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A global systematic review of empirical evidence of ecotourism impacts on forests in biodiversity hotspots

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Ecotourism is growing rapidly in biodiversity hotspots because of its promise to achieve both economic growth and environmental conservation. We reviewed the literature for empirical evidence that ecotourism protects forests. Our conclusions are at once both sobering and encouraging. Ecotourism, as it is typically practiced, leads to deforestation. However, when accompanied by conservation mechanisms (e.g. protected area, Payment for Ecosystem Services, monitoring/enforcement), ecotourism can protect forests. Ecotourism sometimes leads to forest regeneration in agrarian landscapes, but trade-offs, for example old-growth deforestation or water pollution, may occur. From a methodological perspective, we found a dearth (only 17) of articles that empirically analyzed ecotourism impacts on forests, and no studies that used counterfactual impact evaluation approaches. We conclude that there is an insufficient evidence base for inferring effects of ecotourism on forests, and we identify research priorities to build knowledge about how, when, and where to implement ecotourism.

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Introduction

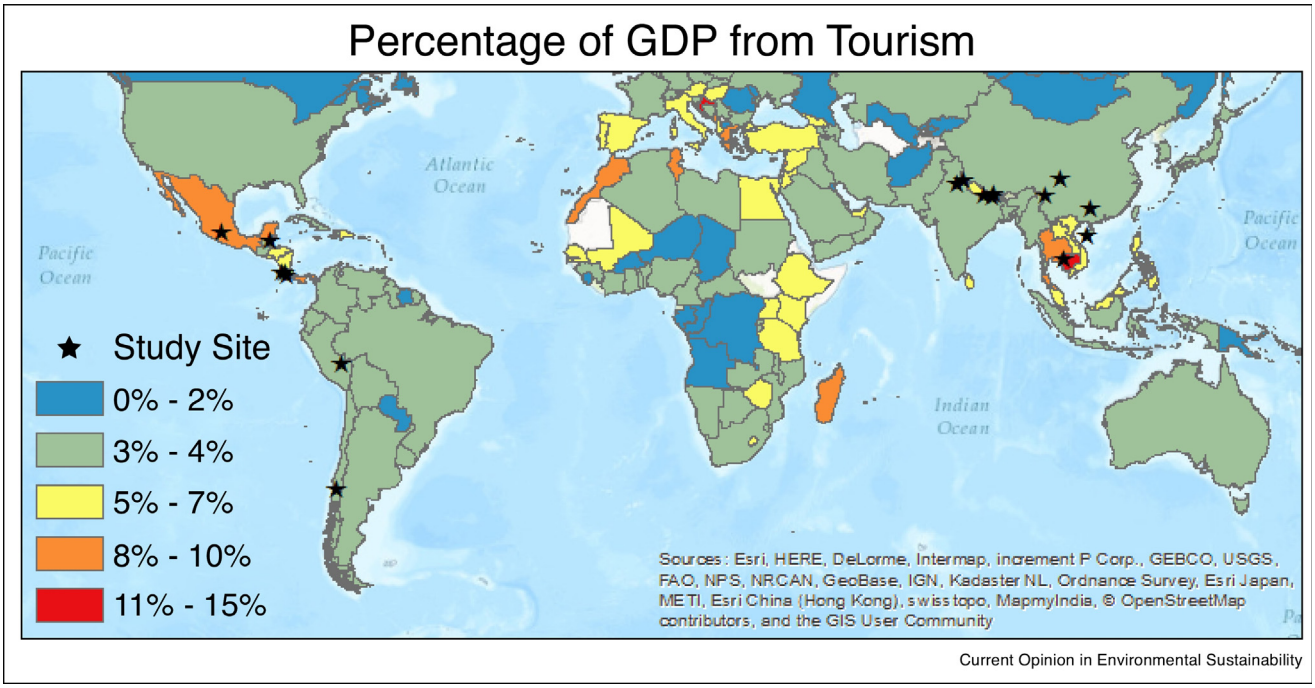
Human population growth and economic development in the next decades will exacerbate the biodiversity crisis [1]. Forests in developing economies face numerous escalating threats. Local livelihoods are dependent on forest resources [2], yet those same forests are exploited to meet international timber demand [3]. Forests could be cleared to provide food for growing populations [4], yet society relies on the conservation of those same forests to mitigate climate change. Less than one-third of the world's remaining forests are inside protected areas, including nearly 30% in developing countries and 16% overall [5]. In coming years, countries will have less ability to place land under strict protection [6]. A grand challenge facing humanity is to identify land use strategies that can both exploit and protect forests simultaneously.

