is rarely applied to sector plans. Fragmentation and connectivity issues are generally not included in EIAs. The main drivers for strategic planning and biodiversity-inclusive EIAs or SEAs are the requirements of multilateral agencies such as the IDB and, to a lesser extent, the World Bank.
- At the project level, the mitigation hierarchy is applied to avoidance and mitigation. Compensation and restoration at the project level is applied mainly because of requirements of policies form lending agencies or as initiatives from private sector investments.

5.1 Implementing the Multi-level Approach

A more systematic approach for natural habitat conservation and protection in infrastructure projects is therefore needed in Latin America. The green infrastructure concept and principles can be used to promote effective mainstreaming of natural habitat issues at the policy, sector, and project levels. How to implement this multi-level approach for green infrastructure? Actions are needed at each level and on different scales:

At the policy and sector levels:

- Avoid critical natural habitats. This is the best and cheapest option available. Critical natural habitats should be flagged as “no-go areas” in planning for infrastructure development. In addition, habitat conservation and restoration needs transboundary conservation efforts in expanding the network of protected areas, creating buffer zones, restoring connectivity between patches of habitat within landscapes, reducing poaching, securing long-term funding, and applying stringent requirements for habitat conservation infrastructure development policies. Finally, the need and the mechanisms for compensation should also be included in environmental regulations.
- Promote habitat conservation in sector plans. Infrastructure sectors have numerous options within the mitigation hierarchy, including having explicit habitat conservation

goals, effective stakeholder engagement, environmental management systems, and biodiversity offsets. Sector plans should assess the induced and cumulative impacts of such plans on natural habitats. Tools like Strategic Environmental Assessment, Cumulative Impact Assessment, and land-use planning should be promoted at the sector level.

At the project level:

- Improve Environmental Impact Assessment Practices. EIAs should include a thorough analysis of alternatives for project siting, avoiding sensitive sites, minimizing direct impacts, and including minimization and compensation in environmental management plans and project costs. Even at the project level, there are still opportunities to analyze cumulative impacts of individual project. Thus, EIA regulations should require cumulative impact assessment on natural habitats. Mainstreaming biodiversity at the feasibility levels will improve the analysis of alternatives for project siting or alignment.

- Apply sound engineering designs at the project level. These could include for roads: the use of open-span bridges/bridge extensions and minimizing paving and design that considers hydrological impacts, to name a few. For hydroelectric projects: fish transfer, ecological flows, or ecological releases.

- Implement good management during construction. Attention should be paid to limiting ancillary roads and settlements and establishing strict policies for workers with respect to hunting, harvesting, pest control, and others.

5.2 The Need for Clear Mandates for Biodiversity Conservation in Infrastructure Projects

A clear mandate of habitat conservation in lending policies is the foundation for fully integrating conservation efforts into the project cycle. Of particular concern is the allocation of funds from project budgets to ensure sufficient capacity building for clients, implementing and/or initiating habitat conservation components of projects, and providing sufficient supervision. Experience shows that such funding should be clearly described as an independent item in project's financial plan and specified in the corresponding legal agreements.

Encouraging policy/regulatory changes in Latin America similar to those in Brazil and Colombia could facilitate biodiversity conservation in infrastructure projects in the region. More often than not, the reluctance of infrastructure sectors to adhere to good ecological policy is the lack of a legal basis for compensation.

5.3 Establishment and Dissemination of Biodiversity Screening Tools

It is worthwhile to highlight the importance of thorough screening at early stage of project planning for potential issues in habitat conservation. The benefits of identifying whether there are any natural habitats of conservation importance, named under certain international treaties, or host certain species that are endangered as early as possible during the project cycle, cannot be overstressed. Only at this stage of project can "avoidance" be possibly integrated into design and hence some potential impacts can be avoided.

Flagging potential issues or risks associated with natural habitats does not necessarily take long. Driven by an increasing awareness internationally of the importance of harmonizing infrastructure development and conservation of natural habitats, coupled with advances in cyber and satellite technologies, a generation of web-based tools for environmental screening has been developed. Such developments have made available numerous interactive maps and search engines. With these tools, environmental specialists can obtain a quick picture of the major conservation targets in the project areas concerned within just a few minutes. However, because of the lack of data or different data categorization methodology, these tools should ultimately be considered as compliments to site visits and up-to-date information collected from local agencies as the environmental assessment process proceeds. In terms of computer software requirements, most of the tools do not require more than the normal settings and high-speed Internet unless otherwise noted.

