Biological Conservation 159 (2013) 96–100

Contents lists available at SciVerse ScienceDirect

Biological Conservation

journal homepage: www.elsevier.com/locate/biocon

Short communication

Commercial harvesting of *Ficus* timber – An emerging threat to frugivorous wildlife and sustainable forestry

Annika M. Felton [a,b,c,*], Adam Felton [a,b,c], Damián I. Rumiz [d,e], Nelly Villaroel [f], Colin A. Chapman [g], David B. Lindenmayer [a]

[a] Fenner School of Environment and Society, The Australian National University, Canberra, ACT 0200, Australia
[b] Instituto Boliviano de Investigación Forestal (IBIF), P.O. Box 6204, Santa Cruz de la Sierra, Bolivia
[c] Southern Swedish Forest Research Centre, Swedish University of Agricultural Sciences, 230 53 Alnarp, Sweden
[d] Wildlife Conservation Society, Casilla 6272, Santa Cruz de la Sierra, Bolivia
[e] Chiquitano Forest Conservation Foundation, Calle René Moreno esp. La Riva, Santa Cruz de la Sierra, Bolivia
[f] Holtz-Industrieberatung (HIB) Latinoamerica S.R.L., B/Equipetrol Psje Enrique Finot #20, Edificio Iguazú Of. 41, Santa Cruz, Bolivia
[g] Department of Anthropology & McGill School of Environment, McGill University, Montreal, Quebec, Canada H3A 2T7

ARTICLE INFO

Article history:
Received 29 June 2012
Received in revised form 18 October 2012
Accepted 22 October 2012

Keywords:
Ficus
Figs
Frugivores
Selective logging
Timber extraction

ABSTRACT

There is an extensive ecological literature documenting the importance of fig trees (*Ficus* spp.) as providers of food and other resources for many tropical animals. What is less apparent is that some *Ficus* species form free-standing stems that are targeted in logging operations. Despite the potential implications of such harvesting for biological conservation, the existence of this market has largely gone unrecognized by ecologists and conservation biologists. Here we describe the extent of this market in the Neotropics and discuss its implications for wildlife conservation and sustainable forestry. We find that large-scale commercial harvesting of *Ficus* timber primarily occurs in Bolivia, although some logging concessions in Peru and Brazil also harvest trees from this genus. Annually extracted volumes increased after records began being collected in Bolivia in 1998, peaked in 2005–2007 at approximately 34000 m^3/year, but are currently relatively low, partly due to the effects of the global financial down-turn of 2008–2009. We suggest that this presents an opportunity to re-assess current *Ficus* harvesting policies before further market expansion and harvest intensification could occur. We emphasize that because selective logging maintains tree species composition, structure, and disturbance regimes to a much greater extent than forest-converting land-use alternatives, it is important that opportunities to ensure ecologically sustainable forest management are identified and acted upon. We therefore call on forest ecologists, certification agencies, and conservation biologists to engage with the issue of commercial scale harvesting of *Ficus*.

1. Introduction

Ficus (Moraceae) is one of the most widespread genera of tropical trees (Weiblen, 2002), and it plays an important and sometimes critical role in the ecology of many tropical frugivores (Bleher et al., 2003; Felton et al., 2008b; Kinnaird and O'Brien, 2005; Shanahan et al., 2001). Their importance is derived in part from their asynchronous provision of large fruit crops over short time-intervals, which often makes their fruits available at times of general fruit scarcity (Janzen, 1979; Milton et al., 1982). In addition, figs contain a wide range of essential nutrients and minerals (O'Brien et al., 1998) and can provide a nutritionally balanced and abundant staple food (Felton et al., 2009). Because of the disproportionately strong influence of *Ficus* on species assemblages at many trophic levels, it has been proposed that a failure to maintain viable fig populations can result in an extinction cascade (Terborgh, 1986).