One of the most rapidly growing sustainable land use strategies is 'ecotourism', because of its promise to achieve both conservation and economic development [7]. From a forest conservation perspective, ecotourism is an incentive-based forest governance intervention, and may interact with institutional interventions (e.g. protected areas (PAs)) or other incentive-based strategies (e.g. payment for ecosystem services (PES)). From an economic standpoint, tourism has huge benefits, accounting for as much as 40% of Gross Domestic Product (GDP) in Maldives (Figure 1), and is growing at a rate of more than 10% annually in other countries (e.g. Thailand, Costa Rica and Mongolia) [8•]. The amount spent on ecotourism is estimated to be 10 times more than that spent by official aid agencies and the United Nations Global Environment Facility on conservation projects [9,10]. However, despite its large and growing economic importance, the impacts of ecotourism on the environment, and on forests in particular, are not well understood [11•,12•,13].

Theoretically, ecotourism could protect forests because of economic incentives. For example, governments invest in PAs to gain revenue from international tourists [14•]. In addition, community ecotourism projects may dedicate a portion of proceeds into conservation [7]. More generally, developing nations typically rely on extraction-based land uses, for example the production of raw goods (e.g. timber or minerals), or the conversion of natural ecosystems (e.g. clearing forest for agriculture). With ecotourism, local residents and governments can generate income from tourism without consuming forest resources [9].

Alternatively, ecotourism could lead to forest loss because it stimulates economic development and related processes that drive deforestation. For example, tourism requires improved transportation networks (i.e. roads, airports, trains), which is strongly associated with

Figure 1



Locations of the 17 empirical articles reviewed, and the percentage of Gross Domestic Product derived from tourism for the world's countries (WTTC 2014) (data not available for countries in white).

deforestation [15]. In addition, tourism stimulates local population growth, both seasonal tourists and economic immigrants, and thus demand for forest resources increases [16]. Finally, tourism inherently leads to market integration, another factor strongly associated with deforestation [17].

Study objective and approach

Our goal here was to review the peer-reviewed literature for empirical evidence that ecotourism protects forests in biodiversity hotspots, where it is particularly urgent to identify effective forest governance strategies. Using search terms: 'ecotourism', 'deforestation', 'impacts', and 'forest conservation', we searched the Web of Science and Google Scholar online databases, and three global comprehensive reviews of ecotourism case studies [18–20]. We included in this review only peer-reviewed publications that used empirical approaches to evaluate the relationship between ecotourism and forests. Our review is structured as follows. First, we discuss the quantity and quality of existing empirical evidence. Second, we identify cases where ecotourism led to (a) deforestation, (b) forest protection, or (c) reforestation, and explore associated mechanisms. Third, we synthesize evidence across the three areas, and finally, we identify research priorities to advance knowledge of ecotourism–forest relationships.

Quantity and quality of evidence

We found a paucity of empirical research on the effectiveness of ecotourism as a forest conservation strategy. To be included in our review pool, we had two criteria: empirical data was used to evaluate both forest change and drivers, and the authors explicitly concluded an association between observed change and ecotourism. We at first restricted our review to recent articles (2015–2017), but found only three, and thus we expanded our search back to 2000. Of the 111 articles we reviewed, we found 17 peer-reviewed publications since 2000 that satisfied our criteria. The majority of the studies (14 of 17) evaluated forest change from satellite data, and three of 17 used social science approaches (i.e. surveys, interviews, or focus groups). We found three general analysis approaches. First, forest change was measured before and after tourism implementation, and in some cases, socio-economic data (e.g. tourist visitors or tourism income) was presented in a descriptive manner to support the association. Second, authors used social science methods, that is, surveys, interviews, or focus groups, to measure people's perceptions of drivers of forest change. Third, linear regression models with forest change as the dependent variable and drivers of change (e.g. distance to market, elevation, percent of counties' income derived from tourism, etc.) as explanatory variables were used to test the relative impact of ecotourism.

