Amazonia revealed: a perspective from the Amazon

As Foley *et al.* indicated (*Front Ecol Environ* 2007; **5[1]**: 25–32), we are now at "a critical point in the history of the Amazon Basin". The examples provided by the authors clearly show that several of the ecosystem goods and services provided by Amazonian forests are being lost due to deforestation. Given that, at the moment, there is a great need to find viable alternatives to forest destruction, we as researchers and conservationists cannot afford to be unclear about the definitions and concepts we provide to policy makers, funding agencies, and governments. Unfortunately, Foley and his co-authors do not make a clear distinction between forest management and unplanned logging, and seem to argue that selective logging is equivalent to deforestation. Such an image is easily absorbed by a public that associates logging with the large clear-cuts common in northern temperate forests, but this does not coincide with the reality in the tropics, where hyper-diverse forests allow for the selective extraction of a few (1–20) trees per hectare. Foley's definition therefore does not conform to reality, does not acknowledge the role of forest management as a conservation tool, and completely denies all the advances made in reducing the deleterious impacts of logging. It also assumes that selective logging and outright deforestation have the same negative impacts on ecological services. Although the authors mention four examples of services that are being deteriorated by deforestation and logging, they only present evidence of the effect of logging on carbon storage. They present no evidence for the effect of logging on water flow regulation, regional and global climate regulation, or vector-borne diseases, probably because it is currently unavailable.

Advocates of forest management as a tool for conservation will not deny that timber production results in forest damage, but will point out that the amount of damage varies with logging intensity, application of reduced-impact logging techniques, and commitment of the logger to long-term sustainability. While logging damage certainly has impacts on the ecological goods and services provided by forests, these impacts are much smaller than that of deforestation. For example, studies in Guyana have shown that the effect of selective logging on water and nutrient cycling is negligible (ter Steege *et al.* 1995). The difference in the impact caused by forest management and deforestation lies basically in the fact that forest management allows for the long-term maintenance of vegetation cover, and therefore of many ecological services. It also allows for rapid recovery of vegetative cover, even in areas heavily damaged during logging operations, such as large logging gaps (eg Broadbent *et al.* 2006). Even in the case where single dominant species have been logged at high intensities, no long-term effects (>75 yr) on forest structure, species composition, or diversity could be detected (ter Steege *et al.* 2002).

There is certainly an urgent need for alternatives to deforestation to guarantee that ecosystem goods and services provided by the Amazon Basin are not lost. Forest management is one of them, if we can manage to put our prejudices aside and if all people committed to forest conservation accept that it is better to have a managed forest than a soybean field or cattle ranch.

Marielos Peña-Claros[1*], Zulma Villegas[1], Rudy Guzman[2], and Lourens Poorter[1,3]

[1]Instituto Boliviano de Investigación Forestal (IBIF), Santa Cruz, Bolivia
[*](mpena@ibifbolivia.org.bo);
[2]Centro Amazónico de Desarrollo Forestal (CADEFOR), Santa Cruz, Bolivia;
[3]Wageningen University, Wageningen, Netherlands

Broadbent EN, Zarin DJ, Asner GP, *et al.* 2006. Recovery of forest structure and spectral properties after selective logging in lowland Bolivia. *Ecol Appl* **16**: 1148–63.

ter Steege HR, Boot L, Brouwer D, *et al.* 1995. Basic and applied research for sound rainforest management in Guyana. *Ecol Appl* **5**: 904–10.

ter Steege H, Welch I, and Zagt R. 2002. Long-term effect of timber harvesting in the Bartica Triangle in Central Guyana. Forest *Ecol Manage* **170**: 127–44.

Forest management versus forest degradation and destruction

Efforts at improving natural forest management as an approach to conservation and development in the tropics are impaired when exploitative logging is confounded with forest management for timber, and when both are thrown in together with deforestation. In the otherwise informative article by Foley *et al.* (*Front Ecol Environ* 2007; **5[1]**: 25–32), selective logging seems to be equated with forest degradation and destruction, with nary a mention of forest management. That some of the logging detected from satellites is being carried out according to government-approved management plans is not even mentioned. The cover image is especially ironic because, although most readers of *Frontiers* will share our anguish over the destruction of such a beautiful tree, the felling technique displayed is remarkably good. Most fellers would simply cut such a tree above the buttresses, thereby wasting a great deal of wood. Notice the small step cut in the stump; that innovation, attributed to Johan Zweede of the Fundaçao Floresta Tropical, decreases the likelihood that the trunk will split when the tree falls. Clearly, what is depicted is a phase of forest management and not, as readers are likely to infer, forest destruction.

