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Cover photo: The cover pictures show examples of knowledge sharing between practitioners, students and researchers in India (Kodagu district, top left), Namibia (Impalila Island, top right), Brazil (São João do Jaburu, central; Acre, bottom left), and the USA (Florida, bottom right). See Special Section (photo credit: top left: Carla Barlagne; top right: Deborah Wojcik; central: Oberaldo Brilhante; bottom left: Amy Duchelle; bottom right: Meg Lowman.).

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Canopy Walkways for Conservation: A Tropical Biologist's Panacea or Fuzzy Metrics to Justify Ecotourism

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DESPITE EXTENSIVE SCIENTIFIC RESEARCH undertaken in tropical ecosystems over the last few decades, approximately half of tropical forests have been destroyed and rates of deforestation continue to accelerate worldwide (Curran *et al.* 2004). Thousands of indigenous cultures and millions of local people need these deteriorating forest resources for their livelihoods, and the challenges of tropical forest conservation looms as a global priority (Laurance & Perez 2006). Meanwhile, the conventional metric used to gauge the success of professional academics in tropical biology is the publication of technical papers, which seems all too disconnected from the metrics of forest conservation. A new consciousness is sorely needed (Leiserowitz & Fernandez 2008; but see Webb 2005, Büscher 2008). Most tropical biologists admittedly enter the profession with a hope to contribute to conservation of these systems, but their hundreds of thousands of hours dedicated to field research and publications do not seem proportional to reversing conservation. If conventional business formulae were applied to tropical research, a likely outcome would be downsizing the industry. New metrics that incorporate conservation benchmarks and facilitate sharing best practices between professional scientists and local stakeholders could foster forest conservation through actions that create sustainable economies.

Canopy research appeared to offer an ideal case study to examine the socioeconomic plus scientific metrics of success, with its spin-off ecotourism operations such as skywalks and ziplines providing data sets to quantify their benefits to local stakeholders (Lowman 2004a). In short, can canopy access tools contribute to local economies and stimulate forest conservation? And second, can projects that promote forest conservation provide acceptable metrics to gauge success among scientific researchers (see also Garnett *et al.* 2009, Sunderland *et al.* 2009)?

Canopy ecology is a relatively new component of tropical forest research, with a toolkit of creative access techniques developed over the last two decades (Lowman 2004b). Business ventures involving canopy exploration are often incorporated into large-scale eco-developments that include bird-watching, education-based nature tours, spas, and holistic medicine (Weaver 2001). These ecotourism opportunities usually meet with generic approval under the guise of 'green businesses'. In this commentary, I grapple with the apparent oxymoron of working as a biological researcher yet building canopy walkways to achieve conservation. Such structures are not the conventional metrics of academic success, but can conservation actions gain traction as metrics of success in our admittedly rigorous academic community of scientists?

Ranging in cost from US$100 to US$3000/m, canopy walkways generate revenues for local stakeholders, and provide ecology education to a broad visitorship (Lowman & Bouricius 1995, Lowman 2004b). Over 20 canopy walkways currently operate in tropical forests around the world serving research, education, and ecotourism (Lowman 2009). Most sites are operated by local stakeholders without sophisticated spreadsheets to quantify their operations. Some sites received initial grants from NGOs or other well-meaning organizations in developed countries to undertake construction in the name of conservation, and others attract 'operators' from developed countries that spawn additional ecotourism activities, thereby making the metrics of the canopy attraction impossible to analyze in isolation.

The first canopy walkway in the world was built in Lamington National Park, Queensland, Australia, at O'Reillys Rain Forest Lodge (Lowman *et al.* 2006). In a developed country such as Australia, one would expect a rigorous business plan calculating the economic success of this structure. However, when asked to provide metrics about the economic success of his skywalk, owner Peter O'Reilly commented, 'I am certain that the canopy walkway contributed greatly to the increase in visitors to our lodge. But it is impossible to isolate the walkway from other amenities that were built simultaneously—improvements to the road, our liquor license, expanding the dining services, and better marketing. We could not create metrics to assess it (canopy walkway) in isolation, but we locals felt strongly that it was critical to our ecotourism success'.