A small proportion of the 120 Neotropical species of *Ficus* (subgenera Pharmacosycea and Urostigma, Berg, 1999) form free-standing and relatively straight stems suitable for harvesting in selective logging operations (Fredericksen et al., 1999). The soft wood of *Ficus* can be used locally after extensive drying and fumigation, although many local forestry companies cannot afford the necessary infrastructure (E. Vargas, CFB, pers.comm). Without such treatment, the wood is non-durable in tropical climates, and is often exported to North America and Europe as doors, furniture, sawn wood, and plywood (CFB, 2010).

Selective logging is a land-use option that retains tree species composition, structures and disturbance regimes more than

* Corresponding author at: Southern Swedish Forest Research Center, Swedish University of Agricultural Sciences, 230 53 Alnarp, Sweden. Tel.: +46 4 415121; fax: +46 4 462325.
E-mail address: Annika.Felton@slu.se (A.M. Felton).

0006-3207/$ - see front matter © 2012 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.biocon.2012.10.025

forest-converting land-uses, such as intensive agriculture (McElhinny et al., 2005; Putz et al., 2012). To ensure the persistence of forestry concessions, forest management must be sustainable with respect to biodiversity and timber yields (Nasi et al., 2011). However, commercial logging of *Ficus* raises concerns in both regards, as densities of *Ficus* trees may be reduced below the minimum population size necessary for pollination by their symbiotic agaonid wasps (Anstett et al., 1997; McKey, 1989), and can lead to significantly reduced food availability for frugivores (Fredericksen et al., 1999). For example, the harvesting of *Ficus* is considered to contribute to the reduced abundance of monkeys in a logged concession in Bolivia (Felton et al., 2010). Furthermore, there is now a demonstrated link between declining population densities of large fruit-eating primates and poor regeneration rates of primate-dispersed trees (Nunez-Iturri et al., 2008). Selectively logged forestry concessions in the tropics typically depend on natural regeneration (Mason and Putz, 2001). In areas where a substantial percentage of timber tree species are animal dispersed (e.g. up to 40% of tree species logged in Bolivia, Felton et al., 2010), the ability of these concessions to sustainably produce timber is dependent on the maintenance of healthy populations of frugivore/seed dispersers and their food resources.

Conservation biology is often a reactive science producing ineffective conservation outcomes (Sodhi and Ehrlich, 2010). Here we highlight an emerging issue that has the potential to negatively affect population viability of tropical frugivores and the long-term integrity of selectively-logged tropical forests. In this paper we examine the extent and trajectory of *Ficus* timber harvesting in the Neotropics, with the principle aim to bring this issue to the early attention of certifying agencies, forest ecologists, and conservation biologists.

2. Methods

We obtained information on the volume of *Ficus* wood traded globally, source countries, the number and location of relevant certified forestry areas, and particular production information and export values regarding Bolivia. Global and regional scale information was obtained from annual reports provided by the International Tropical Timber Organization (ITTO). Unfortunately, Bolivia has not supplied data to the ITTO since 2008 (ITTO, 2008, 2010, 2011). However, Cámara Forestal de Bolivia (CFB) provided data regarding harvesting (1998–2010), timber export (2005–2011) and the number of relevant concessions (2010–2011) (CFB, 2006a,b, 2010, 2012a,b; Villca, 2007). Data on annual harvesting rates (2006–2010) and authorized volumes (2009–2010) was provided by the Bolivian Ministry of Agriculture (ABT, 2012). Authorized volumes are based on inventories undertaken by the forestry company of how many harvestable *Ficus* trees (straight stemmed, good condition) above minimum harvesting size (70 cm dbh) occur per block. Eighty percent of these stems may be harvested, while the remainder must, by law, be retained as future crop trees (Peña-Claros et al., 2008). Data on relevant certified concessions in the region was sourced from the Forest Stewardship Council (FSC, 2010, 2012). As our data stem from governmental and NGO sources, the volume of *Ficus* wood removed by illegal activities is unaccounted for.

