Protected reserves within tropical forests managed for timber production: recommendations using Bolivia as a case study

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SUMMARY

The Bolivian forestry law requires that 10 per cent of areas under forest management must be set aside as 'ecological reserves', serving as protected areas from resource extraction. These guidelines appear to be based largely on reserve design theory from the conservation biology literature including recommendations for large, contiguous blocks of reserves interconnected with other protected areas through corridor networks. Such recommendations, however, are largely applicable to protected areas that are embedded within fragmented landscapes or where there is significant threat of deforestation. In contrast, protected areas within managed forests in Bolivia are surrounded by areas of largely intact forest subjected to low-intensity reduced impact logging and where logging occurs with a felling cycle not less than 20 years. Following an analysis of the current Bolivian law, conservation goals, and pertinent literature, we argue that issues of size and connectivity are perhaps less important within landscapes dominated by areas under forest management for timber production compared to protected areas imbedded within fragmented landscapes. It may, therefore, be more effective to disperse ecological reserves throughout management units to protect critical habitat and sites prone to damage from logging.

Keywords: biodiversity, conservation, forest management, logging, protected area

Réserves protégées à l'intérieur des forêts tropicales sous gestion de production de bois: recommendations en utilisant la Bolivie comme étude-cas.

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La loi de foresterie bolivienne requiert que 10% des zones sous gestion forestière soient mises de côté comme " Réserves écologiques", pour servir de zones protégées de l'extraction des ressources. Ces lignes de conduite semblent être basées largement sur une théorie maquette de réserve issue de la littérature de biologie de conservation, et comprennent des recommendations pour établir de grands blocs continus de réserves connectés à d'autres zones protégées par un ensemble de corridors. Ces recommendations sont cependant largement applicables aux zones protégées au coeur de paysages fragmentés, ou aux zones en fort danger de déboisement. Par contraste, les zones protégées au sein des forêts sous gestion en Bolivie sont entourées de zones de forêt largement intactes sujettes à une coupe de bois à faible intensité et à impact réduit, et , quand la coupe s'opère, elle poursuit un cycle de 20 ans au moins. A la suite d'une analyse de la loi bolivienne actuelle, des buts de conservation et de la littérature appropriée, nous démontrons que les questions de taille et de connectivité sont peut-être moins importantes dans un paysage dominé par des zones sous gestion forestière pour la production du bois, que dans des zones protégées au sein de paysages fragmentés. Il serait peut-être par conséquent plus efficace de disperser les réserves écologiques à travers les unités de gestion pour protéger les habitats critiques et les sites vulnérables lors de la coupe du bois.

Reservas protegidas dentro de bosques tropicales manejados para producción de madera: recomendaciones basadas en un estudio en Bolivia

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La Ley Forestal boliviana requiere que un diez por ciento de las áreas forestales gestionadas debe ser conservado en forma de 'reservas ecológicas', zonas protegidas de la extracción de recursos. Parece que estas pautas son basadas en la teoría de diseño de reservas expresada en el material publicado sobre conservación biológica, ya que incluye recomendaciones para grandes bosques contiguos de reservas interconectados con otras zonas protegidas mediante redes de corredores ecológicos. Sin embargo, estas recomendaciones fueron diseñadas para áreas protegidas dentro de paisajes fragmentados, o donde existe una amenaza significativa de deforestación. En cambio, las zonas protegidas en bosques gestionados en Bolivia suelen ser rodeadas de áreas forestales en su mayoría intactas y sujetas a tala de baja intensidad e impacto reducido, donde la tala sigue un ciclo no menor de viente años. Después de una evaluación de la legislación boliviana actual,

de los objetivos de la conservación y del material publicado relevante, se sugiere que los temas de tamaño e interconectividad pueden ser menos importantes dentro de paisajes forestales gestionados en mayor parte para la producción de madera que en zonas protegidas dentro de paisajes fragmentados. Por eso puede resultar más eficaz proteger el hábitat crítico y los lugares susceptibles a sufrir daños causados por la tala a través de la distribución de las reservas ecológicas por la totalidad de las áreas gestionadas.

INTRODUCTION

Tropical forests are arguably the most biodiverse terrestrial ecosystems on the planet. Protected areas of tropical forest are currently thought to be inadequate for biodiversity protection because they are not sufficient in size, number and distribution over the landscape (Fimbel *et al*. 2001) and because they are often not representative of all forest types and areas with particularly high biodiversity (Frumhoff 1995). With timber harvesting becoming increasingly frequent in tropical forests, the design and placement of protected natural areas within forests subjected to logging may allow for protection of at least some elements of biodiversity within management forests (Marcot *et al.* 2001, Sayer *et al.* 1995.).

