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The Local Impacts of World Bank Development Projects Near Sites of Conservation Significance

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Abstract

We evaluated the local impacts of World Bank development projects on sites of recognized conservation significance (Important Bird and Biodiversity Areas [IBAs]) using tree cover change data and in situ state, pressure, and response monitoring data. IBAs adjacent to World Bank project locations and a matched set of IBAs distant from World Bank project locations had similar rates of tree loss and similar in situ measurements of conservation outcomes. Thus, we did not detect any significant net negative impacts of World Bank projects on tree cover or conservation outcomes. These results are encouraging because 89% of World Bank projects that are close to IBAs are environmentally sensitive projects (so-called Category A and Category B projects) subjected to the organization's most stringent safeguards. However, the limitations of our evaluation design do not allow us to rule out the possibility that World Bank projects had positive or negative effects that were undetectable.

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Facing the dual challenges of human development and biodiversity loss, many aid agencies have made efforts over the past 25 years to incorporate environmental considerations into their development projects (Buntaine, 2011, 2016; Hickey & Pimm, 2011; Hicks, Parks, Roberts, & Tierney, 2008; Keohane & Levy, 1996). The World Bank, in particular, has introduced a safeguard regime that includes environmental impact assessments, environmental education programs, management plans to strengthen habitat protection, reforestation activities, and other efforts to preserve and protect natural habitats and biodiversity (Ledec & Posas, 2003; Nielson & Tierney, 2003; Quintero, 2007). These safeguards apply to most World Bank projects, whether or not their primary purpose is environmental protection, and require compliance with various national and international biodiversity regulations, site-selection criteria that take into consideration biodiversity conservation aims, offsetting of expected losses in natural habitats, and sustainable harvesting of forest products (World Bank, 1999, 2001, 2002).[1]

Some argue that the World Bank has made extensive efforts to mainstream environmental considerations into its project design and implementation processes (Nielson & Tierney, 2003; World Bank, 2002). Others claim that the World Bank safeguards are inconsistently applied or that they constitute a "greenwashing" attempt to satisfy external stakeholders (Gutner, 2002; Rich, 1994). The effectiveness of the environmental safeguards that the World Bank requires of different types of projects is also a source of continuing debate (Nielson & Tierney, 2003; Shandra, Shircliff, & London, 2011; Wade, 1997; World Bank, 2002). However, this debate is hampered by limited empirical evidence on the impacts of World Bank projects since its purportedly stringent environmental safeguard regime was put in place in the late 1990s.

We sought to address the gap in the literature by using a quasi-experimental method of causal inference to empirically evaluate the impacts of World Bank development projects (subject to different types of environmental safeguards) on sites of recognized conservation significance. More specifically, we merged georeferenced project, outcome, and covariate data and employed propensity score matching methods to assess whether development projects funded through the World Bank's primary mechanisms for concessional and nonconcessional lending between 2000 and 2011 had any detectable impacts—either positive or negative—on conservation outcomes in Important Bird and Biodiversity Areas (IBAs), relative to the background rates of change in IBAs.[2]

To measure outcomes of interest, we used in situ biodiversity monitoring data on conservation states (conditions), pressures (threats), and responses (conservation interventions) within IBAs as well as remotely sensed data on tree loss within IBAs (Hansen et al., 2013).[3] We then compared these outcomes in IBAs that were exposed to World Bank project interventions (defined as those <10 km from World Bank project locations) with a matched set of IBAs that were not known to have been exposed to World Bank project interventions (>100 km from World Bank project locations).[4] For the ease of exposition, we refer to the former group as "WB-adjacent IBAs" and the latter group as "WB-distant IBAs."

Using this set of matched pairs, we estimated the effects of World Bank projects by calculating the rate of tree loss in "treated" (WB-adjacent) IBAs and netting out the counterfactual (background reference) rate of tree loss in "control" (WB-distant) IBAs. Likewise, across matched pairs of IBAs with and without known exposure to World Bank projects, we compared in situ measurements of changes in conservation actions and outcomes after the approval of World Bank projects. During the case matching process, we accounted for pretreatment biodiversity outcomes, as recommended by Cook, Shadish, and Wong (2008); specifically, initial condition scores from IBA monitoring, and tree loss between 2000 and 2005, were used to account for common pretreatment outcomes in both WB-adjacent and WB-distant IBAs.[5] We also assessed whether the environmental category of World Bank projects (a measure of how environmentally risky a given project was deemed prior to approval and the stringency of the environmental safeguards applied to the project) influenced whether or not we detected a difference in tree cover change between WB-adjacent IBAs and WB-distant IBAs.[6]

Our results suggest that World Bank investment projects generally do not have net negative impacts on conservation outcomes. We find no evidence of net negative impacts from "Category A" projects, that is, the most environmentally sensitive projects subjected to the organization's most stringent safeguards. We also provide evidence that "Category B" projects—that is, projects identified by World Bank during the preparation phase as posing significant environmental risks that could be readily mitigated during implementation—are associated with a reduction in the rate of tree cover loss in geographically adjacent IBAs. These findings are significant because 67% of World Bank investment projects that are physically proximate to IBAs are "Category B" projects, and 22% of World Bank investment projects that are physically proximate to IBAs are "Category A" projects.

Methods

Treatment and Outcome Data

We used georeferenced data on World Bank projects from AidData (2015). Specifically, we employed a geocoded data set of all projects approved between

2000 and 2011 through the World Bank's concessional and nonconcessional lending windows: the International Development Association (IDA) and the International Bank for Reconstruction and Development (IBRD). Due to a lack of georeferenced data, our study did not assess projects supported by the International Finance Corporation or the Multilateral Investment Guarantee Agency. The IDA and IBRD projects in our sample supported activities in a wide range of sectors, including infrastructure, mining, agricultural production, pollution control, and institution building (Tables S1 and S2). The full data set comprised 3,534 projects implemented across 41,307 locations at a total cost of US$334 billion. We removed projects with insufficient data to be precisely mapped such as projects implemented across entire continents or countries. We also excluded projects that were subnationally geocoded but with an insufficient level of locational precision: projects with latitude and longitude coordinates within 25 km of the exact intervention sites (with AidData precision codes > 2). Exclusion of these data left 1,471 projects in 20,621 locations worth an estimated US$129 billion.

We assumed that these excluded projects and project locations are randomly distributed with regard to IBAs, but we cannot rule out the possibility of systematic exposure to one or more World Bank projects in our WB-distant IBAs in the global analysis. However, to test the reliability of this assumption, we reexamined effects in one country (China) where more than 80% of the projects had a high level of locational precision.

Digital IBA boundaries were obtained for 11,822 IBAs (BirdLife International, 2014), of which 7,256 contained trees according to tree cover data retrieved from Hansen et al. (2013). For each IBA, in situ monitoring at varying levels of periodicity assessed conservation states (conditions, based on the population status of the species for which the IBA is identified as important or their habitats), pressures (threats, based on the scope, severity, and timing of threats to these species), and responses (conservation interventions to undertake relevant management actions for these species or their habitats) on a 4-point scale (0 to 3, with 3 indicating the highest level of threat, a very good state, or greatest response) following the methods of BirdLife International (2006). Pressures (threats) were originally scored on a negative scale ranging from -3 (most threatened) to 0 (least threatened), but we rescaled this indicator to 0 to $+3$ for ease of analysis (0 being least threatened). These data are based on field-based monitoring, undertaken by staff or volunteers of national BirdLife Partner organizations. This simple system means that these monitoring data are standardized and comparable across the whole of the IBA network. Field-based assessment of deforestation pressures broadly match objective assessments derived from remotely sensed data on tree loss (Buchanan, Fishpool, Evans, & Butchart, 2013). Of the 1,780 IBAs, 1,671 had at least one of the three types of in situ data available. The frequency of monitoring varied between these IBAs. Spearman rank correlations indicated that changes in conservation responses between first and last monitoring assessments for IBAs were independent of changes in conservation state and pressure ($r_{s353} = .089$, $p = .234$ and $r_{s751} = .108$, $p = .097$, respectively), but changes in state and pressure were negatively correlated ($r_{s339} = -.285$, $p < .0001$), indicating that these two measures were not independent.