Table 1

A summary of the literature review, with observed outcomes and associated mechanisms and articles. We reviewed 17 articles, two of which measured both forest loss and forest re-growth, yielding a total *n* of 19 in this table

Outcome	Mechanisms	*n*	Citations
Deforestation	Tourism leads to high demand for forest products, but no conservation mechanisms in place. a. Increased timber demand for tourist lodging. b. Increased fuelwood demand for food and heating for tourists. c. Forests cleared for other land uses associated with tourism (tourist resorts, fruit orchards). d. Population growth due to immigrants working in tourism industry. e. Local consumption behaviors change with higher local incomes, increasing demands on forests.	9	Brandt et al. (2012); Garrard et al. (2016); Liu et al. (2001); Mao et al. (2014); Wang and Liu (2013); Mahapatra et al. (2012); Singh et al. (2009); Stevens (2003); Gaughan et al. (2009)
Forest protection	Tourism is accompanied by explicit conservation mechanisms. a. An explicit conservation mechanism (protected area, PES, conservation plan or pledge) is in place. b. Clear spatial boundaries that delineate the conservation/ecotourism area. c. Strong monitoring and enforcement. d. Strong community stake in economic benefits and protection.	4	Manzo-Delgado et al. (2014); Wyman and Stein (2010); Vuohelainen et al. (2012); Nagendra et al. (2005)
Forest re-growth	In settled landscapes, forest re-growth occurs as farmers switch to higher income opportunities. a. Individuals abandon agricultural fields to take part in tourism. b. Ecotourism is implemented in a broader landscape where investments have been made in forest protection and other income opportunities.	6	Almeyda et al. (2010); Broadbent et al. (2012); Allen (2015); Petitpas et al. (2016); Manzo-Delgado et al. (2014); Nagendra et al. (2005)

When does ecotourism lead to deforestation?

The most common finding in the empirical peer-reviewed literature (nine of 17 articles) was that ecotourism led to deforestation. We identified four case studies in China [21•,22–24], two in India [25,26], two in Nepal [27,28], and one in Cambodia [29]. In all nine cases, tourism led to increased demand for forest products. This occurred via five principal mechanisms (Table 1). First, the influx of tourist visitors created higher demand for timber to construct tourist accommodation. Second, demand for fuelwood grew, also to provide services to tourists. Third, immigrants flowed into tourism areas to take advantage of new economic opportunities, further increasing local demand for housing and fuelwood. Fourth, forests were cleared for other land uses, for example tourist resorts and fruit orchards, to satisfy growing local food demand. Finally, as household incomes increased, local people changed consumption behaviors, for example by building more or larger houses.

The archetypal case is that of Wolong Giant Panda Nature Reserve in southwest China [22•], where deforestation was measured before and after Reserve implementation. Surprisingly, deforestation increased after Reserve implementation, and deforestation increased more inside the Reserve than outside. To some extent, deforestation was linked to population growth of communities inside the reserve, but tourism, which created higher demand for timber, fuelwood, and other forest products was also a driver. Furthermore, as local incomes grew, Reserve residents built separate homes (instead of traditional multi-generational homes), further increasing forest demand.

When does ecotourism lead to forest protection?

Four out of 17 empirical articles concluded that ecotourism protected forests, including a Mexican Biosphere Reserve [30], a baboon sanctuary in Belize [31•], ecotourism parks in Peru [32], and Chitwan National Park in Nepal [33•] (Table 1). Though diverse in many ways, all four cases satisfied four main criteria. First, there was a specific forest conservation mechanism in place, such as a PA, PES, or conservation pledge. Second, there was a spatial boundary delineating the area governed by the conservation mechanism. Third, local families received direct economic benefits and fourth, there was strong, community-oriented, monitoring and enforcement.