In Bolivia, the forestry law enacted in 1996 (Forestry Law 1700, MDSP 1996) defines two major types of production forests; forestry concessions and private lands, both of which can be owned by an individual person or by local groups or indigenous communities. For simplicity, we refer to these production forests hereafter as 'managed forests' or 'production forests'. Furthermore, the forestry law not only calls for the implementation of reduced impact logging (RIL) techniques by owners of managed forests , but also requires that owners set aside 'ecological reserves' within their areas under forest management. These reserves consist of areas within production forests where no resource extraction is permitted. The importance of these reserves within production forests is well established in that they provide refuges for wildlife sensitive to logging, protect critical wildlife habitat (e.g., breeding and feeding areas), and protect areas sensitive to logging damage (e.g., water sources and wetlands, steep slopes, soils especially prone to logging damage) (Hunter 1990, Sayer *et al.* 1995, Mason and Putz 2001). In addition, ecological reserves serve as a legacy of undisturbed forest for the purpose of monitoring logging impacts and have heritage values as examples of undisturbed ecosystems.

The guidelines for the designation of ecological reserves can be found within Articles 39 and 40 of the Bolivian forestry law. There is no absolute minimum area that is required to be set aside as ecological reserves within management areas, although some area are required to be protected if they meet certain criteria. Article 39 encourages the creation of reserves by allowing up to 30% of the managed forest area to be exempted from the US$1 per ha tax on managed forests by designating areas as ecological reserves. In addition, it suggests that these areas should be consolidated or linked together through corridors to facilitate their identification and protection, as well as to increase their conservation effectiveness. The article specifically requires that 50% of reserve areas be linked through corridors and not be divided into more than four separate areas. It also directs that the detailed location of the reserves be noted and benefits of the designated locations for the reserves be discussed in the forest management plan for the managed forest.

Article 40 provides more specific information on which areas should be included within ecological reserves. One specification requires that areas with slopes greater than 45% be protected, although areas up to 60% could potentially be harvested where soils are stable and harvest methods are appropriate. Justification for these exceptions is required to be included in the forest management plans. In addition, areas of special biological importance, such as colonial bird nesting sites, must be identified within managed forests and should be surrounded by a 100m protected zone. Finally, water course, such as rivers, ponds, lakes and wetlands should be surrounded by a 50m protected zone, while small streams should have 10m protection zones on each side.

GOALS AND METHODS

In this article the findings of ecological research involving protected areas within production forests and their recommendations are summarized and research conducted within Bolivia as well as in other tropical forests is examined. Information gathered on a workshop on protected areas within managed forests held in Santa Cruz, Bolivia in April, 2002 is also used. This information is combined to propose recommendations for the establishment of protected areas in forests where logging occurs in the tropics.

CONSERVATION IMPORTANCE OF PROTECTED AREAS

The conservation importance of protected areas is of greatest importance when surrounded by a deforested or fragmented landscape (Lovejoy and Bierregaard 1990). In Bolivia, managed forests for timber production are still largely imbedded within a landscape dominated by intact forest. While resource extraction, most notable timber extraction, has occurred within these areas, the extraction intensity has been low relative to forests in other parts of the tropics, and appears to have had marginal impacts on biodiversity (Fredericksen and Putz 2003, Fredericksen 2000). Road building, however, has increased access to forests by colonists throughout Bolivia and wildfire has damaged large tracts of forestland in the Department of Santa Cruz (Steininger *et al.* 2001), which has contributed to the potential for isolation of some timber management areas. Consequently, given that protected areas within managed forest are still imbedded within selectively logged forest, and not within a landscape

dominated by urbanized areas, pastures or agricultural fields, the biological importance of protected areas perhaps is not as high as it would be compared to more isolated forest reserves.

Because of relatively low rates of harvest intensity (< 20 m^3/ha), impacts of selective logging on biodiversity (reduction of the abundance or species richness, or species diversity of organisms) also do not appear to be severe within harvested forests in Bolivia, thus decreasing the relative conservation importance of protected areas as a buffer to logging disturbance. While selective logging can provoke short-term changes in wildlife species composition, most studies of biodiversity responses to logging in Bolivia do not indicate statistically significant declines in the abundance or species diversity of flora or fauna (Mostacedo *et al.* 1998, Fredericksen *et al.* 1999, Fredericksen and Fredericksen 2002, Flores *et al.* 2001, 2002, Herrera *et al.* 2003, Woltmann 2003). In Bolivia, hunting within managed forests appears to have had a much larger impact on biodiversity (Rumíz *et al.* 2001). While many studies do not show severe impacts of logging on biodiversity, this does not reduce the conservation importance of reserves with respect to their role in protecting critical habitats for species (habitats that are essential to the survival and reproduction of a species) and fragile areas which might be sensitive to damage by logging, such as riparian areas, steep slopes, and wetlands.