Tree loss data were extracted from Hansen et al. (2013), who estimated tree cover and tree cover loss between 2000 and 2012 in 30-m cells across the globe using Landsat satellite images. A JavaScipt code (Tracewski et al., 2016) was used to extract and process the data in Google Earth Engine (http://earthengine.google.org/), a cloud-based platform for earth-observation data analysis. The code is available from https://github.com/RSPB/IBA. For each IBA polygon, tree cover in 2000 was then derived from the "treecover2000" layer. The number of pixels from which trees were lost in each subsequent year (based on the "lossyear" layer) was then calculated. This calculation assumed that all of the original tree cover (based on the cover in the "treecover2000" layer) within the pixel was lost. For instance, if the pixel's value in the "treecover2000" layer was 70% and it was marked in the "lossyear" layer in 2005, we assumed total loss (i.e., total loss of the original 70% tree cover) by 2005.[7] Each pixel could be "lost" only once in the "lossyear" layer, and any pixel identified as "tree gain" was ignored, as very young trees are unlikely to support forest-dependent species. Tree loss data are available for years subsequent to 2012, but changes in the algorithm used to calculate these meant that we used the 2000 to 2012 data only.

We identified IBAs located within 10 km of a World Bank project and designated these as WB-adjacent IBAs. The IDA and IBRD projects that were adjacent to IBAs had a significantly different set of observable characteristics than the broader sample of IDA and IBRD projects approved between 2000 and 2011. They were largely focused in environmentally risky sectors (e.g., transport, energy, agriculture, forestry, fishing) and subject to more stringent environmental safeguards (see Figure S1). These projects also involved unusually high levels of environmental expenditure (see Table S3), which further suggests that the World Bank made special efforts to prevent these projects from having damaging environmental impacts. We attempted to measure the unconditional and conditional impacts of these projects by first analyzing the full sample of projects (to identify overall impacts) and then analyzing projects according to their environmental categories (to identify potentially heterogeneous impacts based upon the stringency of the safeguards implemented) and themes (to identify potentially heterogeneous impacts based upon different types of objectives).

In our full sample, approximately 45% of all IBAs were within 100 km of a World Bank project location, and more than a third of these IBAs were within 10 km (including those with World Bank projects within their boundaries). Precisely georeferenced World Bank projects containing at least one location within 10 km of an IBA constitute roughly half of all projects (2,898) approved and financed through IDA and IBRD arms of the World Bank Group between

2000 and 2011. The true proportion is likely higher, as not all projects could be geolocated with a high level of precision.[8] In total, 1,780 IBAs were within 10 km of a World Bank project locations (Figure 1), and for 411 of these, World Bank project locations were actually within the IBAs. These interventions represented 774 World Bank projects, often operating in multiple locations. The median distance between a WB-adjacent IBA and the location of the corresponding

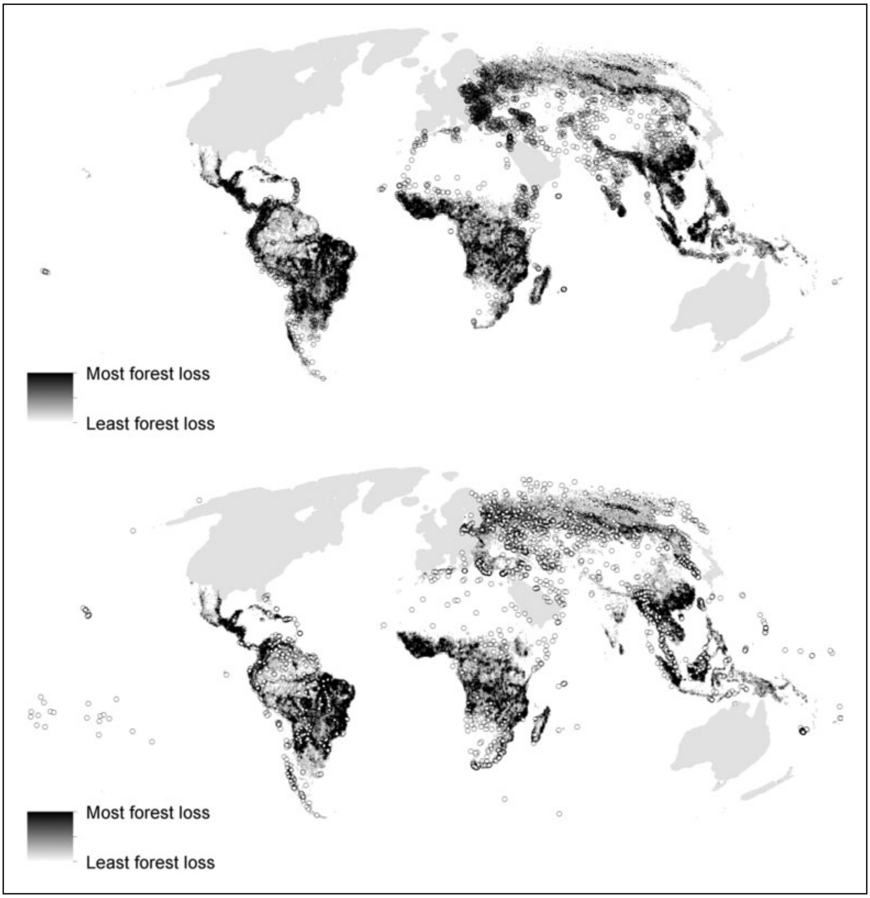

Figure 1. Distribution of IBAs < 10 km of a World Bank project location (top) and IBAs > 100 km of a World Bank project location (bottom) overlaid on map of proportion of tree lost between 2000 and 2012.

Source. Hansen et al. (2013).

Note. Important Bird and Biodiversity Areas (IBAs) in countries that are not World Bank borrowers have been shaded out.

World Bank project was 3.95 km. World Bank financing for these 774 projects in 2,898 locations amounted to US$73.4 billion, although, because some projects operate at multiple locations, not all of this funding was spent within 10 km of the corresponding IBAs.

Data Analyses

We compared the values of seven conservation metrics in WB-adjacent and WB-distant IBAs. These seven metrics can be divided into three groups. The first of these analyses compared the 2006 to 2012 rates of tree loss in WB-adjacent IBAs and a matched set of WB-distant IBAs. To allow for the inclusion of pretreatment biodiversity outcomes in the matching process, we considered only IBAs that were exposed to projects approved up to and including 2005. We also omitted projects that were approved after 2010 as these might not have been initiated by 2012. Thus, we considered only IBAs that were exposed to projects approved from 2006 to 2010.

In addition to running this analysis across all projects, we examined subsamples of WB-adjacent IBAs based upon the environmental categories of the adjacent World Bank projects. The World Bank assigns all of its projects to one of four environmental categories: A, B, C, or F (see online Appendix A). Category A projects pose the most severe environmental risks; they often involve linear infrastructure (e.g., roads, railways, pipelines, electrical transmission lines); airports; seaports; dams; waste water treatment plants; industrial-scale chemical manufacturing; or oil, gas, mining, or timber extraction activities. The World Bank subjects these projects to their most stringent set of environmental mitigation measures, but it also acknowledges that the risks these projects pose can be difficult or impossible to fully mitigate. Category B projects also pose significant environmental risks, but the World Bank expects that it can reasonably and readily mitigate all or most of these risks during implementation. Category C projects are those projects that the World Bank considers to pose no environmental risks or negligible environmental risks. If a project is placed in Category C, it usually requires no mitigation measures during implementation. Category F applies to a small cohort of projects that are funded through financial intermediaries rather than by the World Bank directly. These projects may or may not pose significant environment risks, and the financial intermediaries supported by the World Bank must environmentally screen any subprojects that they consider supporting.