To map the distribution of free-standing and potentially harvestable *Ficus* species in the Neotropics, we consulted the Smithsonian Tropical Research Institute (S.T.R.I., 2012) and a *Ficus* expert, C.C. Berg. The taxonomy of *Ficus boliviana* Berg (locally "bibosi colorado") is currently under scrutiny (C.C. Berg, pers.comm), and the species has been confused with *F. glabrata* and *F. insipida* (Mostacedo and Rumiz, 2010). In this paper we use the name *F.* cf. *boliviana*.

3. Results and discussion

In the Neotropics, large scale commercial harvesting of *Ficus* occurs primarily in Bolivia (CFB, 2010; ITTO, 2008), with some certified Peruvian and Brazilian companies also listing *Ficus* as a harvested genus (FSC, 2010, 2012; Fig. 1). Most likely *F.* cf *boliviana* is the species that represents the majority of extracted trees, as a relatively high proportion of individuals form straight harvestable stems (Fredericksen et al., 1999; Mostacedo and Rumiz, 2010), and this species is found throughout the relevant countries. In addition, other *Ficus* species are occasionally extracted (Fredericksen et al., 1999), and thus contribute to some unknown proportion of total harvest. This uncertainty arises in part from the failure of official sources to distinguish between different *Ficus* species (CFB, 2012b). Extracted volumes are generally reported simply as "bibosi" which may refer to *F. killipii*, *F. maxima*, *F. pertusa*, *F.* cf *boliviana* or possibly other species (ABT, 2012). Given the high levels of misidentification, or lack of identification, we are limited to discussing the likely implications from harvesting *Ficus* in general, or *F.* cf *boliviana* specifically. We are also limited to discussing legal harvesting activities, as illegal activities are unaccounted for in the available data.

Accepting these limitations, our assessment indicates that the volume of *Ficus* wood extracted in Bolivia has increased since 1998 when records began (Fig. 2), with harvesting rates in 2011 25% higher than this baseline. There was a peak in harvesting in 2005–2007. In 2006, approximately 34000 m^3 of *Ficus* wood was legally harvested according to official Bolivian records, representing 3.4% of the nation's total volume of harvested wood (CFB, 2006b). The subsequent reduction in extraction rates (2008 and onwards, Fig. 2) overlaps with the global financial crisis of 2008–2009, which has negatively affected the international trade in all tropical timbers (ITTO, 2010). For example, the ITTO reports that total exports from Latin American producers plunged by 34% in 2009 (ITTO, 2010), corresponding to the 36% decline in Bolivia's *Ficus* harvest that year (Fig. 2). The recovery of the global economy gained momentum during 2010 (IMF, 2012), with associated increases in tropical timber exports and wood prices (ITTO, 2010, 2011). If the *Ficus* export market mirrors this global trend, then we expect to see a corresponding rise in extraction rates. For example, the 40% increase in harvested *Ficus* volumes between 2009 and 2010 (Fig. 2) is consistent with the 65% increase in Bolivia's export of builders' work wood and joinery recorded during the same period (ITTO, 2011), and is indicative of the link between international demand and Bolivia's harvesting rates.

Notably, during the financial crisis local producers compensated for the drop in international demand by shifting their focus towards local markets (CFB, 2012a; Fig. 2). This indicates that more Bolivian companies are investing in the equipment needed to enable the use of *Ficus* wood in tropical climates. It is therefore likely that an increase in harvesting pressure due to a recovering international market may be exacerbated by an increased demand from local markets.