The archetypal case is that of Chitwan National Park, Nepal [33•], where park buffer zones were implemented with explicit goals of forest protection and tourism. Boundaries were well-known, and rules regarding forest use were established in collaboration between communities, the government and non-profits. Economic benefits from tourism flowed into local communities, who in turn

used some of those resources to improve monitoring and enforcement. As a result, buffer zone forests experienced less deforestation than community forests in the same region, where rules were not as well enforced because they lacked ecotourism revenue.

Ecotourism and forest re-growth

Six of the 17 empirical studies found a link between ecotourism and forest re-growth, because farmers abandoned agricultural land for other economic opportunities, including tourism. Three of the six examples occurred in Costa Rica [34,35,36•] (Table 1), which has among the strongest economies and most stable political situation in Latin America, a strong tourism industry, an established PA system, and regional economic and environmental policies that encourage farmers to adopt higher-wage employment [36•]. As a result, many regions of the country are experiencing reforestation. Importantly, in all three cases forest re-growth was accompanied by trade-offs, that is, tourism also led to deforestation and forest fragmentation in primary forests [34,35] or declines in other ecosystem services [36•]. In two of six cases, both forest protection and forest re-growth were observed. In Nepal [33•] and Mexico [30], remaining primary forests were protected by strong conservation mechanisms and community engagement. In the Chilean case study, only forest re-growth was measured, and the fate of remaining primary forests was not discussed [37].

These case studies represent two different types of 'forest transition', that is, when forest regeneration outpaces forest loss [38•]. Forest transitions are typically associated with socio-economic transformations towards increased industrialization and urbanization, which allows the natural regeneration of forests or forest plantations. In the case of tourism, a forest transition would occur when a community abandons farming for tourism-related employment [14•]. Our results suggest that ecotourism is likely an effective strategy to restore forests in settled landscapes, but remaining high-value forests, if not explicitly protected, will be vulnerable. While the opportunities of returning forests are substantial, increasing forest alone does not necessarily mean that the system is on a pathway towards recovery [39]. Secondary forests are not equal to old-growth forest in terms of biodiversity, carbon storage, and ecosystem service provision and do not always return to high diversity ecosystems [40]. Thus, cases where reforestation is coupled with primary forest loss should be considered a net loss.

Synthesis and improving the knowledge base

The literature, though limited, does allow three generalizable conclusions. First, ecotourism protected forests when implemented in conjunction with another strong forest governance strategy. Conversely, ecotourism led to deforestation when implemented as a regional-scale economic development strategy, or without strong forest governance strategies. Finally, ecotourism led to forest regeneration in settled landscapes, but any remaining old-growth forests, without strict protection, were vulnerable.

Of the 111 articles reviewed, only 17 used empirical approaches. In forested areas of West and Central Africa, and parts of southeast Asia and Central America where ecotourism is a large and growing contributor to GDP (Figure 1), we found no empirical articles. Our review revealed an urgent need for more empirical research to evaluate ecotourism impacts on forests. Specifically, counterfactual methods have become standard for other forest governance interventions, because they control for biases inherent with observational datasets [41•]. For example, quasi-experimental matching, which compares treatment and control samples with similar underlying covariates, can effectively reduce observed bias [42]. Fixed-effects difference-in-difference (DID) panel models, which compare treated and control groups before and after treatment, can account for unobserved bias [41•]. Counterfactual approaches have been used to assess PA effectiveness [43,44], community forests [45,46], concessionary management [47], land titling [48], zoning plans [49], certification policies [50], hotel investment and eco-certification [51], and national forest governance policies [52]. However, within the forest ecotourism studies reviewed here, counterfactual approaches were not used to evaluate ecotourism impacts.

We suggest four main research priorities to expand our knowledge base. First, counterfactual analysis would allow us to explore three untested hypotheses: (H*a*) Deforestation is similar in ecotourism areas compared to areas without ecotourism; (H*b*) Ecotourism results in similar rates of deforestation as other development strategies; and (H*c*) Ecotourism results in similar rates of deforestation as other forest governance interventions.