Therefore, the environmental categories to which World Bank projects are assigned not only capture the expected level of the environmental risk (as assessed by environmental experts at the World Bank prior to project implementation), but also the scale and scope of the risk mitigation measures that will be required. To gauge whether these different types of projects have heterogeneous conservation impacts, we compared tree loss in WB Category A-adjacent

IBAs and a matched set of WB-distant IBAs, WB Category B-adjacent IBAs and a matched set of WB-distant IBAs, WB Category C-adjacent IBAs and a matched set of WB-distant IBAs, and WB Category F-adjacent IBAs and a matched set of WB-distant IBAs.

We also examined subsamples of WB-adjacent IBAs according to the themes of the adjacent World Bank projects. The World Bank categorizes all of its projects, prior to approval, according to themes that capture "the goals/objectives of Bank activities."[9] We selected themes for which there were more than 100 WB-adjacent IBAs with tree loss data to maintain reasonable sample sizes (Table 1) and then compared tree loss in WB-adjacent IBAs (in cases where all of the adjacent World Bank projects shared a common theme code) and a matched set of WB-distant IBAs.

The second analysis focused on three outcomes measured via in situ monitoring. The scores for state, pressure, and response on WB-adjacent IBAs were compared with scores from a matched set of WB-distant IBAs. Data from the year closest to 2014 were used if IBAs had been monitored on multiple occasions. We discarded data that were collected before or less than 2 years after World Bank project approval.

The third analysis focused on temporal change in the state, pressure, and response scores for WB-adjacent IBAs and a matched set of WB-distant IBAs. Change in condition state, pressure, or response was calculated as the difference between the monitoring score prior to approval of the adjacent World Bank

Table 1. Significance of Wilcoxon Tests for Tree Loss on Matched Samples of World Bank (WB)-Adjacent Important Bird and Biodiversity Areas (IBAs) and WB-Distant IBAs for Themes for Which There Were >100 WB-Adjacent IBAs With Tree Loss Data.

Theme (and code)	*n*	*W*	*p*
Pollution management and environmental health (84)	76	2875	.9632
Infrastructure services for private sector development (39)	141	8994.5	.1668
Rural services and infrastructure (78)	125	7516.5	.6044
Trade facilitation and market access (49)	94	4664.5	.5089
Urban services and housing for the poor (71)	48	1200	.7252
Municipal governance and institution building (73)	43	1018	.4189
Administrative and civil service reform (25)	34	460	.1481
Participation and civic engagement (57)	74	2008	.004882
Rural markets (75)	41	702.5	.2015
Natural disaster management (52)	52	1299	.7321
Regional integration (47)	37	715	.7447
Improving labor markets (51)	20	183.5	.6646

project and the monitoring score after this period (providing at least 3 years had elapsed). We were not able to subset the second and third analyses by World Bank environmental categories of theme codes due to small sample sizes.

We used a statistical matching algorithm (Andam, Ferraro, Pfaff, Sanchez, & Robalino, 2008) to create matched sets of WB-adjacent and WB-distant IBAs to account for the potentially nonrandom distribution of project locations with respect to conditions that might affect our outcomes of interest within IBAs. Specifically, we matched sites using the MatchIt (Ho, Imai, King, & Ferrer, 2011) package in R, and the nearest neighbor propensity score matching method. We dropped IBAs that did not have common support and matched IBAs without replacement. The maximum difference between matched sites was set to 0.5 standard deviations for each matching covariate. Matching was repeated individually for each of the seven analyses of conservation metrics.

The covariates we included in the matching algorithm were those that we have used previously in assessments of pressures on IBAs or that were correlated with land cover changes in or near IBAs (Beresford et al., 2013, 2017; Tracewski et al., 2016). Specifically, they were (a) ruggedness of terrain within an IBA (a measure of topographic and altitudinal variation based upon 30 arc seconds global data; United States Geological Survey, 2004) and a 3- × 3-cell area as a measure of how accessible the IBA was and how amenable to conversion (Riley, DeGloria, & Elliot, 1999), (b) whether IBAs overlapped a protected area (based on comparison with the World Database on Protected Areas; International Union for Conservation of Nature and United Nations Environment Programme-World Conservation Monitoring Centre, 2013) as a measure of legal protection of land within the IBA, (c) human population density (mean human population density per km^2) using data for 2000 at a 0.25-degree resolution (Center for International Earth Science Information Network, 2013) as an indicator of the pressure upon the IBA from human activity, (d) the proportion of agricultural land within the IBA (Bartholomé & Belward, 2005) as an area adjacent to agriculture is more susceptible to conversion (Beresford et al., 2017), and (e) the total length of primary and secondary roads within a 25-km radius (based on a buffer produced in Arc Map) of the IBA in 1997 (National Imagery and Mapping Agency, 2012) as a measure of IBA accessibility, and gross domestic product (US$) per capita in 2015 (World Bank, 2016).

We matched exactly on the continent within which each IBA was located, which means that all matched IBA pairs were restricted to pairs within continents. We also conducted a separate analysis in which we matched exactly on country (by restricting all matched IBA pairs to pairs within countries), but this resulted in much reduced sample sizes for the subsequent tests and did not always improve covariate balance in the sample of matched IBAs. Based on the recommendations of Cook et al. (2008), we also included a measure of pretreatment outcomes in the matching algorithm for the four tests where we were interested in the change over time. Thus, initial condition scores from IBA monitoring or tree loss between 2000 and 2005 were used to account for common pretreatment trends across WB-adjacent and WB-distant IBAs.

To determine if our selection of a 10-km threshold to define "adjacency" influenced the results, we repeated this matching analysis across a range of distance thresholds from the IBAs. We did this only for the analyses that included a measure of pretreatment outcomes in the matching algorithm, as these should be the analyses that best control for potentially confounding effects (Cook et al., 2008).[10] We tested for differences in outcomes at distances of 0 km (i.e., World Bank projects within the IBA only), 5 km, 15 km, 20 km, 30 km, 40 km, and 50 km (Figure 2).

