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## BIODIVERSITY CONSERVATION IN ROAD PROJECTS: LESSONS FROM WORLD BANK EXPERIENCE IN LATIN AMERICA

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**Abstract:** The unprecedented and irreversible loss of biodiversity in modern times is caused primarily by the elimination or degradation of natural habitats around the world. Since the construction and improvement of roads sometimes leads, directly or indirectly, to the loss and degradation of natural habitats, road construction and biodiversity aims are often at odds. However, many potentially serious conflicts between road projects and biodiversity conservation can be avoided.

Induced negative impacts of road projects on biodiversity can be minimized by careful project siting, taking special care to avoid passing through protected areas and other critical natural habitats, including forested areas (which are especially vulnerable to induced impacts). Where some natural habitat loss is inevitable, appropriate mitigation may include the establishment of strict protection zones alongside the road, or compensatory protected areas elsewhere to offset the expected road-related natural habitat loss (as is typically required under the World Bank's Natural Habitats Policy). This kind of mitigation requires effective inter-agency collaboration--for example, between the agencies responsible for roads and protected areas.

Direct adverse impacts of road works on biodiversity can also be significant, but they are generally simpler to avoid or mitigate, because they are more fully under the control of road construction agencies, contractors, and concessionaires. Biodiversity loss and environmental damage can be considerably reduced when planners and road construction agencies site roads adjacent to existing railways, pipelines, or transmission lines; practice sound road engineering; maintain good drainage and natural water flows; minimize roadside habitat loss; and, exercise care in the siting and design of borrow pits, construction camps, and other complementary facilities. Environmental rules for contractors, including transparent penalties for noncompliance, need to be incorporated within bidding documents and contracts.

Ideally, road projects are designed and implemented so as to avoid or compensate adequately for any adverse impacts on natural habitats and biodiversity. Through mitigation measures such as support for compensatory protected areas, potentially controversial projects can even produce significant net environmental benefits--a win-win outcome.

**Note:** The personal opinions expressed in this paper are those of the authors and do not necessarily represent the official views of the World Bank.

## **BIODIVERSITY CONSERVATION IN ROAD PROJECTS: LESSONS FROM WORLD BANK EXPERIENCE IN LATIN AMERICA**

### **INTRODUCTION**

The conservation of biodiversity (the variety of life on Earth, including ecosystems, species, and genes) has become a major, worldwide concern. The modern loss of biodiversity--evident in the recent and impending extinction of many animal and plant species--is unprecedented and irreversible; it is caused primarily by the elimination or degradation of natural habitats around the world. The construction and improvement of roads of all types sometimes leads, directly or indirectly, to significant loss or degradation of natural habitats and increased wildlife mortality (1). As a result, road projects frequently pose conflicts with biodiversity conservation objectives. The challenge for people who plan, build, and maintain roads is to reconcile the improvement of transportation infrastructure with the need to avoid serious damage to natural habitats and biodiversity.

In considering the adverse impacts of road works (construction, improvement, rehabilitation, and maintenance) on biodiversity and how to avoid or mitigate them, it is often useful to distinguish between direct and induced (indirect) impacts. **Direct impacts** are the effects of the road works themselves on natural habitats or species of conservation concern. **Induced impacts** are the result of those human activities which road construction or improvement make possible, rather than of the road works themselves. In most cases, the induced impacts of road works on biodiversity are both more serious and more difficult to control than the direct impacts.

### **INDUCED IMPACTS**

The most dramatic induced impact of a new or improved road is often the extensive deforestation that results when the road makes a remote forested area more accessible. In tropical Latin America, this deforestation is largely for extensive cattle pastures which generate little long-term employment and are often unsustainable (2). Even where new or improved road access does not result in deforestation for new pastures or croplands, it may facilitate increased logging, mining, hunting, or other activities which often threaten biodiversity. To prevent or minimize the loss of forests or other natural habitats and their biodiversity through induced impacts, road projects should be designed and implemented according to the following considerations.