Second, economic development is also goal of ecotourism, and during our literature search, we found an abundant literature that focuses on socio-economic impacts of ecotourism. For example, the literature on protected areas effectiveness uses counterfactual approaches to evaluate PA impacts on socio-economic conditions and forests [43,44]. Moving forward, ecotourism studies should address economic benefits concurrently with forest change, for example, by calculating a 'forest change per unit of economic growth' among different development strategies.

Third, we have little knowledge about the interactions between ecotourism and other conservation strategies, such as PES, PAs, or education strategies. For example, one of the studies we included in our review [31•] revealed that when ecotourism was accompanied by a household pledge to protect forests, tourism *decreased* deforestation probability, but in the absence of the

pledge, tourism *increased* deforestation probability. However, it is unclear the nature of this pledge: is it a pledge based on educating tourists, or residents? And more generally, what types of education are correlated with positive conservation efforts? Relatively minor interventions have large effects in terms of influencing ecotourism outcomes, but we did not find empirical studies that evaluate specific interactions.

Fourth, we found that the majority of studies (14 of 17) used satellite-derived deforestation as the outcome variable. However, satellites do not effectively measure forest degradation, which is pervasive and poses a large threat to biodiversity. Empirical research that uses a variety of measures of forest integrity to more fully investigate impacts of ecotourism is necessary. Finally, as with other environmental governance interventions, it is likely that ecotourism impacts will vary in different places and over time [53], and case studies in diverse social-ecological contexts, and at different spatial and temporal scales, is essential.

Conclusions

Our review revealed that there has been insufficient effort to evaluate the effectiveness of ecotourism as a forest conservation strategy. The majority of empirical evidence that does exist, indicates that when implemented in developing economies, ecotourism is associated with negative impacts on forests, because it stimulates development processes that are strongly associated with deforestation. Ecotourism should not be considered a conservation strategy by itself. However, when accompanied by an explicit conservation mechanism, a local economic benefit, and strong monitoring and enforcement, ecotourism can lead to forest protection. Our finding that ecotourism success is linked to monitoring, enforcement and community benefit is consistent with the literature for other environmental governance strategies [54–56]. Ecotourism can lead to forest re-growth, especially in settled landscapes where farmers abandon agriculture for other opportunities. However, forest re-growth can be accompanied by deforestation if remaining high-value forests are unprotected. Overall, our conclusions are based on a relatively small empirical knowledge base, and we call for more rigorous empirical study of ecotourism impacts on forests.

Conflicts of interest

None declared.

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References and recommended reading

Papers of particular interest, published within the period of review, have been highlighted as:

- • of special interest

1. Tilman D, Clark M, Williams DR, Kimmel K, Polasky S, Packer C: **Future threats to biodiversity and pathways to their prevention**. *Nature* 2017, **546**:73-81.

2. Rasmussen LV, Watkins C, Agrawal A: **Forest contributions to livelihoods in changing agriculture-forest landscapes**. *Forest Policy Econ* 2017.

3. Meyfroidt P, Rudel TK, Lambin EF: **Forest transitions, trade, and the global displacement of land use**. *Proc Natl Acad Sci U S A* 2010, **107**:20917-22092.

4. Ordway E, Asner G, Lambin E: **Deforestation risk due to commodity crop expansion in sub-Saharan Africa**. *Environ Res Lett* 2017, **12**:044015.

5. Morales-Hidalgo D, Oswalt SN, Somanathan E: **Status and trends in global primary forest, protected areas, and areas designated for conservation of biodiversity from the Global Forest Resources Assessment 2015**. *Forest Ecol Manag* 2015, **352**:68-77.

6. Bertzky B, Corrigan C, Kernsey J, Kenney S, Ravilious C, Becançon C, Burgess N: *Protected Planet Report 2012: Tracking Progress Towards Global Targets for Protected Areas*. Gland, Switzerland/Cambridge, UK: IUCN/UNEP-WCMC; 2012.