For tree cover loss between 2006 and 2012, the matching process improved covariate balance between WB-adjacent IBAs and WB-distant IBAs by 76%. The difference between the WB-adjacent and WB-distant IBAs was just 0.0056, well within the 0.0557 SD of the WB-distant IBAs. For state scores, the matching process improved covariate balance across the "treated" and "control" IBAs by 47%. The difference between the means was just 0.0995, which was still well within the 0.2767 SD of WB-distant IBAs. For pressure scores, the matching process improved covariate balance in the covariate distance between WB-adjacent and WB-distant IBAs by 71%, with a mean difference of 0.0189, which was well within the 0.3553 SD of the WB-distant IBAs. The pattern was very similar for the response scores; the matching process improved covariate balance across

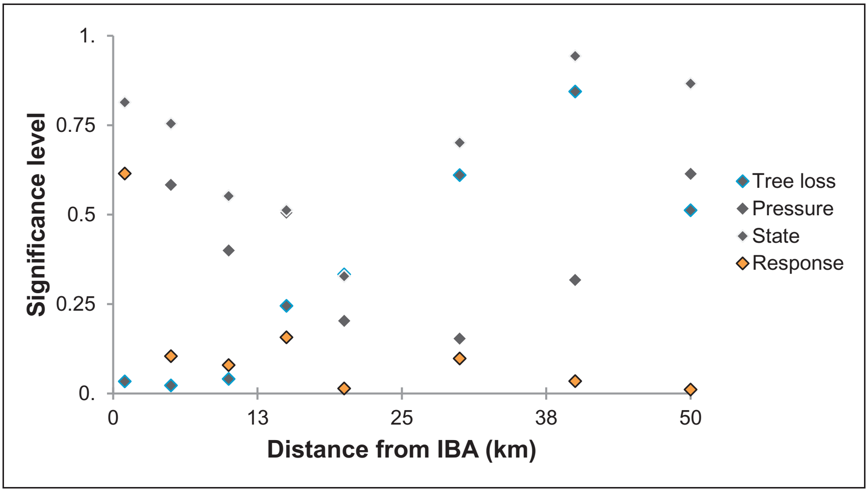

Figure 2. Significance of Wilcoxon tests for tree loss, pressure, state, and response after matching including initial condition for increasing distances to closest World Bank project (i.e., increasing distance used to define WB-adjacent).
Note. IBA = Important Bird and Biodiversity Area.

the "treated" and "control" IBAs by 71%. The difference between the means of WB-adjacent and WB-distant IBAs was 0.0112, again within the 0.092 SD of the WB-distant IBAs. Sample sizes were much smaller for the analysis of change in the condition of IBAs, which limited the pool of IBAs available for matching. For the change in state, the matching process improved covariate balance between WB-adjacent and WB-distant IBAs by 74%. However, as the difference between the means of WB-adjacent and WB-distant IBAs was 0.0936 (relatively high compared with the 0.1938 SD around the mean for WB-distant IBAs), the balance between WB-adjacent and WB-distant IBAs was imperfect. Although the percentage improvement in covariate balance for change in pressure was lower than for change in state, at 59%, the difference between the mean for the matched WB-adjacent and WB-distant IBAs was, at 0.0479, much less than the 0.1351 SD around the mean for WB-distant IBAs. For change in response, the matching process improved covariate between WB-adjacent and WB-distant IBAs by 41%. The difference between the means of WB-adjacent and WB-distant IBAs, at 0.0285, was relatively high compared with the 0.0654 SD around the mean for WB-distant IBAs. The matching process increased the differences in surrounding agriculture and protection between WB-adjacent and WB-distant IBAs. However, the matching process produced a better covariate balance in the preproject initiation response scores between the WB-adjacent and WB-distant IBAs (Tables S5 and S6). A summary of the country-level matching results is given in Table S6.

We used a Wilcoxon rank-sum test to compare between the WB-adjacent and WB-distant IBAs. Statistical tests were interpreted with two-tailed distributions of probability.

Results

The rate of tree loss during 2006 to 2012 in the 489 WB-adjacent IBAs was slightly lower than the rate of tree loss in the 489 matched WB-distant IBAs (1.442% vs. 1.468%; Figure 3; $W = 110540$, $p = .0409$). Thus, for our sample of IBAs close to World Bank project sites, we found no evidence of a net negative impact in terms of tree loss. Nor did the analysis based on country-specific matching reveal any significant difference between rates of loss on WB-adjacent and WB-distant IBAs ($W = 113800$, $p = .1917$). Rates of tree loss near 23 WB-adjacent IBAs in China, where 83% of World Bank project sites had high levels of locational precision, were similar to the rates of tree loss near 23 matched WB-distant IBAs (1.007% vs. 1.108%; $W = 224$, $p = .3778$[11]).

The 2006 to 2012 rate of tree loss in 771 Category B-adjacent IBAs was lower than the rate of tree loss in the matched set of 771 WB-distant IBAs (1.488% vs. 1.676%; $W = 280060$, $p = .0489$). However, we did not detect any tree loss rate differences between IBAs that were adjacent to Category A, C, or F projects and matched set of WB-distance IBAs (Category A: $n = 295$ vs. 295, $W = 44233$,

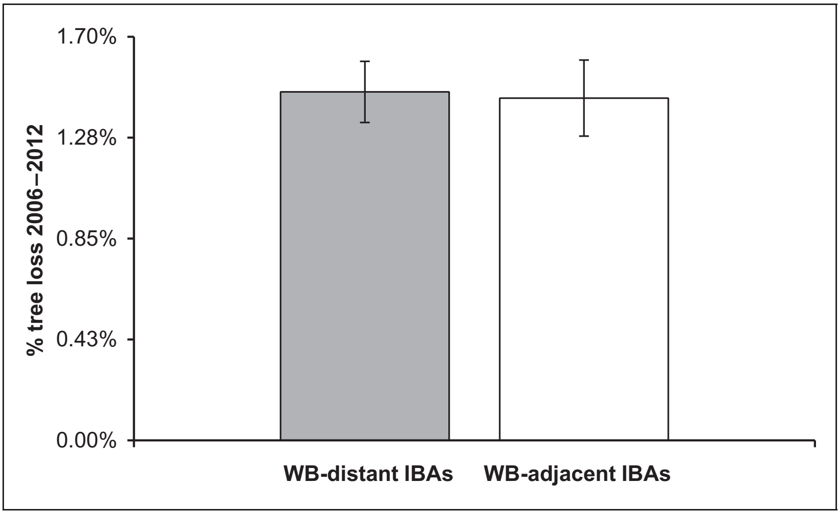

Figure 3. Mean (±SE) percentage gross tree loss between 2006 and 2012 for WB-distant IBAs (filled bar) and WB-adjacent IBAs (open bar).
Source. Hansen et al. (2013).
Note. IBA 1/4 Important Bird and Biodiversity Area; WB 1/4 World Bank.

$p = .7273$; Category C: $n = 90$ vs. 90, $W = 4565$, $p = .1393$; $W = 4463$, $I = 0.2350$; Category F: $n = 67$ vs. 67, $W = 20.19.5$, $p = .3175$). This empirical pattern is noteworthy because Category B projects represent investments that the World Bank judges (during the preparation phase) as posing significant environmental risks that can be readily mitigated during implementation, and Category A projects represent investments that World Bank believes poses significant environmental risks that will be more difficult to mitigate. As Category B projects compose 67% of World Bank projects near IBAs, our results suggest that the vast majority of World Bank investment projects near IBAs have modestly positive impacts on tree cover, while the second-largest category of World Bank investment projects near IBAs (Category A projects, composing 22%) have net neutral impacts on tree cover.[12]

There were more than 100 project locations for only 12 of the 62 project themes. Matching within these themes revealed one significant difference (Table 1). The rate of tree loss in IBAs that were geographically adjacent to World Bank investment projects with a "participation and civic engagement" theme was lower than that of a matched set of WB-distant IBAs (0.73% vs. 1.04%). For the 11 additional subsamples that we analyzed (i.e., subsample of project themes with at least 100 project locations), we found no evidence that there was a statistically significant difference in the rate of tree loss in the WB-adjacent IBAs and the WB-distant IBAs. This pattern suggests that our

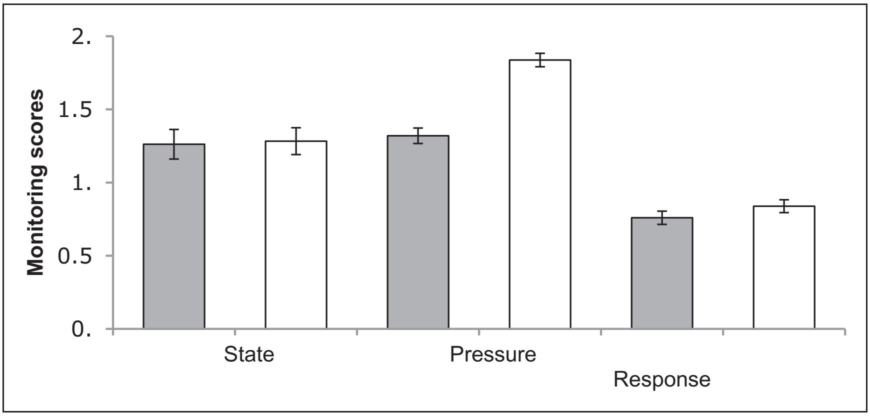

Figure 4. Mean (±SE) monitoring scores for state, pressure, and response for WB-distant IBAs (filled bar) and WB-adjacent IBAs (open bar).
Note. WB = World Bank; IBA = Important Bird and Biodiversity Area.

overall finding that World Bank investment projects generally do not have net negative impacts on conservation outcomes is not the result of sectoral heterogeneity in World Bank project impacts. That is to say, we do not find much evidence of countervailing impacts from World Bank projects with different types of objectives in geographically adjacent IBAs.