With Brazil leading the world in natural tropical forests certified as well-managed by the Forest Steward-

ship Council, and with an area about the size of New England officially designated for forest management in the Brazilian Amazon (Veríssimo *et al.* 2002), it is high time for such confusion to cease. Unfortunately, with fewer people working in the woods, confusion is likely to reign unless researchers and the policy makers they inform are very careful to differentiate between forest management and forest destruction.

Francis E Putz[1*], Jack Ewel[1], and Ariel Lugo[2]

[1]*Department of Botany, University of Florida, Gainesville, FL*

[*]*(fep@botany.ufl.edu)*

[2]*USDA Forest Service IITF, Jardin Botanico Sur, San Juan, Puerto Rico*

Veríssimo A, Cochrane MA, and Souza Jr C. 2002. National forests in the Amazon. *Science* **297**: 1478.

The authors reply

Peña-Claros *et al.* and Putz *et al.* rightly point out the critical role of forest management as a determinant of the long-term efficacy of timber resource use in the Amazon region. They are correct to note that good forest management practices are the way forward, but this hasn't yet happened at the large, nearly continental scale that we aimed to address in our paper. They failed, as we did, to fully describe what has occurred in the recent past in the Brazilian Amazon. About half of the selective logging in the region is illegal and, hence, unregulated (Barreto *et al.* 2006). Moreover, up through 2002, selective logging was regionally dominated by high-damage extraction operations that left the forest susceptible to drought and fire (Nepstad *et al.* 1999; Gerwing 2002; Souza *et al.* 2003; Asner *et al.* 2006). Logging was often a precursor to deforestation (Asner *et al.* 2006), facilitated by the increased access to the forest that unofficial logging roads provide to people on the landscape (Souza *et al.* 2005). Furthermore, as of 2005, the total land under Forest Stewardship Council (FSC) green certification was 12 619 km^2 (FSC 2005), which is only ~ 3% of the land supplying timber to markets (Barreto *et al.* 2006). Thus, in recent years, the evidence suggests that selective logging was not dominated by the kind of well-managed, low-impact, green certification operations intended to preserve forest cover, structure, diversity, and function, and serving an alternative to deforestation.

Meanwhile, organizations like the Fundaçao Floresta Tropical are beacons of hope for change. They are teaching reduced-impact logging (RIL) methods to loggers, and are spreading knowledge of ways to make forest use more sustainable. RIL methods decrease forest damage per cubic meter of wood extracted (Pereira *et al.* 2002), and RIL is reported to be cost-effective (Holmes *et al.* 2001). With an even more rapid expansion of RIL methods throughout the entire Amazon, along with the planned control of timber extraction via concessions in Brazil (Veríssimo *et al.* 2002), the link between selective logging and forest degradation might be broken.

We certainly agree that good management is the path to creating a forest use scenario that will supply goods and services to society for the long term and serve as an alternative to deforestation. We also agree that the term degradation is abused in the literature, and that we did not correct this situation. In the future, from an ecological science standpoint, we might consider using the term *disturbance* in place of *degradation* (Asner *et al.* 2006).

As for the cover photo, that image was chosen by *Frontiers* staff, not by the authors, and yes, it does show exceptionally good felling practices at work.

Jonathan Foley[1*], Greg Asner[2], *et al.*

[1]*Center for Sustainability and the Global Environment, Nelson Institute for Environmental Studies, University of Wisconsin, Madison, WI*

[*]*(jfoley@wisc.edu)*

[2]*Department of Global Ecology, Carnegie Institution of Washington, Stanford, CA*

Asner GP, Broadbent EN, Oliveira PJC, *et al.* 2006. Condition and fate of logged forests in the Brazilian Amazon. *P Natl Acad Sci USA* **103**: 12947–50.

Barreto P, Souza Jr C, Noguerón R, *et al. 2006*. Human pressure on the Brazilian Amazon forests. Belém, Brazil: World Resources Institute. www.globalforestwatch.org/common/pdf/Human_Pressure_Final_English.pdf. Viewed 23 Apr 2007.

Gerwing J. 2002. Degradation of forests through logging and fire in the eastern Brazilian Amazon. *Forest Ecol Manag* **157**: 131–41.

FSC (Forest Stewardship Council). 2005. Florestas certificadas. www.fsc.org.br/index.cfm?fuseaction=conteudo&IDsecao=180. Viewed 23 Apr 2007.

Holmes TP, Blate GM, Zweede JC, *et al.* 2001. Financial and ecological indicators of reduced impact logging performance in the eastern Amazon. *Forest Ecol Manag* **163**: 93–110.

Nepstad DC, Verissimo A, Alencar A, *et al.* 1999. Large-scale impoverishment of Amazonian forests by logging and fire. *Nature* **398**: 505–08.