**Project Site Selection.** To prevent biodiversity loss, new or improved road construction should, to the maximum extent possible, avoid natural habitat areas. Special attention is needed to avoid damaging **critical natural habitats**, which are defined in the World Bank's Natural Habitats Policy to include existing or proposed protected areas, as well as natural areas which lack legal protection but are of known high conservation value (3). To prevent serious and often irreversible induced impacts, new road alignments should avoid crossing or even passing close to critical natural habitats, unless effective mechanisms are in place to control these impacts. For existing national parks or other protected areas, any new road works should be recognized in the protected area management plan and agreed to and supervised by the protected area agency. This is the case for road improvements supported by the World Bank in several Argentine National

Parks under the Native Forests and Protected Areas Project approved in 1996; these improvements were carefully justified as a means to increase tourism and park revenues, with the understanding that any adverse induced impacts could be effectively controlled by park staff (4).

More broadly, it is important to avoid road construction or major improvements within most **natural forests**. Forested areas are typically more vulnerable to drastic, road-induced land use changes (such as deforestation) than are croplands, grasslands, or other non-forest areas. Road access is a necessary condition for most of the deforestation that is currently taking place in Latin America. In many remote areas, the most important (often, the only) policy option for effectively protecting the forests is to keep roads away from them, until effective mechanisms to control settlement and land use are devised in the future. In some forested areas (such as Amazonia), it is feasible to consider new or improved river or rail transportation as a viable alternative to new road construction, with a lower risk of extensive colonization and deforestation.

Biodiversity loss from the induced impacts of road projects can largely be avoided by choosing project locations away from forested “agricultural frontier” areas. With road construction and improvement in more densely-settled, **non-frontier rural areas**, the risks of deforestation and related biodiversity loss are greatly reduced, while a relatively larger population stands to benefit from improved access to markets and services.

In those cases where road construction or improvements are explicitly intended to open new lands to settlement, the burden should be on project planners to demonstrate that (i) the resulting regional development would indeed be sustainable, in terms of soil fertility and other environmental conditions, and (ii) the roads are fully justified economically, with no implicit subsidies for deforestation or other environmentally damaging practices. In those situations where such road projects are fully justified but significant loss or degradation of natural habitats is nonetheless likely to result, the projects should incorporate a specific component to support compensatory protected areas (as described below).

**Protected Area Establishment.** Despite the best site selection efforts, some projects involving road construction or improvement will inevitably pass through forests or other natural habitats, often with significant risk of adverse induced impacts on biodiversity. In some cases, it is feasible to establish and enforce **strict protection zones** to encompass the environmentally sensitive areas made accessible by the road (5). For example, Costa Rica’s Braulio Carrillo National Park was expanded in 1978 to encompass a forested areas with steep slopes that would be bisected by the new San José-Guápiles highway. Because of effective protection by the National Park Service, the area surrounding this section of highway is still forested today. However, this strategy of establishing roadside protected areas is likely to succeed only where there is adequate on-the-ground protection, with a sufficient number of field staff who are properly trained and equipped and receive strong political support. This favorable situation is still the exception, not the rule, in the Latin American tropics, so that many new or improved roads in natural areas would inevitably lead to significant loss of biodiversity and other induced environmental damage. If roadside protected areas are established, it is crucial for the on-the-ground protection measures to be fully in place before any construction begins (ideally, even before road survey markers are installed, since squatters sometimes use these markers to determine where to place their houses).

Another approach with considerable promise for conserving biodiversity is the establishment or strengthening of **compensatory protected areas** (away from the road's immediate area of influence). Compensatory protected areas are intended to partially offset the expected loss of natural habitats from a road or other project. Under the World Bank's Natural Habitats Policy, compensatory protected areas should be ecologically similar to, and no smaller than, the natural habitat area likely to be lost or degraded by a project, considering both induced and direct impacts (3). In World Bank-supported road projects requiring them, compensatory protected areas may be newly established, or existing protected areas may be strengthened to improve their on-the-ground protection and management. Support for compensatory protected areas in road projects typically requires an operating agreement between the agency responsible for road construction and the agency responsible for protected area management. Since the costs of environmental mitigation should normally be borne by the project causing the damage, the costs of establishing and managing compensatory protected areas should be considered part of the costs of the overall road project. Compensatory protected areas provide an opportunity to turn a negative project feature (natural habitat loss) into something environmentally beneficial (new or strengthened protected areas).