7. Buckley R: **Evaluating the net effects of ecotourism on the environment: a framework, first assessment and future research**. *J Sustain Tourism* 2009, **17**:643-672.

8. • WTTC: **This report is a global analysis of the economic importance of tourism in each country.**. *World Travel Tourism Council: The Economic Impact of Travel and Tourism 2014*. London; 2014.

9. Kirkby CA, Giudice R, Day B, Turner K, Soares-Filho BS, Oliveira-Rodrigues H, Yu DW: **Closing the ecotourism-conservation loop in the Peruvian Amazon**. *Environ Conserv* 2011, **38**:6-17.

10. Waldron A, Miller DC, Redding D, Mooers A, Kuhn TS, Nibbelink N, Roberts JT, Tobias JA, Gittleman JL: **Reductions in global biodiversity loss predicted from conservation spending**. *Nature* 2017, **551**:364.

11. • Romero-Brito TP, Buckley RC, Byrne J: **NGO partnerships in using ecotourism for conservation: systematic review and meta-analysis**. *PLOS ONE* 2016, **11**:19.
A review of 214 case studies worldwide, to synthesize evidence for 'success' of ecotourism conducted by non-governmental organizations. The review included studies that assessed 'success' using a broad range of economic, socio-cultural, and environmental criteria.

12. • Donnelly RE, Katzner T, Gordon IJ, Gompper ME, Redpath S, Garner TWJ, Altwegg R, Reed DH, Acevedo-Whitehouse K, Pettorelli N: **Putting the eco back in ecotourism**. *Anim Conserv* 2011, **14**:325-327.
This article conducts a review of the literature and finds that while the social outcomes of ecotourism is well-studied, outcomes and consequences of ecotourism from a perspective of biodiversity conservation has been largely ignored by conservation scientists.

13. Weaver DB, Lawton LJ: **Twenty years on: the state of contemporary ecotourism research**. *Tourism Manag* 2007, **28**:1168-1179.

14. • Buckley R: **Tourism and environment**. In *Annual Review of Environment and Resources*, vol 36. Edited by Gadgil A, Liverman DM . 2011:397-416.
A comprehensive review of 138 articles that discuss the relationship between tourism and the environment.

15. Laurance WF, Clements GR, Sloan S, O'Connell CS, Mueller ND, Goosem M, Venter O, Edwards DP, Phalan B, Balmford A *et al.*: **A global strategy for road building (vol 513, pg 229, 2014)**. *Nature* 2014, **514**:262.

16. Hall C, Lew A: In *Understanding and Managing Tourism Impacts*. Edited by Hall C. London, New York: Routledge; 2009.

17. Lambin EF, Meyfroidt P: **Global land use change, economic globalization, and the looming land scarcity**. *Proc Natl Acad Sci U S A* 2011, **108**:3465-3472.

18. Buckley R: *Ecotourism Principles and Practices*. Oxfordshire, UK: CAB International; 2009.

19. Buckley R: *Conservation Tourism*. Oxfordshire, UK: CAB International; 2010.

20. Honey M: *Ecotourism and Sustainable Development*. edn 2. Island Press; 2008.

21. • Brandt JS, Kuemmerle T, Li H, Ren G, Zhu J, Radeloff VC: **Using Landsat imagery to map forest change in southwest China in response to the national logging ban and ecotourism development**. *Rem Sens Environ* 2012, **121**:358-369.
A 'before and after' empirical approach to studying the relationship between ecotourism and forests. Forest change was measured using satellite data before and after tourism was implemented in the case study area, and socio-economic data was collected for the same time period to describe the trajectory of social change.

22. • Liu J, Linderman M, Ouyang Z, An L, Yang J, Zhang H: **Ecological degradation in protected areas: the case of Wolong Nature Reserve for Giant Pandas**. *Science* 2001, **292**:98-101.
Archetypal case study for negative forest outcomes of ecotourism.

23. Mao XY, Meng JJ, Wang Q: **Tourism and land transformation: a case study of the Li River Basin, Guilin, China**. *J Mountain Sci* 2014, **11**:1606-1619.