DEFINING ELEMENTS TO BE INCLUDED IN PROTECTED AREAS

Marcot *et al.* (2001) list several universal considerations for inclusions within protected areas which include key habitats for priority wildlife species, buffer areas around streams, scarce and declining habitats, and specialized habitats. Priority species include threatened and endangered species and species of special concern. They also include regional or local endemic species. Their habitats may include nest or den sites, resting sites, or important feeding sites.

There is a large body of research that supports the need to protect perennial, intermittent, and ephemeral streams (see Pringle and Benstead 2001). Riparian buffers lessen erosion and subsequent sedimentation (Phillips 1989). Vegetation close to streams provides cover for wildlife when visiting water sources and other wildlife whose habitat is restricted to riverine areas (Mason 1995, Wallace *et al.* 1996, Machtans *et al.* 1996). Riparian areas provide habitat for many endangered species, including the giant otter (*Pteronura brasiliensis*) and the black caiman (*Melanosuchus niger*). Riparian forests are particularly important in areas with strong dry seasons, where they may serve as the only sources of water for wildlife (Guinart 1997). These forests often host a particularly high abundance of fleshy-fruited species important for wildlife including those in the families Palmae, Moraceae, Sapotaceae, and Annonaceae. Bats and other birds may use streams and rivers as flyways. Amphibians depend on moist riparian sites for breeding and protection against desiccation (Fredericksen and Fredericksen 2004, Vitt and Caldwell 2001). Some species of monkeys preferentially use riparian forests, such as howler monkeys (Guinart 1997).

It has been recommended that locally or regionally scarce or declining habitats and areas containing special locations, such as salt licks, caves, rock outcrops, palm groves, and ponds, be considered for protection (Marcot *et al.* 2001). Salt licks are areas of bare mineral soil where salts accumulate at the surface. Salt licks usually occur in or near wetlands and rivers and are used by peccaries, tapirs, deer, parrots, guans, and many other types of wildlife (Guinart 1997). Caves are also important roosting areas for many species of bats and may provide denning sites for other medium and large mammals. Forests around rock outcrops often support a unique flora and fauna (Fredericksen and Fredericksen 1998). Flow of water and deposition of organic matter and minerals often create productive forests at the bases of rock outcrops and these areas often support high concentrations of palms and fleshy-fruited species (Fredericksen and Fredericksen 1998). The rock outcrop itself often contains concavities that fill with water providing drinking sources for wildlife and loose rocks provide shelter and roosting areas. Thermal heat retention often supports nocturnal insect activity attracting a large number of birds and bats (Fredericksen and Fredericksen 1998). Finally, rock outcrops often host endemic plant and animal species (Ibisch *et al.* 1995, Fredericksen and Fredericksen 1998).

DEFINING THE SIZE AND PLACEMENT OF PROTECTED AREAS

There has been an ongoing debate in conservation biology concerning the size, shape, and placement of ecological reserves, but most of the debate has revolved around the placement of reserves embedded in fragmented landscapes (Saunders *et al.* 1991, Bierregaard *et al.* 1992). Numerous recommendations have been made for reserve size and placement (Table 1), but many of these recommendations appear to be arbitrary. Edge effects are particularly important for small blocks of forest surrounded by non-forested areas and are perhaps less important in areas subjected to selective logging within intact forests.