We emphasize that there is substantial room for increasing harvesting rates within current legal requirements. For the years 2009 and 2010, when comparative data is available, harvested volumes were 30–40% below authorized extraction volumes (ABT 2012). Regulatory barriers are therefore not acting as limits to harvesting. Whether increases in harvesting rates are possible will however ultimately depend on the number of individual *Ficus* trees possessing stems suitable for harvesting (Fredericksen et al., 1999). Although this is a valid consideration when projecting the limits of market expansion, the proportion of *F.* cf. *boliviana* suitable for harvesting does not appear to be sufficiently low to prevent adverse impacts on at least some important seed-dispersers (toucans

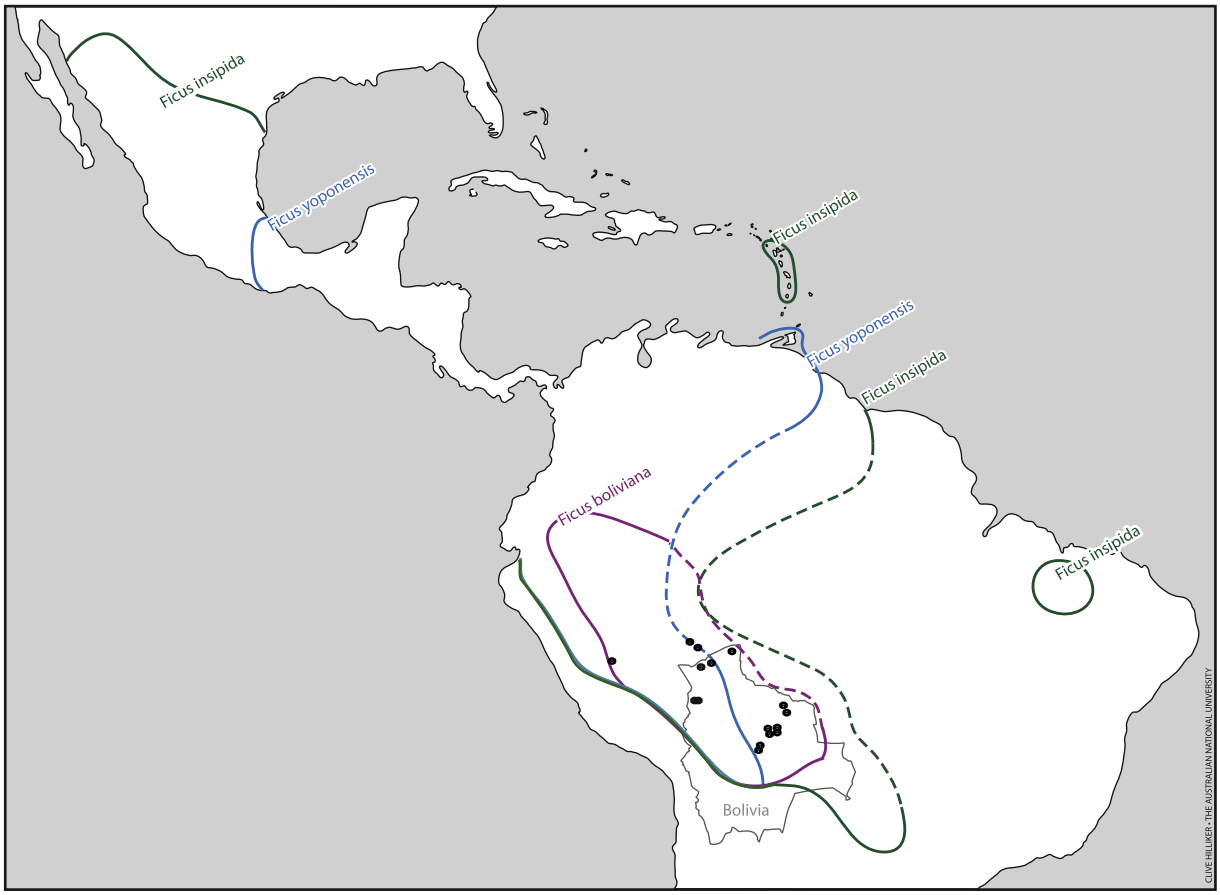

Fig. 1. Map of Latin and South America displaying the distribution *Ficus* cf. *boliviana*, *F. insipida* and *F. yoponensis*, which may form harvestable stems. Uncertain boundaries are indicated by hatching. Also shown are the approximate location of 13 forestry areas (dots) that harvested *Ficus* in 2010 (CFB, 2010): At least 11 of these were certified by the Forest Stewardship Council (FSC, 2010). (Sources for map: S.T.R.I., 2012, and C.C. Berg, pers.comm.)