For all three of the analyses of single time point in situ monitoring scores for biodiversity (representing the state, pressure, and response in IBAs) our findings indicated either null or positive impacts of being proximate to World Bank projects when compared with being distant from World Bank projects. Monitoring scores for the state of biodiversity in IBAs (as indicated by the condition of bird populations and their habitats) showed no consistent difference between the 134 WB-adjacent IBA sites and the 134 matched WB-distant IBA sites ($W = 8647$, $p = .596$; Figure 4). This result indicates that while World Bank projects provided no detectable net benefits to proximate sites of conservation importance, there is also no evidence of any net negative impacts. There was a statistically significant difference in the pressure scores across matched set of IBAs: Pressure scores were lower for the 384 WB-adjacent IBAs than for the WB-distant IBAs ($W = 53412$, $p < .001$; Figure 4), which might indicate a benefit of proximity to World Bank projects. There was no notable difference in response scores ($W = 68974$, $p = .0797$; Figure 4). The results from the analysis based on exact matching on country were similar, although the difference in conservation responses across the matched set of WB-adjacent and WB-distant IBAs was larger and statistically significant (Figure S2).

For all three of the analyses of change in situ monitoring scores for biodiversity, our findings indicated a null impact of being proximate to World Bank projects, when compared with being distant from World Bank projects. We found no differences in the change in conservation state scores between the 10 WB-adjacent IBAs and the 10 matched WB-distant IBAs ($W = 42$, $p = .552$; Figure 5). However, this comparison is limited in value and should be treated with caution. In addition to the sample size constraints, a short timescale (a maximum of 12 years) and the relative coarseness of the IBA monitoring system (i.e., assessed in four broad categories) reduced the power of our analysis. Consequently, the matching process did not produce a balanced set of IBAs for comparison with this test. We also found no difference in the change in pressure scores between the 60 WB-adjacent IBAs and the 60 matched WB-distant IBAs ($W = 1947.5$, $p = .400$; Figure 5).[13] Finally, there was no significant difference in the change in response scores ($W = 2546$, $p = .0794$), although the WB-adjacent IBAs had slightly greater scores than the 66 matched WB-distant IBAs (Figure 5). The results from the analysis based on exact matching on country were similar, although the difference in the change in conservation response was larger (Figure S3).

There was no general effect associated with varying the distance threshold used to define "adjacency" (Figure 2). For tree loss, significant (p from .0409 to .0226) effects were detected when the distance was up to or equal to 10 km, but the significance dropped off rapidly beyond the 10 km. Using 0 km, 5 km, and 10 km thresholds for adjacency, rates of tree loss were lower in WB-adjacent IBAs than in a matched set of WB-distant IBAs. The reverse was true for

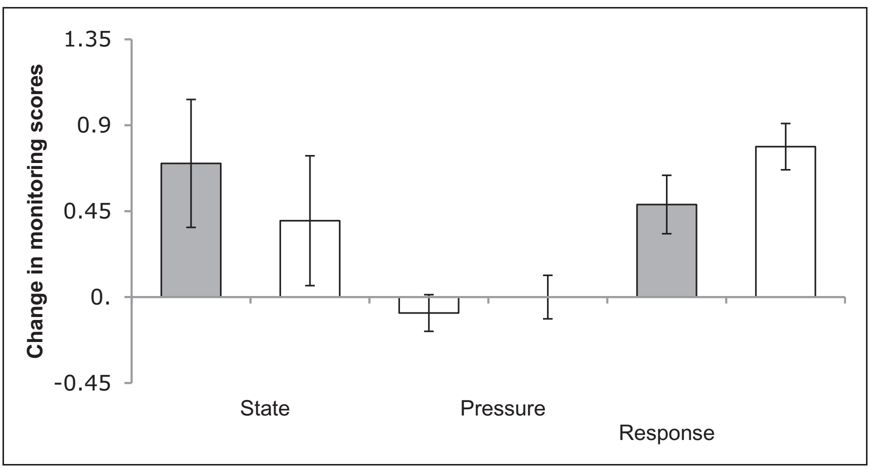

Figure 5. Mean (±SE) differences in scores between initial and repeat monitoring for pressure, response, and state WB-distant IBAs (filled bar) and WB-adjacent IBAs (open bar). Positive values indicate improvements in state, reductions in pressure, and increases in response.

Note. WB = World Bank; IBA = Important Bird and Biodiversity Area.

conservation responses. The conservation responses underway in WB-adjacent IBAs were significantly higher (*p* from .0335 to .0109) at the 20 km, 40 km, and 50 km adjacency thresholds. There was no pattern for pressures or states monitoring scores.

Discussion

In this study we found no evidence of net negative changes in biodiversity outcomes within IBAs close to the sites of World Bank projects relative to otherwise similar sites that are located far away from World Bank projects. Our analysis was observational rather than experimental in nature, but we used propensity score matching methods to address a major threat to causal inference: site-selection bias. It is not only possible but likely that project financiers and implementers are attracted to geographic locations that are less likely to experience biodiversity loss, thereby making any correlation between World Bank development projects and biodiversity outcomes a spurious one (Joppa & Pfaff, 2010). To address this challenge, we compared matched pairs of "treated" and "control" IBAs that have otherwise similar observable characteristics that could increase or decrease the probability that they experience biodiversity loss independently of their exposure to World Bank development projects.

The evidence presented in this study is also consistent with the suggestion put forward by Ledec and Posas (2003) and Dani, Freeman, and Thomas (2011) that safeguard policies have generally limited the negative environmental impacts of World Bank projects. We found that Category B projects—projects flagged during the preparation phase as posing significant environmental risks that could be readily mitigated during implementation—reduced the rate of tree cover loss in geographically adjacent IBAs. We also found evidence that Category A projects—the most environmentally risky projects financed by the World Bank, which are subject to the organization's most stringent safeguards—had no net negative impact on tree cover loss in geographically adjacent IBAs. These findings are noteworthy because, together, Category A and Category B projects represent nearly 90% of all IDA and IBRD investment projects located within 10 km of IBAs. However, we were not able to examine the mechanisms through which negative environmental effects were mitigated. Identifying these mechanisms should be a priority for future research.