Some decision support tools have been developed to provide the foundation for information and spatial analysis that provide a strong starting point for this environmental baseline. Currently, the most advanced of these tools for Latin America is the Environmental Safeguards Tool on the Data Basin technology platform (www.databasin.org). This tool aggregates and updates data on Protected Areas (World Database on Protected Areas), species of concern (Alliance for Zero Extinction, Key Biodiversity Areas, Important Bird Area), and terrestrial ecosystems (TNC/NatureServe priority map of terrestrial ecosystems).

In areas where the level of environmental and biological inventory is not sufficient to document the existence of critical conservation features across the project area of influence, additional baseline data collection efforts are required. These efforts should use available current resources to indicate what important ecological and biological features might be in the project area of influence. Range maps for known species of concern can be accessed through web resources provided by the IUCN Red List (www.iucnredlist.org) and NatureServe (www.natureserve.org/infornatura/). In addition to these regional scale information resources, local scientists and conservation experts should be consulted to identify whether any critical species should be inventoried in the project area of influence.

Regardless of the amount of research and inventory available, there will always be gaps in our information base. Documented data gaps should be reported to address potential risk to natural habitats that may be identified later in the project cycle.

A web-based screening tool for infrastructure projects (linear, spatial) has been developed in Colombia by Conservation International-Colombia. TREMARCTOS-COLOMBIA (http://www.tremarctoscolombia.org/home.html) is a web-based biodiversity system that screens potential impacts on biodiversity from infrastructure projects and provides recommendations for eventual compensation that must be included in the project design. It can screen linear projects (roads, transmission lines, pipelines), and spatially defined projects (such as dams, reservoirs, and mining projects). Screening criteria include species distribution, threatened species, protected areas, and areas of socio-cultural importance. It includes over 30,000 reference polygons for the distribution of threatened, migratory, and endemic species of Colombia.

5.4 Biodiversity-Inclusive EIA and SEA

Although EIA has been widely used throughout the region for over four decades, biodiversity issues are still treated in a very superficial manner. There is a need to raise awareness of biodiversity/ecological tools in impact assessment. Furthermore, although SEAs are being used throughout the region, also in an ad hoc manner, biodiversity-inclusive SEAs are infrequent in the region.

In Latin America, important sectors driving not only the investments in infrastructure but also the policies that provide incentives to private sector initiatives have not always been the drivers of the SEA processes that affect their sectors. In cases where they are, there is a greater likelihood of adoption of the policy and programmatic approaches emerging from the analysis. Challenges to achieving this include the lack of specialized personnel with environmental and social training to drive the process, especially in view of the absence of legal requirements and competing institutional mandates for other operational activities (such as supervising projects).

In promoting SEAs, the concept of tiering needs to be included. Linking SEAs to EIAs can be more effective in guaranteeing mainstreaming throughout the project cycle. For instance, in the hydroelectric sector, SEAs can be utilized at the policy and plan level (10-year investment program); Cumulative Impact Assessments can then be carried out at the basin level to screen out high-impact projects, and issues such as ecological flows, no-go areas, regional compensatory area programs can be evaluated; and EIAs will continue to assess siting issues and mitigation and compensation measures to be implemented by a specific project.

The preparation and dissemination of guidelines, training, and capacity building in biodiversity- inclusive EIAs and SEAs is a priority for the region.

5.5 The Role of Multilateral Banks

Last but not least, it is important for multilateral agencies' environmental specialists to recognize their roles in bridging efforts on biodiversity conservation and engineering. They should be able to promote the concepts of biodiversity and ecology via effective communication with governments, investors, project designers, and engineers. After all, it is inter-disciplinary collaboration that will enable and sustain conservation activities.

Recognizing the rich biodiversity of most countries in Latin America, infrastructure development, a dire need for the region, can play an important role in advancing green infrastructure principles in the region.

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