An interesting example of compensatory protected area establishment is in the World Bank-supported Colombia Toll Road Concession Project approved in 1998. This project involves the construction of a new, 68-kilometer section of highway to reduce travel time between Bogotá and Medellín, as well as between Bogotá and the Atlantic Coast. Construction of this important road segment entails the clearing of several very small fragments of natural forest (although this amount has been minimized by careful road siting). As compensation for this environmental loss, the project provides for the establishment of a new, 200 hectare protected area in the Rio Negro Canyon, encompassing rare Andean foothill forest of considerable conservation interest (6). In the case of this project, the bidding documents for road construction and operation specify that the concessionaire must pay for the physical demarcation, basic infrastructure, and management plan of the new reserve, which is to be managed under a contract with a non-governmental organization experienced in protected area management. The recurrent costs of managing this reserve are to be covered by road tolls as a highway operating expense for the life of the concession (24 years).

## DIRECT IMPACTS

The adverse direct impacts of road works on biodiversity are generally easier to avoid or mitigate than the induced impacts, since direct impacts are typically more fully under the control of road construction agencies, contractors, and concessionaires. While direct impacts are normally less extensive than the more severe induced impacts, they can nonetheless be very significant for natural habitats and biodiversity. For example, in the mid-1970s, a new coastal highway connecting Barranquilla and Santa Marta was built atop a dike without adequate drainage works. This interrupted natural water flows and altered the salinity of coastal lagoons, resulting in the death of thousands of hectares of mangrove trees. Among other heavy environmental costs, the loss of these mangroves threatens the survival of various rare animals, such as the endangered Sapphire-bellied Hummingbird (*Lepidopyga lilliae*), which only occurs in mangroves along Colombia's Atlantic coast (7).

The guidelines that follow are intended to reduce the adverse direct impacts of road works

(including new construction, improvement, rehabilitation, and maintenance) on biodiversity and natural habitats. Many of these guidelines can also be adapted for use in other types of **linear infrastructure projects**, including railways, pipelines, and power transmission lines.

**Project Site Selection.** As with induced impacts, proper selection of the road corridor and alignment can be the single most important measure to avoid or minimize adverse direct impacts on biodiversity. In this respect, environmental assessments that explicitly include biodiversity considerations are very useful (8, 9). To minimize risks to biodiversity, new or improved roads should be sited to avoid crossing or otherwise affecting critical natural habitats or other highly sensitive areas (unless access to these areas is an explicit project objective, such as carefully controlled tourism). To the maximum extent feasible, roads should be sited to share the same corridor with existing or planned railways, pipelines, or transmission lines, to minimize disturbance to forests, wetlands, and other natural habitats. It is particularly important for biodiversity conservation to minimize the fragmentation of natural forests, because many forest-based animals do not successfully cross roads. For example, several monkey species including spider monkeys (*Ateles spp.*), Humboldt's Woolly Monkey (*Lagothrix lagothrica*), and the Black-bearded Saki (*Chiropotes satanas*) in the Amazon rainforest spend their entire life cycle in the trees and do not cross roads or other openings on the ground. Without careful planning of infrastructure corridors, the populations of these species can become highly fragmented and genetically isolated, threatening their long-term survival.

**Road Engineering.** Besides reducing other types of damage, sound road engineering and design work can significantly minimize harm to biodiversity. One of the most important engineering measures is ensuring proper drainage underneath the road. In particular, the **natural water flows** of streams, lagoons, and other wetlands need to be maintained through adequate bridges, culverts, or other drainage works. When a road functions as a dike or dam because of missing or inadequate drainage works, substantial damage to both aquatic and terrestrial biodiversity can result (as with the Colombia mangrove example noted above).