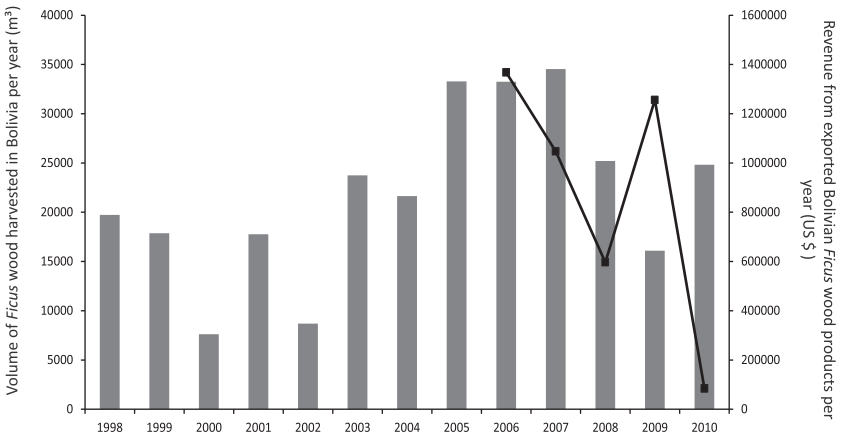

Fig. 2. Official production values of *Ficus* wood (m^3/year, grey bars) harvested in Bolivia 1998–2010. For the years 2006–2010 data on annual revenue gained from the exportation of *Ficus* wood products from Bolivia (US $) is available (second axis, black squares and line) (CFB, 2006a, 2012a,b; Villca, 2007).

Ramphastos tucanus, Felton et al., 2008a; spider monkeys *Ateles chamek*, howler monkeys *Allouatta seniculus* and guans *Penelope jacquacu*, Fredericksen et al., 2007).

This is because the removal of large *Ficus* individuals can result in a drastic reduction of food resources, as many frugivorous species are disproportionately reliant on large fig crops (Korine et al., 2000). Thus, what may appear as a relatively low harvesting rate of *Ficus* trees may cause a severe depletion of food resources. For example, the *F.* cf. *boliviana* harvesting rate of 0.4 trees/ha in a Bolivian forestry concession in 1998, equated with the loss of approximately 30% of spider monkeys' staple food source (Felton et al., 2010). In addition to the effect on food availability, the felling of large *Ficus* individuals disproportionately contributes to canopy discontinuity (Felton et al., 2006), which can compound negative effects on the energy expenditure of large-bodied arboreal frugivores (Felton et al., 2003; Hardus et al., 2012; Marsh et al., 1987).

Similarly, the relatively low proportion of well-formed stems of *F.* cf. *boliviana* (Fredericksen et al., 1999) has not prevented

harvests from contributing to the decline of this tree species' abundance, and as a result, instigated a move to change its conservation status. Mostacedo and Rumiz (2010) used IUCN criteria to conclude that *F.* cf. *boliviana* should have its conservation status in Bolivia changed to vulnerable. This was due to the species' restricted geographic distribution, limited abundance (Mostacedo et al., 2003), and the low or non-existent rates of natural regeneration within normal logging gaps (Fredericksen and Pariona, 2002). Their conclusion was consistent with a prior independent assessment (Meneses and Beck, 2005). Notably, both assessments argue that timber harvesting has contributed to this tree species' vulnerable status (Meneses and Beck, 2005; Mostacedo and Rumiz, 2010), even though harvesting rates have been below authorized limits.

The impact of *Ficus* timber harvesting on wildlife thus needs to be considered in combination with the implications for the tree species itself and the sustainability of forestry operations. Considering the limited knowledge regarding the taxonomy, ecology, distribution, and regeneration rates of the various harvested *Ficus* species, a precautionary approach is warranted until sufficient knowledge is available to ensure sustainable extraction.