Pereira R, Zweede J, Asner GP, and Keller M. 2002. Forest canopy damage and recovery in reduced-impact and conventional selective logging in eastern Para, Brazil. *Forest Ecol Manag* **168**: 77–89.

Souza Jr C, Firestone LA, Moreira L, and Roberts DA. 2003. Mapping forest degradation in the eastern Amazon from SPOT 4 through spectral mixture models. *Remote Sens Environ* **87**: 494–506.

Souza Jr C, Brandão Jr A, Anderson A, and Veríssimo A. 2005. The expansion of unofficial roads in the Brazilian Amazon. http://www.imazon.org.br/downloads/index.asp?categ=5. Viewed 23 Apr 2007.

Veríssimo A, Cochrane MA, and Souza Jr C. 2002. National forests in the Amazon. *Science* **297**: 1478.

The best papers are the boldest

John Grace's comments on what constitutes a good paper and the problems of citation counting were timely (Pathways to Effective Communication; *Front Ecol Environ* **5[1]**: 49–50). However, as someone who is both a "Roger" and a "Rebecca", I would suggest that papers addressing the interdisciplinary challenge of sustainability are more important (Cloud 2005). It

won't matter how many citations and promotions you have without a livable planet to enjoy them on.

The challenge of working with other "tribes" should not be neglected (Russell 1995). And the often perverse incentives and traditions in promotion, retention, and tenure that discourage this type of paper, downrate applied research, and ignore problem-solving, should be dismantled (Baumann 2002; Moore 2005). I would suggest that multidisciplinary papers be given a bonus, instead of being penalized. Incentives to make student and faculty research and data more accessible are also needed.

David A Bainbridge
Marshall Goldsmith School of Management, Alliant International University, San Diego, CA (dbainbridge@alliant.edu)

Baumann H. 2002. Publish and perish? The impact of citation indexing on the development of new fields of environmental research. *J Ind Ecol* **6**: 13–26.

Cloud JP. 2005. Education for sustainability: what is the core content? *NAAEE Communicator* **35**: 1–10.

Moore J. 2005. Barriers and pathways to creating sustainability education programs: policy, rhetoric and reality. *Environ Educ Res* **11**: 537–55.

Russell CS. 1995. Are we lost in the vale of ignorance or on the mountain of principle? *Ecol Econ* **14**: 91–99.

The author replies

David Bainbridge suggests that sustainability science is somehow discouraged by the traditional publication routes and that multidisciplinary papers ought to be "given a bonus" instead of being penalized. I think he is mistaken; the best work on sustainability appears in *Science* and *Nature* from the 1990s. An example of the genre is Jane Lubchenco's paper from 1998, which, as I write this letter, has been cited 159 times. And successful multidisciplinary journals do occur; *Global Change Biology* has been spectacularly successful (although there are others that are more truly multidisciplinary and they have not caught on). If there is a problem at all, it lies with the funding councils. They have been astonishingly slow to realize that ecologists, economists, and modelers do in fact have important multidisciplinary work to do in sustainability science. If this sort of work were funded, successful journals would appear just as night follows day, and there would be more collaboration between ecologists and economists.

In the UK, it is ironic that people, the media, and the government have finally been convinced about the reality of climate change not because the Chief Government Scientist says it is real, or because the IPCC says so; it has taken an economist, Sir Nicholas Stern, to convince us all. There is a lesson for us here. Scientists are still seen as "boffins", not to be taken seriously. Economists, on the other hand, speak the truth.

John Grace
School of GeoSciences, The University of Edinburgh, Edinburgh, UK (jgrace@ed.ac.uk)

Lubchenco J. 1998. Entering the century of the environment: a new social contract for science. *Science* **279**: 491–97.

Techniques for determining percent ground cover

Luscier *et al.* (*Front Ecol Environ* 2006; **4[8]**: 408–13) present a useful technique for determining percent ground cover in vegetation plots with a digital camera and image analysis software. Their failure to alert readers to some basic photogrammetric principles could, however, lead users of this technique to neglect potential biases and errors.

Relief displacement occurs because the objects higher than the ground in a photographed scene are displaced outward from the center of the photograph. It is a simple geometric consequence of imaging a three-dimensional world on a flat surface. Relief displacement is greatest at the edge of the photograph and is nil directly below the camera. Using a camera 1.5 m above the ground as specified by Luscier *et al.*, simple geometry indicates that an object, such as the canopy of a small shrub, 0.5 m above the ground surface and extending 0.5 m to 0.6 m away from the camera pole will appear 20% larger in linear dimension than would an object of the same size on the ground. Estimate surface area would suffer corresponding distortion. The same geometric reasoning demonstrates that an object on the ground will be hidden from the camera's view by an intervening taller object.