In forested areas, many roads could be designed to maintain partial **tree canopy cover** over them. In this manner, many animals could successfully cross the road over arboreal "bridges" and forest fragmentation would be reduced. A fine example of successfully maintaining tree canopy cover over a road is the paved highway between Maracay and Ocumare de la Costa in Venezuela, which passes through the mountainous Henri Pittier National Park (Ledec personal observation, 1992). Of course, maintaining tree canopy cover over roads is feasible only where induced deforestation (discussed above) can be successfully prevented.

Animal passage facilities (underpasses or overpasses) are sometimes justified on high-speed roads in order to keep significant numbers of wild animals (especially threatened species) from being killed by highway traffic. Animal passage facilities should be planned well in advance of road construction, with adequate studies of the natural (pre-highway) movements of the species of special concern (10, 11, 12, 13, 14, 15). Additional means of minimizing **wildlife road kills** include strategically-placed speed bumps, maintaining key road sections at lower standards to reduce traffic speeds, caution and animal crossing signs, broader educational programs (16, 17), strict enforcement of speed limits, and prohibiting driving at night (when most wildlife mortality occurs). Although some of the above may be politically difficult to implement, they may be viable options in some areas of special conservation interest.

Environmental specialists can help determine which of the above measures would be most appropriate and how and when road engineers could best implement them.

**Complementary Works.** Just as with the roads themselves, the siting of construction camps, storage yards, and other complementary works can affect biodiversity. To the extent feasible, these facilities should be sited away from forests, wetlands, or other natural habitats. In natural habitat areas, such facilities should be designed so as to minimize the removal of natural vegetation (consistent with safety and efficiency objectives). Construction camps and similar facilities should never be sited within protected areas, unless (as with roads) their placement is consistent with the management plan and approved by the protected area agency. In such cases, any camp buildings or similar facilities should be removed following road construction, unless the protected area agency wishes to keep them for park management purposes. In areas that were natural habitats prior to camp establishment, the natural vegetation should be restored as part of camp removal. It is important for the native species and ecosystems that no invasive exotic species be introduced.

**Construction and Maintenance Practices.** During construction, following good environmental practices can be important for protecting biodiversity, especially aquatic biodiversity. Measures to **control erosion and runoff** during construction (such as sediment traps) are important for maintaining water quality and aquatic life in adjacent streams, ponds, and other wetlands. Excavated earth, as well as all other **solid and liquid wastes**, needs to be deposited in pre-approved locations to avoid the degradation of waterways and wetlands. In this context, it is worth noting a special example of road works that can benefit biodiversity: paving a dirt road can substantially reduce erosion and runoff into water bodies, thereby benefiting fish and other aquatic life, provided that the induced impacts of increased human use are adequately controlled. (However, this environmental benefit of road paving is typically more than offset by the direct impact of increased road kills due to higher vehicle speeds, and more importantly, the induced land development that frequently results.)

Some of the **raw materials** used in road works can be of special concern for biodiversity conservation. For example, gravel extraction from river beds may harm sensitive aquatic life, by removing river-bottom habitat (often important for fish breeding) and increasing turbidity. Sand mining from coastal or riverine beaches may destroy the nesting grounds of rare birds or turtles. The timber used in construction may be of concern if it is from depleted or threatened tree species (as sometimes occurs with the durable woods used for railway ties). To safeguard biodiversity, **borrow pits** and other sources of raw materials should be chosen carefully to avoid critical natural habitats or other highly sensitive areas. Gravel should be extracted from wet river beds only as a very last resort, if no other feasible sources of material are available. New borrow pits and quarries should be sited and designed to minimize the loss of natural vegetation. Old borrow pits, if not drained, can become artificial wetlands attractive to native wildlife. To be most useful for biodiversity, these artificial ponds should have (i) gradual, not steep, banks (to facilitate re-growth of vegetation and wildlife use), and (ii) an irregular (not rectilinear) shape, ideally with small peninsulas, bays, and even islands.

Good **machinery maintenance** practices are important to prevent the contamination of water bodies and consequent harm to aquatic biodiversity. Specifically, the washing of vehicles or other machinery and the changing of lubricants should never be permitted in any rivers,

streams, or other water bodies.