Analysis by project theme also made it possible to address the possibility that different types of projects near IBAs produce different environmental impacts. Previous cross-country research suggests that the environmental impacts of World Bank lending may vary by sector and according to the policy conditions attached to loans (Shandra, Rademacher, & Coburn, 2016; Sommer, Shandra, & Restivo, 2017). However, we did not find a clear pattern of heterogeneous impacts by project theme. Nor did we find any evidence of positive and negative impacts cancelling each other out. At the same time, the statistical power of this theme-specific analysis was limited.[14]

Another limitation of our study is the fact that our outcome measures do not necessarily capture the full set of threats to biodiversity posed by development projects. For example, infrastructural investments that increase accessibility to sensitive ecological areas can open them up to hunting and bush meat trade. Such threats might not be detected through our tree loss analysis, although some of these pressures may be recorded as threats in the field-based monitoring data. It is also possible that some project impacts materialize over longer periods than we cover in this analysis.

Nor can we rule out the possibility that World Bank development projects were intentionally or inadvertently sited in or near locations that already faced fewer conservation pressures, given that WB-adjacent IBAs had lower pressure scores initially. At the same time, it is notable that after we sought to address this source of selection bias by accounting for differential pretreatment outcomes across "treated" and "control" IBAs during the matching process,[15] our analysis of change in tree cover and pressure indicated that IBAs located closer to World Bank development projects fared no worse (and perhaps even somewhat better) than IBAs located far away from World Bank development projects.[16]

Also, to minimize the influence of systematic differences across the different countries included in our sample (another potentially important source of confounding), we replicated our results with an exact country matching procedure. This approach of restricting matched IBA pairs to those within countries reduced the sample size available for testing but produced broadly similar results to the results based upon continent-matching (the identification of matched pairs within continents).

It should also be noted that our impact estimates were derived from a group of IBAs that was not exposed to a fully representative sample of World Bank projects. We were not able to include many World Bank projects in our sample because they lacked sufficiently precise locational information. Consequently, we were not able to directly estimate the impacts of these projects. This constraint also makes it impossible to rule out the possibility of exposure to World Bank funded projects in our WB-distant IBAs. However, we did seek to test the plausibility of the assumption that the WB projects and project locations excluded from our analysis are randomly distributed with regard to WB-adjacent and WB-distant IBAs, and our findings were encouraging. We found that the omission of imprecisely geocoded projects from analysis of one country (China) where more than 80% of the projects had high locational precision had a negligible impact on our results.

Our analysis was also limited by the absence of georeferenced data on International Finance Corporation and Multilateral Investment Guarantee Agency projects. Therefore, our results cannot necessarily be generalized to the entire World Bank project portfolio (Pandey & Wheeler, 2001). It should also be noted that our study is based on a subsample of IDA and IBRD projects consisting mostly of economic infrastructure activities rather than social or institutional development activities (see Tables S1 and S2). World Bank projects that focus on the ''hardware'' of economic development (roads, bridges, dams, ports, and electricity grids) usually pose significant environmental risks but are also subjected to more stringent environmental safeguards. The fact that Category B projects near IBAs actually registered lower rates of tree loss than a matched set of IBAs far away from World Bank projects suggests that World Bank environmental safeguards are having their intended effects.[17] Conservationists should also be encouraged by the fact that we found no net negative impacts from Category A projects, which pose the most severe environmental risks and are subjected to the World Bank's most stringent environmental safeguards.

At the same time, several limitations of our evaluation design make it impossible to rule out the possibility that World Bank investment projects had positive or negative effects on conservation outcomes that were undetectable. This study treated IBAs as the relevant subnational units of observation, but it is possible that with finer-scale or coarser-scale units of observation, we would have arrived at a different set of results.[18] The modifiable areal unit problem is a challenge for virtually all studies that seek to establish causality with subnationally georeferenced program, outcome, and covariate data (Avelino, Baylis, & Honey-Rosés, 2016). We attempted to address this challenge by varying the definition of ''adjacency'' (i.e., treatment) to determine if our results are conditional upon the selection of a 10-km distance threshold. However, we did not find any evidence that the direction of World Bank project impacts is conditional upon the distance-based measure of ''treatment'' that is selected (see Figure 5).[19]

Another caveat about our analysis is that we were unable to account for the potentially confounding effect of development projects financed by institutions other than the World Bank.[20] That is to say it is unclear whether and to what extent our results might be attributable to spatial clustering of international development finance, a known pattern whereby donors and lenders are attracted to locations where other development projects have been initiated (Findley, Marineau, Powell, & Weaver, 2015; Nunnenkamp, Albena, & Rainer, 2016). Such clustering could potentially mask the real impact of development finance if, for example, a World Bank project registered a negative impact and a project financed by another institution registered a positive impact in the same IBA. More research will therefore be needed to determine if the patterns we observed are truly due to the effective implementation of environmental safeguards or evaluation design limitations.

In summary, the results presented in our study have various limitations, but they contribute to a small body of research that seeks to rigorously evaluate the biodiversity impacts of (World Bank) development projects (Batra, Anand, Goodman, Nyoteshwar, & Runfola, 2017; BenYishay, Bradley, Daniel, & Rachel, 2016; BenYishay, Silke, Daniel, & Rachel, 2017; Runfola et al., 2017;

Sommer et al., 2017). We are not aware of any other spatially explicit study that has sought to examine this question across a large number of sites of conservation importance worldwide. Nor are we aware of any other quasi-experimental studies that estimate the biodiversity impacts of development projects subjected to different types of environmental safeguards. Of course, the World Bank is only one of many organizations that fund overseas development activities, so rigorous comparative evaluation of the biodiversity impacts of development projects financed and implemented by other donors and lenders (e.g., the Export–Import Bank of China, the Asian Infrastructure Investment Bank) with qualitatively different environmental safeguard policies would also help to quantify their efficacy (BenYishay et al., 2016).

Finally, it should be noted that subnationally georeferenced data on development projects, human development outcomes, and biodiversity outcomes are rapidly expanding in number, scope, and accessibility.[21] These data sets are opening new avenues for research on relationships among aid, human development, and biodiversity.

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Notes

1. The World Bank is widely considered to be a norm-setting, industry leader in the design and implementation of environmental safeguards; indeed, it is emulated by many other bilateral and multilateral development agencies (Buntaine, 2016; Park, 2010). Its safeguard regime took shape in response to several large-scale road infrastructure projects that had disastrous environmental consequences (Buntaine, 2016; Park, 2010). The Polonoroeste project in Brazil, which paved a 1,500-km road into a remote part of the Amazon and triggered widespread deforestation, was a landmark event that fundamentally altered the World Bank's environment safeguard regime (Nielson & Tierney, 2003; Wade, 1997, 2016).
2. IBAs form a global network of sites of internationally recognized biodiversity importance, based on data for birds, and are identified using standardized criteria for

populations and assemblages of threatened, restricted-range, biome-restricted, and congregatory species (BirdLife International, 2014).