In short, the Australians could not generate enough data to satisfy even a brief note in a journal, but yet they are intuitively confident that their walkways aided conservation. If an expertly run business in a developed country cannot provide accurate metrics about the exact formulae for commercializing rain forest conservation, then how can indigenous villages do so?

Today, over 1.6 billion people from all cultures and all walks of life participate in different avenues of tourism, spending over US$2 trillion (Hawkins & Lamoureux 2001). On a global scale, ecotourism is growing because of its international appeal, educational opportunities, and social appeal to advocate a conservation ethic. As human-dominated ecosystems become the norm,

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ecological research and its education outreach through ecotourism become critical at both continental and local scales to inspire the sustainability of earth's dwindling resources (Palmer *et al.* 2005, Peters *et al.* 2008). Canopy research promotes forest conservation at three scales: through biological discoveries published in the scientific literature, by offering innovative sustainable economic opportunities for local stakeholders such as canopy walkways, and through educating a broader visitorship through ecotourism. Despite the existence of over 20 canopy walkways around the world for research and education, and several dozen more for ecotourism alone, accurate records are not often kept by local operators. In addition, local labor and materials mask the true costs of the structure; other amenities cloud the ability to isolate economic metrics; and the broader-scale impact of educating a global audience of visitors is not easy to quantify. Although Büscher (2008) reminded conservation biologists not to ignore their 'rigorous empirical research' training, should we sometimes rejoice about conservation 'wins' such as canopy walkways despite a lack of rigorous data sets to justify their existence (see also Sunderland *et al.* 2009)?

AMAZON CASE STUDY

In the Amazon, tropical rain forests are disappearing at unprecedented rates. But the Amazon provides essential ecosystem services on a global scale: pollination, flood control, carbon sequestration, regulation of fresh water, regulation of atmosphere, amelioration of disease, genetic libraries that include food and other biodiversity, and prevention of soil erosion (Foley *et al.* 2007). Almost 10 yr ago, nearly 15 percent of the Amazon basin was already cleared (Nepstad *et al.* 1999). Perhaps more urgently than other tropical forests, economic incentives for local stakeholders to conserve forests in the Amazon represent a win-win.

In 1993, a canopy walkway was constructed along the Sucasari tributary of the Rio Napo downstream from Iquitos, Peru (Table 1). Hardwood canopy trees were utilized as supports for a series of 13 connected bridges, at a cost of approximately US$100/m (P. Jenson, pers. comm.). With the use of local labor and materials, this cost was significantly less expensive than structures built on telephone poles or other imported structures that can cost up to US$3000/m (http://www.canopyconstruction.com). Explorama Lodges, partnering with CONEPEC (a Peruvian conservation group), maintains this canopy walkway as an ecotourism and research destination called Amazon Conservatory for Tropical Studies (ACTS). In 2007, 2625 eco-tourists paid US$150 to tour the canopy, totaling US$393,750 (with approximately US$30/person distributed to travel agents). The remaining profit (estimated at US$315,000) and associated services provided jobs for approximately 212 local villagers representing over 100 families (P. Becur & P. Jenson, owners of Explorama Lodge, pers. comm.). Over 8000 visitors come to Explorama annually; by rough calculations at US$150 per visitor, gross revenues for the walkways exceed US$1 million. This not only employs local people but also provides career livelihoods from ecotourism instead of logging (Fig. S1). Even more difficult to quantify, this cadre of international visitors return to their home countries with a first-hand education about the complexity of tropical rain forests. The ACTS walkway also inspired a major science education program called the Jason Expedition, where approximately 3 million middle school students around the world studied canopy ecology via satellite technologies (Lowman *et al.* 2006; http://www.jason.org). As a consequence, the ACTS walkway is now the destination of choice of countless teachers, families, and school groups (http://www.environmentalexpeditions.org). The metrics are fuzzy, but the conservation success is evident.