Important biodiversity can often be conserved through proper **natural vegetation management** along the right-of-way or legal corridor for a road. For some Latin American highways, the legal right-of-way on each side of the road may be 30 meters or even wider (such as along federal roads in Northeast Brazil and along Route 12 between Corrientes and Posadas in Northern Argentina). Although it is important to maintain a narrow strip adjacent to the road free of tall vegetation for adequate drainage and human safety (emergency parking, pedestrian walking space, and visibility around curves), the remainder of the right-of-way can be valuable for biodiversity conservation if natural vegetation is maintained. Some road rights-of-way with natural vegetation serve as important biological corridors which connect larger patches of natural habitat on the same side of the road. While road kills still occur, there tends to be a net positive effect on biodiversity because of the increased connectivity of natural habitats. In natural grassland areas (such as portions of the Southern Cone), highway rights-of-way may harbor vegetation that is more natural than elsewhere because livestock grazing is prohibited (or should be, for safety reasons). Unfortunately, road maintenance programs (especially by private concessionaires) often unnecessarily eliminate natural vegetation in rights-of-way in an effort to make the roadways look more manicured, despite the higher economic costs. With biodiversity conservation in mind, the environmental specifications for road maintenance should be revised to maximize the presence of natural vegetation along roadways, consistent with safety and other important objectives.

**Worker Behavior.** To minimize harm to biodiversity during road construction (or improvement, rehabilitation, or maintenance), it is important to regulate the behavior of workers in the field. Specifically, workers on road (or other) projects should be prohibited from hunting, fishing, wildlife capture (including for pets), plant collection, or burning of natural vegetation, anywhere in or near the project area. Only security personnel (not other workers) should be allowed to possess firearms. Workers need to be clearly informed of these and similar environmental rules of conduct, along with the penalties for noncompliance (which should be strict and transparent).

**Environmental Supervision.** To ensure that damage to biodiversity (or other environmental concerns) is avoided or properly mitigated in the field, strict environmental supervision of road works is needed. This is especially important for projects in natural habitats and other environmentally sensitive areas. **Bidding documents and contracts** for road works should specify the environmental rules which contractors would be required to follow, along with noncompliance penalties and environmental supervision arrangements (8, 18).

**Experience with World Bank Safeguard Policies.** Mandatory Safeguard Policies, first instituted in early 1990s, establish institutional standards and provide a mechanism for introducing good practices and mitigation measures into World Bank-supported projects, including the ones described above. The Environmental Assessment and Natural Habitats policies (3, 19), in particular, lay the groundwork for more effective biodiversity conservation by ensuring that local environmental and social issues are considered, critical natural habitats are protected, and non-critical habitat loss is mitigated or compensated. These Safeguard Policies recognize biodiversity conservation as an integral part of a broader environmental sustainability agenda that includes conserving natural habitats, protecting valuable environmental services, and

promoting more sustainable human development. Other World Bank Safeguard Policies related to the environmental or social aspects of development projects (including road works) include Involuntary Resettlement, Indigenous Peoples, Cultural Property, Pest Management, International Waterways, and Disputed Areas.

## CONCLUSION

Effective implementation of the above guidelines would go a long way towards reducing the conflicts that exist between road works and biodiversity conservation. Minimizing the adverse direct impacts of road projects on biodiversity implies following good environmental practices related to project siting, engineering, construction, and maintenance. These good practices do not just protect biodiversity; they can also help maintain clean water supplies and public health, minimize local flooding, avoid conflicts between construction workers and local populations, reduce vegetation maintenance costs, and minimize damage to the roads themselves from water infiltration, erosion, and landslides. Dealing adequately with induced impacts is often more complex, sometimes requiring collaboration between the entities responsible for road construction and protected area management. However, many potentially serious conflicts between road projects and biodiversity conservation can be avoided by careful project siting, taking special care to avoid passing through critical natural habitats or other highly sensitive areas (including most tropical forests). Incorporating biodiversity conservation into the design and implementation of road projects is an important example of how the goal of environmentally sustainable development can be translated into a concrete reality.

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