4. Conclusions

We suggest that the commercial timber harvesting of *Ficus* in the Neotropics needs to be re-assessed for four key reasons: First, there is an extensive literature documenting the importance that members of this genus play in forest ecosystem function and biodiversity retention. Second, there is evidence that timber harvesting has contributed to *F.* cf. *boliviana* becoming vulnerable to extinction in Bolivia. Third, several unidentified *Ficus* species are being harvested despite uncertainty regarding their ecology and population status. Fourth, global economic recovery is likely to reinvigorate the international trade in *Ficus* tree species, with associated increases in harvesting rates beyond those already called into question. We therefore suggest that now may be an opportune time for a potential adjustment in regulations, as the market in *Ficus* timber appears not to have fully recovered. Timber certification bodies could take this opportunity to re-assess whether the harvesting of *Ficus* should be reduced or avoided, due to potentially detrimental impacts on the long-term sustainability of certified concessions, the tree species themselves, and the wildlife populations they support. Furthermore, the global distribution of *Ficus* means that this issue may extend beyond the Neotropics to the biodiverse regions of tropical Africa and Asia (e.g. harvesting of *F. sycomorus* in Uganda, Odokonyero, 2005). Official data regarding the harvesting of most *Ficus* species globally is scarce, and this lack of information needs to be addressed. We trust that our findings will foster discussion among interested parties about the impacts of commercial harvesting of *Ficus* trees.

Acknowledgements

The work of AMF was financially supported by the Wildlife Conservation Society, Conservation International, the Rufford Foundation, and the Primate Society of Great Britain. We thank Marielos Peña Claros, Edwin Vargas Brychcy, Joe Wright, Cornelis Berg and Todd Fredericksen for advice and information. Clive Hilliker helped produce the map.

References

ABT, 2012. Base de datos de volumenes extraidos por gestión 2009–2010. De Autoridad de Fiscalización y Control Social de Bosques y Tierras.

Anstett, M.C., Hossaert-McKey, M., McKey, D., 1997. Modeling the persistence of small populations of strongly interdependent species: figs and fig wasps. Conserv. Biol. 11, 204–213.

Berg, C.C., 1999. A new species of *Ficus* (Moraceae) from Bolivia and Peru. Brittonia 51, 395–397.

Bleher, B., Potgieter, C.J., Johnson, D.N., Bohning-Gaese, K., 2003. The importance of figs for frugivores in a South African coastal forest. J. Trop. Ecol. 19, 375–386.

CFB, 2006a. Exportación de productos forestales de Bolivia, Gestiones: 1998–2006. Anuario estadístico del sector forestal de Bolivia 2006. Cámara Forestal de Bolivia.

CFB, 2006b. Volumen Extraído Por Especie, Gestiones: 1998–2006. Anuario estadístico del sector forestal de Bolivia 2006. Cámara Forestal de Bolivia.

CFB, 2010. Busqueda de Productos y Especies. <http://www.cfb.org.bo/CFBInicio/>, Accessed 10.05.10. Cámara Forestal de Bolivia.

CFB, 2012a. Exportación de productos forestales de Bolivia, Gestiones: 2006–2011. Anuario estadístico del sector forestal de Bolivia 2011. Cámara Forestal de Bolivia. Data source: Autoridad de Fiscalización y Control Social de Bosques y Tierras.

CFB, 2012b. Volumen Extraído Por Especie, Gestiones: 2006–2011. Anuario estadístico del sector forestal de Bolivia 2011. Cámara Forestal de Bolivia. Data source: Autoridad de Fiscalización y Control Social de Bosques y Tierras.

Felton, A., Felton, A.M., Wood, J., Lindenmayer, D.B., 2006. Vegetation structure, phenology, and regeneration in the natural and anthropogenic tree-fall gaps of a reduced-impact logged subtropical Bolivian forest. Forest Ecol. Manage. 235, 186–193.