24. Wang JY, Liu YS: **Tourism-led land-use changes and their environmental effects in the southern coastal region of Hainan Island, China**. *J Coast Res* 2013, **29**:1118-1125.

25. Mahapatra PS, Pandey R, Pradhan S: **River rafting in mountainous regions of Uttarakhand: impacts, suggested mitigation measures and sustainability**. *J Mountain Sci* 2012, **9**:511-522.

26. Singh RB, Mal S, Kala CP: **Community responses to mountain tourism: a case in Bhyundar Valley, Indian Himalaya**. *J Mountain Sci* 2009, **6**:394-404.

27. Garrard R, Kohler T, Price MF, Byers AC, Sherpa AR, Maharjan GR: **Land use and land cover change in Sagarmatha National Park, a world heritage site in the Himalayas of Eastern Nepal**. *Mountain Res Dev* 2016, **36**:299-310.

28. Stevens S: **Tourism and deforestation in the Mt Everest region of Nepal**. *Geogr J* 2003, **169**:255-277.

29. Gaughan AE, Binford MW, Southworth J: **Tourism, forest conversion, and land transformations in the Angkor basin, Cambodia**. *Appl Geogr* 2009, **29**:212-223.

30. Manzo-Delgado L, Lopez-Garcia J, Alcantara-Ayala I: **Role of forest conservation in lessening land degradation in a temperate region: the Monarch Butterfly Biosphere Reserve, Mexico**. *J Environ Manag* 2014, **138**:55-66.

31. • Wyman MS, Stein TV: **Modeling social and land-use/land-cover change data to assess drivers of smallholder deforestation in Belize**. *Appl Geogr* 2010, **30**:329-342.
The article demonstrates an explicit interaction between ecotourism and a conservation mechanism. when ecotourism was accompanied by a household pledge to protect forests, tourism decreased deforestation probability, but in the absence of the pledge, tourism increased deforestation probability.

32. Vuohelainen AJ, Coad L, Marthews TR, Malhi Y, Killeen TJ: **The effectiveness of contrasting protected areas in preventing deforestation in Madre de Dios, Peru**. *Environ Manag* 2012, **50**:645-663.

33. • Nagendra H, Karmacharya M, Karna B: **Evaluating forest management in Nepal: views across space and time**. *Ecol Soc* 2005, **10**.
This article demonstrates an archetypal case of how ecotourism can lead to forest protection. Economic benefits from tourism enabled local communities to improve monitoring and enforcement of forest rules, leading to reduced deforestation compared to community forests without ecotourism.

34. Almeyda AM, Broadbent EN, Wyman MS, Durham WH: **Ecotourism impacts in the Nicoya Peninsula, Costa Rica**. *Int J Tourism Res* 2010, **12**:803-819.

35. Broadbent EN, Zambrano AMA, Dirzo R, Durham WH, Driscoll L, Gallagher P, Salters R, Schultz J, Colmenares A, Randolph SG: **The effect of land use change and ecotourism on biodiversity: a case study of Manuel Antonio, Costa Rica, from 1985 to 2008**. *Landsc Ecol* 2012, **27**:731-744.

36. • Allen KE: **Trade-offs in nature tourism: contrasting parcel-level decisions with landscape conservation planning**. *Ecol Soc* 2015, **20**:10.
This case study is an archetypal example of how ecotourism can lead to environmental trade-offs. Farmers leave farming to participate in the tourism industry, leading to forest re-growth on abandoned land. However, the tourism industry can lead to other environmental problems, for example, river water quality declines due to increased pollution and garbage.

37. Petitpas R, Ibarra JT, Miranda M, Bonacic C: **Spatial patterns over a 24-year period show an increase in native vegetation cover and decreased fragmentation in Andean temperate landscapes, Chile**. *Cienc Invest Agrar* 2016, **43**:384-395.