Because different vegetation types are likely to have different heights in the sequence shrub, forb, grass, and leaf litter, results from the digital analysis are likely to overestimate percent cover in the same order. The result would be biased assessments of the amount of cover in each class. Orthorectification based on the use of stereo photography can correct for relief displacement and might be worth exploring as an additional technique in the analysis of ground cover.

Luscier *et al.* also do not discuss the importance of properly leveling the camera, an aspect of technique that is especially important when using a monopod as they recommend. If the support pole for the camera is not perfectly vertical, the camera plane will not be parallel to the ground and distances in the photographic image will be distorted in size from one side of the image to the other. Such error may not be differential with respect to ground cover class but should still be avoided as much as possible.

In the absence of photogrammetric techniques, mounting the camera on a taller pole, careful attention to ensuring that the pole is vertical and the camera's image plane is parallel to the ground, and limiting the analysis to the central part of the image will minimize distortion. Further, the technique should be restricted to plots in which the relief of the vegetation is small relative to the height of the camera.

Wayne Richter
Greenfield Center, NY (wrichter@nycap.rr.com)

The authors reply

Richter raises important points regarding potential sources of error in our technique for using object-based image analysis to estimate percent ground cover from digital photographs.

Relief displacement error can be problematic when employing 2-dimensional analysis methods to estimate a 3-dimensional surface at the spatial scale and height of ground vegetation studies. Vegetation canopy at this scale represents a complex surface characterized by discontinuities at the level of individual leaves or blades of grass. Unfortunately, Richter's recommended adjustment based on stereo photography with orthorectification often cannot be applied because it requires a continuous surface (Ivanov *et al.* 1995). Similarly, his estimate of 20% bias is only applicable to a very narrow range of vegetation studies with continuous canopy surfaces in a linear dimension. Even when feasible, stereo photography with orthorectification requires a complete understanding of the ground/camera geometry for accurate alignment of two camera positions, manual identification of individual plant parts in both images to obtain accurate stereo registration (Prusin-kiewicz 1998), and extensive time for data pre-processing (see Ivanov *et al.* [1995] for details), which would render our approach unusable.

A by-product of relief displacement is that certain plants may be obscured but, based on our study, we do not believe the magnitude of the bias is typically as large as Richter implies from his calculation, based on continuous vegetation surfaces. The relative importance of this bias depends on the density of foliage, position of leaves, and/or diversity in vertical structure of foliage. We agree that researchers should evaluate the potential influence of this bias within the context of their studies. To decrease relief displacement, Richter suggested using a taller pole for camera mounting and restricting subsequent analysis to the image center. This is worthy of further investigation. Note that there are trade-offs between the height of the pole and the ability to keep the camera reasonably level, the ability to transport the longer pole (or extendable pole) into the field, maintaining image resolution, and the potential need for a longer camera-mounting arm required to minimize inclusion of extraneous objects (eg feet, pole) in the images.

We agree with Richter that accurately leveling the camera would indeed improve the geometry of the camera. This would not correct for the geometry of the vegetation (ie the discontinuous surface), however, so this is an incomplete solution. There are devices for maintaining camera geometry (eg Gebhardt *et al.* 2006), but they involve large units on wheels that could potentially be destructive to habitat. Good leveling equipment is also expensive and hence would increase the cost of our relatively economical device.

Although Richter is correct about potential errors incurred by relief displacement on continuous surfaces, the magnitude of these errors for discontinuous surfaces encountered in ground vegetation studies is difficult to estimate and is context specific. Further, concealment of vegetation from relief distortion also afflicts traditional ocular-estimation methods. Our technique has the added advantages of being objective and repeatable, while maintaining its unobtrusiveness and allowing for rapid collection of field data. Richter's suggestion of using a taller mounting pole has potential to improve our technique and we encourage researchers to evaluate this option.

Jason D Luscier[1*], William L Thompson[2], John M Wilson[1], Bruce E Gorham[1], and Lucian D Dragut[3]

[1]Fayetteville, AR [*](jluscie@uark.edu); [2]Anchorage, AK; [3]Salzburg, Austria

Gebhardt A, Schellberg J, Lock R, and Kuhbauch W. 2006. Identification of broad-leaved dock (*Rumex obtusifolius* L) on grassland by means of digital image processing. *Prec Agric* **7**: 165–78.

Ivanov N, Boissard P, Chapron M, and Andrieu K. 1995. Computer stereo plotting for 3-D reconstruction of a maize canopy. *Agr Forest Meteorol* **75**: 85–102.

Prusinkiewicz P. 1998. Modeling of spatial structure and development of plants: a review. *Sci Hortic-Amsterdam* **74**: 113–49.