Felton, A., Wood, J., Felton, A.M., Hennessey, B., Lindenmayer, D.B., 2008a. Bird community responses to reduced-impact logging in a certified forestry concession in lowland Bolivia. Biol. Conserv. 141, 545–555.

Felton, A.M., Engström, L.M., Felton, A., Knott, C.D., 2003. Orangutan population density, forest structure and fruit availability in hand-logged and unlogged peat swamp forests in West Kalimantan. Indonesia. Biol. Conserv. 114, 91–101.

Felton, A.M., Felton, A., Foley, W.J., Lindenmayer, D.B., 2010. Timber tree species play a critical role in the nutritional ecology of spider monkeys (*Ateles chamek*) in a certified logging concession. Bolivia. Forest Ecol. Manage. 259, 1642–1649.

Felton, A.M., Felton, A., Wood, J.T., Foley, W.J., Raubenheimer, D., Wallis, I.R., Lindenmayer, D.B., 2009. Nutritional ecology of spider monkeys (*Ateles chamek*) in lowland Bolivia: how macro-nutrient balancing influences food choices. Int. J. Primatol. 30, 675–696.

Felton, A.M., Felton, A., Wood, J.T., Lindenmayer, D.B., 2008b. Diet and feeding ecology of the Peruvian spider monkey (*Ateles chamek*) in a Bolivian semi-humid forest: the importance of *Ficus* as a staple food resource. Int. J. Primatol. 29, 379–403.

Fredericksen, N.J., Terceros, C., Chubinu, J., Karamians, R., Fredericksen, T.S., 2007. Impacts of silvicultural treatments on wildlife populations in a Bolivian humid forest: determining the impacts of logging on wildlife using indicator species. Proyecto BOLFOR.

Fredericksen, T.S., Pariona, W., 2002. Effect of skidder disturbance on commercial tree regeneration in logging gaps in a Bolivian tropical forest. Forest Ecol. Manage. 171, 223–230.

Fredericksen, T.S., Rumiz, D., Bravo, M.J.J., Abacay, R.A., 1999. Harvesting free-standing fig trees for timber in Bolivia: potential implications for forest management. Forest Ecol. Manage. 116, 151–161.

FSC, 2010. Certificate database. <http://info.fsc.org/>, Accessed 10.05.10. Forest Stewardship Council.

FSC, 2012. Certificate database. <http://info.fsc.org/>, Accessed 16.05.12. Forest Stewardship Council.

Hardus, M.E., Lameira, A.R., Menken, S.B.J., Wich, S.A., 2012. Effects of logging on orangutan behavior. Biol. Conserv. 146, 177–187.

IMF, 2012. World economic outlook: growth resuming, dangers remain. International Monetary Fund, Washington, DC.

ITTO, 2008. Annual Review and Assessment of the World Timber Situation. International Tropical Timber Organization, Yokohama, Japan.

ITTO, 2010. Annual Review and Assessment of the World Timber Situation. International Tropical Timber Organization, Yokohama, Japan.

ITTO, 2011. Annual Review and Assessment of the World Timber Situation. International Tropical Timber Organization, Yokohama, Japan.

Janzen, D.H., 1979. How to be a fig. Ann. Rev. Ecol. Syst. 10, 13–51.

Kinnaird, M.F., O'Brien, T.G., 2005. Fast foods of the forest: the influence of figs on primates and hornbills across Wallace's line. In: Dew, J.L., Bouble, J.P. (Eds.), Tropical Fruits and Frugivores: the Search for Strong Predictors. Springer, Dordrecht, pp. 155–184.

Korine, C., Kalko, E.K.V., Herre, E.A., 2000. Fruit characteristics and factors affecting fruit removal in a Panamanian community of strangler figs. Oecologia 123, 560–568.

Marsh, C.W., Johns, A.D., Ayres, J.M., 1987. Effects of habitat disturbance on rain forest primates. In: Marsh, C.W., Mittermeier, R.A. (Eds.), Primate Conservation in the Tropical Rain Forest. Alan R. Liss, New York, pp. 83–107.