38. • Meyfroidt P, Lambin E: **Global forest transition: prospects for an end to deforestation**. *Annu Rev Environ Resour* 2011, **36**:1-29.
This article describes forest transition theory, which is important context for the analysis of forest change trajectories, especially in countries in the midst of economic development.

39. Kauppi PE, Ausubel JH, Fang JY, Mather AS, Sedjo RA, Waggoner PE: **Returning forests analyzed with the forest identity**. *Proc Natl Acad Sci U S A* 2006, **103**:17574-17579.

40. Chazdon RL, Peres CA, Dent D, Sheil D, Lugo AE, Lamb D, Stork NE, Miller SE: **The potential for species conservation in tropical secondary forests**. *Conserv Biol* 2009, **23**:1406-1417.

41. • Butsic V, Lewis DJ, Radeloff VC, Baumann M, Kuemmerle T: **Quasi-experimental methods enable stronger inferences from observational data in ecology**. *Basic Appl Ecol* 2017, **19**:1-10.
A thorough review of various quasi-experimental methods, with specific examples, that can be used to test environmental outcomes of policy or other interventions. Such methods may be proved valuable for future research on ecotourism outcomes.

42. Andam KS, Ferraro PJ, Pfaff A, Sanchez-Azofeifa GA, Robalino JA: **Measuring the effectiveness of protected area networks in reducing deforestation**. *Proc Natl Acad Sci U S A* 2008, **105**:16089-16094.

43. Pfaff A, Robalino J: **Spillovers from conservation programs**. *Annu Rev Resour Econ* 2017, **9**:299-315.

44. Ferraro PJ, Hanauer MM: **Through what mechanisms do protected areas affect environmental and social outcomes?** *Philos Trans R Soc B: Biol Sci* 2015, **370**:20140267.

45. Brandt JS, Butsic V, Schwab B, Kuemmerle T, Radeloff VC: **The relative effectiveness of protected areas, a logging ban, and sacred areas for old-growth forest protection in southwest China**. *Biol Conserv* 2015, **181**:1-8.

46. Rasolofoson RA, Ferraro PJ, Jenkins CN, Jones JPG: **Effectiveness of community forest management at reducing deforestation in Madagascar**. *Biol Conserv* 2015, **184**:271-277.

47. Bruggeman D, Meyfroidt P, Lambin EF: **Production forests as a conservation tool: effectiveness of Cameroon's land use zoning policy**. *Land Use Policy* 2015, **42**:151-164.

48. Blackman A, Corral L, Lima ES, Asner GP: **Titling indigenous communities protects forests in the Peruvian Amazon**. *Proc Natl Acad Sci U S A* 2017, **114**:4123-4128.

49. Nolte C, Gobbi B, le Polain de Waroux Y, Piquer-Rodríguez M, Butsic V, Lambin EF: **Decentralized land use zoning reduces large-scale deforestation in a major agricultural frontier**. *Ecol Econ* 2017, **136**:30-40.

50. Miteva DA, Loucks CJ, Pattanayak SK: **Social and environmental impacts of forest management certification in Indonesia**. *PLOS ONE* 2015, **10**:e0129675.

51. Blackman A, Naranjo MA, Robalino J, Alpízar F, Rivera J: **Does tourism eco-certification pay? Costa Rica's Blue Flag Program**. *World Dev* 2014, **58**:41-52.

52. Brandt JS, Allendorf T, Radeloff V, Brooks J: **Effects of national-level forest management regimes on non-protected forests of the Himalaya**. *Conserv Biol* 2017.

53. Ostrom E, Janssen MA, Anderies JM: **Going beyond panaceas**. *Proc Natl Acad Sci U S A* 2007, **104**:15176-15178.

54. Agrawal A, Chhatre A: **Explaining success on the commons: community forest governance in the Indian Himalaya**. *World Dev* 2006, **34**:149-166.

55. Bruner AG, Gullison RE, Rice RE, da Fonseca GAB: **Effectiveness of parks in protecting tropical biodiversity**. *Science* 2001, **291**:125-128.

56. Ostrom E: **Design principles in long-enduring irrigation institutions**. *Water Resour Res* 1993, **29**:1907-1912.