3. We acknowledge these indicators cannot detect the full range of potential impacts on biodiversity.
4. Matching has proved to be a useful method for evaluating the effectiveness of conservation and development interventions in and around protected (and other sensitive ecological) areas, which are nonrandomly distributed (e.g., Andam, Ferraro, Pfaff, & Sanchez, 2007; Andam et al., 2008; Buntaine, Hamilton, & Millones, 2015; Holland et al., 2017; Independent Evaluation Office of the Global Environment Facility [GEF-IEO], 2016; Joppa & Pfaff, 2010).
5. We match only on pretreatment trends in tree cover and conservation outcomes.
6. As described in online Appendix A, the World Bank classifies proposed projects into one of four environmental categories: A, B, C, and F. Projects in Categories A and B represent projects that pose particular high risks of environmental damage. These projects are subjected to the World Bank's most stringent environmental safeguards.
7. The data of Hansen et al. (2013) have limitations, including the saturation of tree cover estimates at high levels of tree cover (i.e., the data might not actually be able to separate out differences at higher percentage cover figures but rather labels cover as 100% even if it might not reach this level). This can cause problems defining tree cover. Studies have applied differing thresholds to define pixels as having tree cover. As a consequence of the uncertainty, we do not apply any threshold.
8. For example, more than 40% of World Bank projects were geocoded to the first-order or second-order administrative level, and all of these projects were excluded from our analysis.
9. On the World Bank's theme categorization scheme, see http://siteresources.worldbank.org/PROJECTS/Resources/Themes.pdf.
10. A major threat to causal inference is selection bias—that is, the possibility that the World Bank is attracted to geographic locations close to IBAs that have a particularly low (or high) risk of forest loss (e.g., Andam et al., 2007, 2008; Buntaine et al., 2015; GEF-IEO, 2016; Holland et al., 2017; Joppa & Pfaff, 2010). Therefore, a correlation between the presence of World Bank projects and tree loss might only indicate that the very same locations that received World Bank would have also experienced the same level of tree loss in the absence of World Bank projects. Consequently, accounting for pretreatment tree cover change outcomes in the "treated" and "control" IBAs is particularly important because doing so allows us to expunge otherwise unobservable selection effects (e.g., local economic development trends, the quality of local environmental regulatory enforcement) that would have biased our treatment effect estimates in the second stage of our matching routine.
11. China represents a country with a larger number of World Bank projects that could be geolocated with high accuracy. As it is not a special case in terms of World Bank development aid or IBAs, this result indicates that the results of the country-level test are valid.
12. Figure S1 demonstrates that, in our full sample of IDA and IBRD projects prior to matching, 67% of projects within 10 km of IBAs are Category B projects, 22% are Category A projects, 7% are Category C projects, and 5% are Category F projects.

13. Note that the pressure scores for the WB-adjacent IBAs were initially lower than those of the WB-distant IBAs (Figure 3).
14. Another limitation of this study is that it did not enable comparison of the impacts of conservation projects and "mixed aid" projects with conservation and development objectives (Miller, 2014). Previous research suggests that when biodiversity conservation spending is focused exclusively on conservation goals, it can produce positive results (Waldron et al., 2017). However, the effects of projects with conservation and development objectives are less well documented.
15. We used matching algorithms to preprocess our data such that our WB-adjacent and WB-distant IBAs were as similar as possible on a variety of relevant covariates. However, it is likely that potentially important confounding variables were omitted from our matching analysis (e.g., economic activity, local attitudes to conservation), thereby biasing our estimates of impact. Pretreatment conditions represent one potentially key source of confounding. Therefore, we included pretreatment outcome measures (i.e., in situ monitoring scores and tree loss outcomes before World Bank projects were approved and initiated) in our matching procedures where it was feasible to do so.
16. There was weak evidence for a potential increase in the conservation response under way after the initiation of World Bank projects. This response may take time to translate in turn into reduced pressure.
17. The fact that Category A projects did not register similar treatment effects should be interpreted with caution, as the sample of Category A projects was significantly smaller than the sample of Category B projects.
18. For examples, road building could have an impact on forest along a small, linear tract (Chomitz, 2007). Such a pattern might not be picked up in our analysis.
19. Our use of 10 km might have resulted in our overlooking indications that conservation responses increased on IBAs within 20 to 50 km for a World Bank project location. However, at the 10 km distance, we detected a potential trend for this pattern ($p = .0794$).
20. This is a common challenge across impact evaluations of development and conservation projects (e.g., BenYishay et al., 2017; Buntaine et al., 2015; GEF-IEO, 2016; Holland et al., 2017; Jones et al., 2017; Sims, 2010).
21. By way of illustration, a new spatial data integration and extraction tool called GeoQuery (http://geoquery.org/) enables program evaluators, policy analysts, and scientists without geographical information system or computer science training to easily fuse together and access spatially referenced data on bilateral and multilateral development projects, protected areas, economic development levels and trends, vegetation density, tree cover outcomes, and a wide variety of covariate measures.

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References

AidData. (2015). *Geocoded data from the World Bank IBRD-IDA, Version 1.0*. Retrieved from http://aiddata.org

Avelino, A. F. T., Baylis, K., & Honey-Rosés, J. (2016). Goldilocks and the raster grid: Selecting scale when evaluating conservation programs. *PLoS One*, *11*(12), e0167945. doi:10.1371/journal.pone.0167945

Andam, K., Ferraro, P., Pfaff, A., & Sanchez, A. (2007). *Protected areas and avoided deforestation: A statistical evaluation*. Washington, DC: Global Environment Facility Evaluation Office.

Andam, K., Ferraro, P., Pfaff, A., Sanchez, A., & Robalino, J. (2008). Measuring the effectiveness of protected area networks in reducing deforestation: A rigorous impact evaluation approach. *Proceedings of National Academy of Science*, *105*(42), 16089–16094.

Bartholomé, E., & Belward, A. S. (2005). GLC2000: A new approach to global land cover mapping from Earth observation data. *International Journal of Remote Sensing*, *26*, 1959–1977.

Batra, G., Anand, A., Goodman, S., Nyoteshwar, J., & Runfola, D. (2017). *A value for money analysis of GEF interventions in land degradation and biodiversity*. Washington, DC: GEF. Retrieved from http://www.gefieo.org/evaluations/value-money-analysis-gef-interventions-land-degradation-and-biodiversity

BenYishay, A., Bradley, P., Daniel, R., & Rachel, T. (2016, December). *Forest cover impacts of Chinese development projects in ecologically sensitive areas* (AidData Working Paper No. 32). Williamsburg, VA: AidData.

BenYishay, A., Silke, H., Daniel, R., & Rachel, T. (2017). Indigenous land rights and deforestation: Evidence from the Brazilian Amazon. *Journal of Environmental Economics & Management*, *86*(C), 29–47.

Beresford, A. E., Buchanan, G. M., Phalan, B., Eshiamwata, G. W., Balmford, A., Brink, A. B., . . . Donald, P. F. (2017). Correlates of long-term land-cover change and protected area performance at priority conservation sites in Africa. *Environmental Conservation*, *45*(1), 49–57.

Beresford, A. E., Eshiamwata, G. W., Donald, P. F., Balmford, A., Bertzky, B., Brink, A. B., . . . Buchanan, G. M. (2013). Protection reduces loss of natural land-cover at sites of conservation importance across Africa. *PLoS One*, *8*(5), e65370.

BirdLife International. (2006). *Monitoring Important Bird Areas: A global framework*. Cambridge, England: Author.

BirdLife International. (2014). *Important Bird and Biodiversity Areas: A global network for conserving nature and benefiting people*. Cambridge, England: Author.

Buchanan, G. M., Fishpool, L. D. C., Evans, M. I., & Butchart, S. H. M. (2013). Comparing field-based monitoring and remote-sensing, using deforestation from logging at Important Bird Areas as a case study. *Biological Conservation*, *167*, 334–338.

Buntaine, M. (2011). Does the Asian Development Bank respond to past environmental performance when allocating environmentally-risky financing? *World Development*, *39*, 336–350.

Buntaine, M. (2016). *Giving aid effectively: The politics of environmental performance and selectivity at multilateral development banks*. Oxford, England: Oxford University Press.

Buntaine, M., Hamilton, S., & Millones, M. (2015). Titling community land to prevent deforestation: An evaluation of a best-case program in Morona-Santiago, Ecuador. *Global Environmental Change*, *33*, 32–43.

Center for International Earth Science Information Network. (2013). *Gridded Population of the World, Version 3 (GPWv3)*. Palisades, NY: Socioeconomic Data and Applications Center, Columbia University.

Chomitz, K. (2007). *At loggerheads? Agricultural expansion, poverty reduction, and environment in the tropical forests*. Washington, DC: The World Bank.