Mason, D.J., Putz, F.E., 2001. Reducing the impacts of tropical forestry on wildlife. In: Fimbel, R.A., Grajal, A., Robinson, J.G. (Eds.), The Cutting Edge: Conserving Wildlife in Logged Tropical Forests. Columbia University Press, New York, pp. 473–509.

McElhinny, C., Gibbons, P., Brack, C., Bauhus, J., 2005. Forest and woodland stand structural complexity: its definition and measurement. Forest Ecol. Manage. 218, 1–24.

McKey, D., 1989. Population biology of figs – applications for conservation. Experientia 45, 661–673.

Meneses, R.I., Beck, S., 2005. Especies amenazadas de la flora de Bolivia. Unpublished manuscript. Herbario Nacional de Bolivia, La Paz, p. 34.

Milton, K., Windsor, D.M., Morrison, D.W., Estribi, M.A., 1982. Fruiting phenologies of two Neotropical *Ficus* species. Ecology 63, 752–762.
Mostacedo, B., Justiniano, M.J., Toledo, M., Fredericksen, T.S., 2003. Guía dendrológica de espécies forestales de Bolívia-Volumen I. Proyecto BOLFOR, Santa Cruz, Bolívia.
Mostacedo, B., Rumiz, D.I., 2010. Estimación del estado de conservación de las especies maderables de la Chiquitania en Bolivia. Revista Boliviana de Ecología y Conservación Ambiental 28, 43–52.
Nasi, R., Putz, F., Pacheco, P., Wunder, S., Anta, S., 2011. Sustainable forest management and carbon in tropical Latin America: the case for REDD+. Forests 2, 200–217.
Nunez-Iturri, G., Olsson, O., Howe, H.F., 2008. Hunting reduces recruitment of primate-dispersed trees in Amazonian Peru. Biol. Conserv. 141, 1536–1546.
O'Brien, T.G., Kinnaird, M., Dierenfeld, E.S., 1998. What's so special about figs? Nature 392, 668.
Odokonyero, G.G.O., 2005. Pitsawn timber production in natural forests of Uganda; Forest Harvesting Case-Study (report #22). Food and Agriculture Organization of the United Nations, Rome.
Peña-Claros, M., Fredericksen, T.S., Alarcón, A., Blate, G.M., Choque, U., Leaño, C., Licona, J.C., Mostacedo, B., Pariona, W., Villegas, Z., Putz, F.E., 2008. Beyond reduced-impact logging: silvicultural treatments to increase growth rates of tropical trees. Forest Ecol. Manage. 256, 1458–1467.
Putz, F.E., Zuidema, P.A., Synnott, T., Pena-Claros, M., Pinard, M.A., Sheil, D., Vanclay, J.K., Sist, P., Gourlet-Fleury, S., Griscom, B., Palmer, J., Zagt, R., 2012. Sustaining conservation values in selectively logged tropical forests: the attained and the attainable. Conserv. Lett. 5, 296–303.
S.T.R.I., 2012. Neotropical Tree Species Checklist, Centre for Tropical Forest Science. Smithsonian Tropical Research Institute.
Shanahan, M., So, S., Compton, S.G., Corlett, R., 2001. Fig-eating by vertebrate frugivores: a global review. Biol. Rev. 76, 529–572.
Sodhi, N.S., Ehrlich, P.R., 2010. Conservation biology for all. Oxford University Press, Oxford.
Terborgh, J., 1986. Keystone plant resources in the tropical forest. In: Soulé, M.E. (Ed.), Conservation Biology. Academic Press, New York, pp. 330–344.
Villca, E.I., 2007. Base de datos sobre el sector forestal de Bolivia 1997 a 2006. Ministerio Desarollo Rural, República de Bolivia/FAO Bolivia, La Paz.
Weiblen, G.D., 2002. How to be a fig wasp. Annu. Rev. Entomol. 47, 299–330.