For reserve size, some scientists have advocated large contiguous reserves, while others have promoted more widely-dispersed smaller reserves (Diamond 1975). The connection of reserves using corridors has been recommended by some researchers, but others argue that some types of corridors, particularly narrow ones, many increase mortality risks for wildlife traveling through them (Simberloff *et al.* 1992). Within areas managed for timber, Marcot *et al.* (2001) promote larger versus smaller reserves that are compact and contiguous, with the exception of riparian buffers, in order to minimize edge effects. In addition, they recommend that reserves be closer together rather than spread apart in order to increase the opportunities for wildlife to move among them. These areas may be connected by corridors, which may include riparian forests. Lugo (1995), however, promoted a network of diffuse reserve areas scattered within small

TABLE 1 *Summary of some quantitative recommendations for the size of protected areas and buffer zones in areas under forest management*

Subject	Recommendation	Reference
Minimum size of protected areas	100-200 ha blocks. At least 10% of total area. 1000 ha blocks 10% of total forest area.	Blockhus *et al.*, 1992 Mason and Putz, 2001 Fimbel *et al.*, 1998 Blockhus *et al.*, 1992 Wadsworth cited in Lugo 1995
Riparian buffers	10-30 m 10-40 m 20-40 m 20-50 m	Sist *et al.*, 1998 Pringle and Benstead, 2001 Lugo 1995 Blockhus *et al.*, 1992
Limitation of logging on slopes	Not above 30-70% depending on equipment	Sist *et al.*, 1998

watersheds. It is important to note that many areas within forests managed for timber are not logged because they are on steep slopes, wetlands, or contain unproductive forests. These areas thus become *de facto* protected areas (Frumhoff 1995), and may be designated as 'official' protected areas, even though they may not be important habitat for wildlife or be representative of the major forest types within the managed areas. Non-forested areas, tracts with low productivity, and areas burned by wildfire have been conveniently designated as protected areas in some Bolivian production forests (Barrancos 2002). Forests consumed by wildfire, which is becoming increasingly common in Bolivia, can not be used for timber production and they have greatly reduced value for biodiversity conservation. The placement of reserves in these damaged areas allows forest managers to reach the mandatory 10% protection limit, therefore allowing them to harvest more intact forests elsewhere within the production forests.

Whether in large or small blocks, many researchers recommend that reserves represent a wide diversity of habitats in order to include types of habitat used by specific types of wildlife, as well as to provide a full range of undisturbed habitat used by wide-ranging species (Lovejoy and Bierregard 1990, Frumhoff 1995, Marcot *et al.* 2001). The recommendations for reserve sizes in the literature typically include a minimum are of 10% of the managed area (Blockhus *et al.* 1992, Lugo 1995, Fimbel *et al.* 2001, Mason and Putz 2001).

The landscape surrounding management areas should be considered in the design of protected areas. If possible, protected areas within managed forests could be combined with other protected areas outside of production forests to increase their effectiveness (Marcot *et al.* 2001). In any case, protected areas should be placed in areas difficult to access so that they are less likely to be invaded by colonists and poachers (Davies *et al.* 2001).

Riparian areas are perhaps the most frequently cited location of refugia within areas subjected to logging. The width of riparian buffers should vary by stream size and forest type and should be large enough to provide sufficient shading, vegetation structure, and sources of coarse woody debris into streams (Marcot *et al.* 2001). Sist *et al.* (1998) recommended buffer zones from 10-30 m along permanent streams in Malaysia. Mason (1995), however, indicated that riparian buffers larger than 100 m may be more important for protecting sensitive bird and mammal species. Fredericksen and Fredericksen (2001) recommended an area inclusive within 10 m on each side of temporary and perennial streams within Bolivian forests for the protection of amphibians.

RECOMMENDATIONS FOR PROTECTED AREAS IN MANAGED FORESTS

Based on the existing literature on protected areas and on the Bolivian experience in setting up protected areas in forests managed for timber production the following recommendations for setting aside protected areas are provided that may better fulfill the expectations of their creation:

1.Guidelines for defining protected areas in managed forests do not need to be as stringent as for isolated forest reserve areas when areas under forest management are enclosed in a forested matrix.

2. Specific guidelines governing the continuity of protected areas in forests within highly fragmented landscapes have limited applicability in intact forested landscapes where only light selective logging occurs. Consequently, it may be more effective to disperse the reserves throughout managed forests to protect smaller areas of critical habitat and other sites highly prone to damage from logging, such as steep slopes and riparian areas.

3. Protected areas should not be arbitrarily located. Forest inventories, aerial photos, and satellite data can be used to identify areas likely to be important for biodiversity protection or where they may be merged within the landscape matrix to increase their effectiveness and reduce their chance

of being damaged by wildfire or forest invasions. Foresters should become familiar with areas critical for wildlife and note the location of these areas during inventories. Local people familiar with managed forest areas often know where these critical habitat areas are located. Areas requiring protection should be determined by professional foresters and biologists and demarcated in the field. A general lack of knowledge concerning specific management areas perhaps hindered the ability of forest managers to appropriately designate protected areas during the preparation of the first management plan. However, after some years of active management, the Bolivian Forestry Superintendent's Office should expect that forest managers design a more ecologically appropriate system of protected reserves.