Cook, T. D., Shadish, W. R., & Wong, V. C. (2008). Three conditions under which experiments and observational studies produce comparable causal estimates: New findings from within-study comparisons. *Journal of Policy Analysis and Management*, *27*, 724–750.

Dani, A., Freeman, A., & Thomas, V. (2011). *Evaluative directions for the World Bank Group's safeguards and sustainability policies*. Washington, DC: World Bank.

Findley, M., Marineau, J., Powell, J., & Weaver, C. (2015). 'The swarm principle': A subnational spatial analysis of aid targeting and donor coordination in sub-Saharan Africa. Retrieved from http://www.josiahmarineau.com/uploads/4/0/1/2/40124603/swarm_principle_coordination_13_august_2015.pdf

Gutner, T. L. (2002). *Banking on the environment: Multilateral development banks and their environmental performance in Central and Eastern Europe*. Cambridge, MA: MIT Press.

Hansen, M. C., Potapov, P. V., Moore, R., Hancher, M., Turubanova, S. A., Tyukavina, A., . . . Townshend, J. R. (2013). High-resolution global maps of 21st-century forest cover change. *Science*, *342*, 850–853.

Hickey, V., & Pimm, S. L. (2011). How the World Bank funds protected areas. *Conservation Letters*, *4*(4), 269–277.

Hicks, R. L., Parks, B. C., Roberts, J. T., & Tierney, M. J. (2008). *Greening aid? Understanding the environmental impact of development assistance*. Oxford, England: Oxford University Press.

Ho, D. E., Imai, K., King, G., & Ferrer, E. A. (2011). MatchIt: Nonparametric preprocessing for parametric causal inference. *Journal of Statistical Software*, *42*, 1–28.

Holland, M. B., Jones, K. W., Freire, J. L., Morales, M., Naughton-Treves, L., & Suárez, L. (2017). Titling land to conserve forests: The case of Cuyabeno Reserve in Ecuador. *Global Environmental Change*, *44*, 27–38.

Independent Evaluation Office of the Global Environment Facility. (2016). *Value for money analysis for the land degradation projects of the GEF*. Washington, DC: GEF. Retrieved from https://www.thegef.org/sites/default/files/council-meeting-documents/EN_GEF.ME_C.51.Inf_02_VFM%20Analysis%20for%20LD%20Projects%20of%20GEF.pdf

International Union for Conservation of Nature and United Nations Environment Programme-World Conservation Monitoring Centre. (2013). *The World Database on Protected Areas*. Retrieved from http://www.wdpa.org/

Jones, K. W., Holland, M. B., Naughton-Treves, L., Morales, M., Suárez, L., & Keenan, K. (2017). Forest conservation incentives and deforestation in the Ecuadorian Amazon. *Environmental Conservation*, *44*(1), 56–65.

Joppa, L., & Pfaff, A. (2010). Re-assessing the forest impacts of protection: The challenge of non-random protection and a corrective method. *Annals of the New York Academy of Sciences*, *1185*, 135–149.

Keohane, R. O., & Levy, M. A. (1996). *Institutions for environmental aid: Pitfalls and promise*. Cambridge, MA: MIT Press.

Ledec, G., & Posas, P. J. (2003). Biodiversity conservation in road projects: Lessons from World Bank experience in Latin America. *Journal of the Transportation Research Board of the National Academies*, *1819*, 198–201.

Miller, D. C. (2014). Explaining global patterns of international aid for linked biodiversity conservation and development. *World Development*, *59*, 341–359.

National Imagery and Mapping Agency. (2012). *VMap0*. Retrieved from http://www.mapability.com/info/vmap0_download.html

Nielson, D., & Tierney, M. J. (2003). Delegation to international organizations: Agency theory and world bank environmental reform. *International Organization*, *57*, 241–277.

Nunnenkamp, P., Albena, S. A., & Rainer, T. (2016). Do aid donors specialize and coordinate within recipient countries? The case of Malawi. *Development Policy Review*, *34*(6), 831–849.

Pandey, K. D., & Wheeler, D. (2001, April). *Structural adjustment and forest resources: The impact of World Bank operations* (Policy Research Working Paper 2584). Washington, DC: World Bank.

Park, S. (2010). The World Bank's global safeguard policy norm? In S. Park, & A. Vetterlein (Eds.), *Owning development: Creating policy norms in the IMF and the World Bank* (pp. 181–203). Cambridge, England: Cambridge University Press.

Quintero, J. D. (2007). *Mainstreaming conservation in infrastructure projects: Case studies from Latin America*. Washington, DC: World Bank.

Rich, B. (1994). *Mortgaging the Earth: The World Bank, environmental impoverishment, and the crisis of development*. Boston, MA: Beacon Press.

Riley, S. J., DeGloria, S. D., & Elliot, R. (1999). A terrain ruggedness index that quantifies topographic heterogeneity. *Intermountain Journal of Sciences*, *5*(1–4), 23–27.

Runfola, D., Yishay, A. B., Tanner, J., Buchanan, G., Nagol, J., Leu, M., . . . Marty, R. (2017). A top-down approach to estimating spatially heterogeneous impacts of development aid on vegetative carbon sequestration. *Sustainability*, *9*(3), 409.

Shandra, J. M., Rademacher, H., & Coburn, C. (2016). The World Bank and organized hypocrisy? A cross-national analysis of structural adjustment and forest loss. *Environmental Sociology*, *2*(2), 192–207.

Shandra, J. M., Shircliff, E., & London, B. (2011). World Bank lending and deforestation: A cross-national analysis. *International Sociology*, *26*, 292–314.

Sims, K. R. E. (2010). Conservation and development: Evidence from Thai protected areas. *Journal of Environmental Economics and Management*, *60*(2), 94–114.

Sommer, J. M., Shandra, J. M., & Restivo, M. (2017). The World Bank, contradictory lending, and forests: A cross-national analysis of organized hypocrisy. *International Sociology*, *32*(6), 707–730.

Tracewski, Ł., Butchart, S. H. M., Donald, P. F., Evans, M., Fishpool, L. D. C., & Buchanan, G. M. (2016). Patterns of twenty-first century forest loss across a global network of important sites for biodiversity. *Remote Sensing in Ecology and Conservation*, *2*(1), 37–44.

United States Geological Survey. (2004). *Shuttle radar topography mission*. College Park, MD: Global Land Cover Facility, University of Maryland.

Wade, R. (1997). Greening the Bank: The struggle over the environment, 1970-1995. In D. Kapur, J. P. Lewis, & R. Webb (Eds.), *The World Bank: Its first half century* (Vol. 2, pp. 611–734). Washington, DC: The Brookings Institution.

Wade, R. (2016). Boulevard to broken dreams, part 1: The Polonoroeste road project in the Brazilian Amazon, and the World Bank's environmental and indigenous peoples' norms. *Revista de Economia Política*, *36*(1), 214–230.
Waldron, A., Miller, D. C., Redding, D., Mooers, A., Kuhn, T. S., Nibbelink, N., . . . Gittleman, J. L. (2017). Reductions in global biodiversity loss predicted from conservation spending. *Nature*, *551*, 364–367.
World Bank. (1999). *Environmental assessment. Operational policy/bank procedures/good practices 4.01*. Washington, DC: Author.
World Bank. (2001). *Natural habitats. Operational policy/bank procedures/good practices 4.04*. Washington, DC: Author.
World Bank. (2002). *Promoting environmental sustainability in development: An evaluation of the World Bank's performance*. Washington, DC: Author.
World Bank. (2016). *GDP per capita*. Washington, DC: Author. Retrieved from https://data.worldbank.org/indicator/NY.GDP.PCAP.CD

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