TABLE 1. *Metrics for three canopy walkways illustrating the variability with regard to obtaining accurate metrics from which to gauge success. Potential benefits: 1 = conservation education; 2 = income; 3 = employs locals; 4 = reduced logging or clearing pressure. Potential drawbacks: 1 = destruction of local ecosystems; 2 = extinction of species; 3 = addition of human infrastructure; 4 = no drawbacks observed.*

Site	Samoa	Peru	Florida
Initial cost	US$75,000	US$250,000	US$120,000
Visitors	~240/yr	> 8000/yr	> 298,749/yr
Revenue/yr	~US$12,000[a]	US$1.2 million[b]	~US$750,000[c]
Major benefits	2, 3, 4	1, 2, 3, 4	1, 4
Drawbacks	4	4	3
Reference	Elmqvist *et al.* (1993)	P. Jensen & P. Betencur, pers. comm.	Lowman *et al.* (2006)

[a]Walkway organizer Paul Cox estimated a revenue of US$12,000/yr. With a fee of US$50 per visitor, the estimated number of visitors was calculated based at 240.

[b]Explorama charges US$150 for a one-day trip to their walkway. If 8000 lodge visitors paid this fee, the revenue would be US$1.2 million. But again, this revenue has many ancillary costs attached. A better metric might be to cite employees, '200 families who do not earn their living by cutting down trees to provide their food or earn their money to survive' (Peter Jensen, co-owner of Explorama Lodges).

[c]Approximately 300,000 visitors come to the park in 2005; if each car holds two visitors, the revenue (at US$5/carload) is estimated at US$750,000. Obviously many factors such as weather and family size and marketing will influence these estimates. Hence, even at a state park in a developed country, it is difficult if not impossible to calculate the isolated economic benefits of one ecotourism operation in the midst of a region with existing tourism. In short, rigorous metrics are hard to come by.

FLORIDA CASE STUDY

North America's first public canopy walkway was constructed in Florida in 2000 (Table 1). Similar to tropical rain forests, the subtropical hammocks of Florida are declining due to human activities, and hence conservation education was an important goal. Built in 10 d, the Myakka River Canopy Walkway cost US$90,000 for a 33 m bridge (approximately US$3000/m) connecting two platforms, plus approximately US$30,000 for a tower (Lowman *et al.* 2006). Maintenance has been minimal with the exception of graffiti cleaning (P. Benschoff, pers. comm.). Perhaps the biggest success of the Florida canopy project was a significant increase in park visitorship. During a decade where visitors to both state and national parks declined precipitously (Louv 2005), the Myakka state park visitorship increased by at least 26 percent from 236,552 in 1995 to 298,749 in 2005, including repeated visits by local schools, churches, and other citizen groups to the walkway. On weekends, volunteers have logged up to 200 canopy visitors/h (totaling over US$500 in gate fees at US$5/car and assuming two people/carload). Despite best efforts, even Florida state government math was fuzzy for the skywalk. Issues such as staff shortfalls, weather, cutbacks in park infrastructure, and inability to separate walkway visitors from fisherman or boaters precluded a rigorous analysis. Like its Australian counterpart, the Myakka walkway has proven enormously successful in education outreach (http://www.treefoundation.org).

Despite its shortfall in rigorous metrics, canopy access has been embraced by local stakeholders as an economic opportunity for forest conservation. Two priorities are important as tropical forests continue to undergo deterioration: (1) promote a new ethic, whereby biologists are encouraged to contribute their tools and discoveries to inspire sustainable economic ventures for local stakeholders; and (2) configure metrics for success in conservation activities in terms of socioeconomic as well as scientific acceptance. When constructed and operated locally, canopy access systems may inspire useful outcomes: to facilitate critical ecological research, to bolster local economy, to inspire environmental education, and ultimately to encourage forest conservation at both local and global scales.

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SUPPORTING INFORMATION

Additional Supporting Information may be found in the online version of this article:

FIGURE S1. Willy Sanchez Flores, a local villager from the Rio Napo region in Peru, supports his family with employment as a fulltime guide for a growing local ecotourism industry centered around the canopy walkway.

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