4. Protected areas should include representative portions of all forest types within managed areas, although priority should be given to areas that are sensitive to logging disturbance or represent critical habitat for wildlife. The representative forest type classification could be very general. For example, an equal representation of reserves could be established for high productivity forests, moderate productivity forests, and low productivity forests. Reserve areas in each forest type would allow for long-term monitoring of changes in forest species composition and structure in representative areas of managed forests for assessing the impacts of harvesting. These areas will help conserve tree species that might be over-exploited in harvested areas.

5. The appropriate size of protected areas is likely to vary widely among different forests and will largely depend on the number of water courses, steep slopes, critical habitats, and other areas that would need protection. The adequacy of the protected areas detailed in the management plan should be closely reviewed by the Forest Superintendent's Office.

6. Protected areas could be used for some purposes. Some possible uses of ecological reserves might include research, seed collection, and limited ecotourism. Despite their more limited impact compared to timber harvesting, extractive use of many non-timber products is probably not compatible with the conservation goals of protected areas. In some cases, conflicts with non-timber product uses may be inevitable when determining the placement of protected areas. For example, species suitable for heart-of-palm harvesting are typically confined to riparian areas, which would normally merit protected area status. While the disturbance from heart-of-palm harvesting is not nearly as great as timber harvesting, it still involves the felling of trees and may not be a suitable activity within a protected area. Extraction of non-timber forest products is important on many lands owned by indigenous peoples and community groups, particularly in northern Bolivia, where extraction of Brazil nuts (*Bertholletia excelsa*) is often more important than timber harvesting. While there is no felling of trees associated with this activity, it involves movement of large numbers of people into the forest who largely depend on hunting for meat provision. Consequently, this activity will not be compatible with the purposes of protected areas.

7. Protected areas should not be used as an excuse for maximizing the area of forest allocated to timber production at the expense of true protection, nor should they be used to avoid the forest tax under the false premise of ecological protection, as they appear to be used now by many production forests in Bolivia (Barrancos 2002). For example, some concessionaires or owners have conveniently placed their protected areas within areas destroyed by wildfire, where timber production is not possible nor where there is any conservation purpose for having a protected area. The placement of protected areas in these damaged areas allows them reach the mandatory 10% protection limit, therefore allowing them to harvest more intact forests elsewhere within the managed forests. In some cases, rehabilitation or recovery areas may need to be designated so that forest concessionaires or owners do not have to pay a tax on these properties if they had been damaged through no fault of the concessionaires.

8. Protected areas should not be placed in areas where they are vulnerable to invasion from colonists, hunters, or timber thieves, or where they are in high risk of being damaged by wildfire. Therefore, protected areas should not be placed along unprotected borders of the managed forest, particularly if there is a large human presence along these borders. Access to the perimeter of the protected areas should be maintained in order to ensure that these areas are not being invaded and to provide fire protection if necessary. Obviously, the access roads need to be controlled so that they are not used by colonists or poachers.

CONCLUSION

Protected areas are often envisioned as providing areas for maintenance of biodiversity within a mostly deforested landscape (Bawa and Seidler 1998). The size and connectivity among protected areas within a fragmented or an unfragmented landscape is often important since ecological reserves need to protect all of the forest biodiversity within a given region (Franklin 1993). Guidelines for ecological reserves within areas under forest management in Bolivia and elsewhere perhaps do not need to be as stringent as for isolated forest reserve areas when they are surrounded (at least at the present time) by forests that are typically only lightly selectively logged. Research suggests that low-intensity logging does not have a large direct impact on wildlife species, although intrusion into remote forests may encourage secondary impacts, such as hunting, wildfire, or colonization (Laurence 2001). Therefore, it is largely unnecessary to design protected areas that function as wildlife or biodiversity refuges. Despite the low impact of logging on these forests, protected areas within managed forest do play other important roles, such as protecting critical habitat types, fragile soils, and water quality that could be damaged during logging.

The provision for protected areas within managed forests and their appropriate placement expands considerations of forest management beyond the realm of reduced-impact logging, which largely deals with considerations at the stand level and not the entire property being managed. Effective design, placement, and monitoring of protected areas within timber production forests provides for more effective management of tropical forests where reduced-impact logging is being practiced. The Bolivian forestry law's inclusion of protected areas within managed forests was one of the factors that helped promote a large number of forestlands qualifying for third-party certification of forest management (Nittler and Nash 1996).

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