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Ecological and Social Outcomes of a New Protected Area in Tanzania

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Abstract: *Balancing ecological and social outcomes of conservation actions is recognized in global conservation policy but is challenging in practice. Compensation to land owners or users for foregone assets has been proposed by economists as an efficient way to mitigate negative social impacts of human displacement from protected areas. Joint empirical assessments of the conservation and social impacts of protected area establishment involving compensation payments are scarce. We synthesized social and biological studies related to the establishment of the Derema forest corridor in Tanzania's biodiverse East Usambara Mountains. This lengthy conservation process involved the appropriation of approximately 960 ha of native canopy agroforest and steep slopes for the corridor and monetary compensation to more than 1100 claimants in the surrounding villages. The overarching goals from the outset were to conserve ecological processes while doing no harm to the local communities. We evaluated whether these goals were achieved by analyzing 3 indicators of success: enhancement of forest connectivity, improvement of forest condition, and mitigation of negative impacts on local people's livelihoods. Indicators of forest connectivity and conditions were enhanced through reductions of forest loss and exotic species and increases in native species and canopy closure. Despite great efforts by national and international organizations, the intervention failed to mitigate livelihood losses especially among the poorest people. The Derema case illustrates the challenges of designing and implementing compensation schemes for conservation-related displacement of people.*

Keywords: biodiversity, compensation, corridor, Eastern Arc, East Usambara, protected areas

Resultados Ecológicos y Sociales de un Área Protegida Nueva en Tanzania

Resumen: *El equilibrio de los resultados ecológicos y sociales de las acciones de conservación está reconocido en la política de conservación global pero es un reto en la práctica. La compensación para los dueños de los terrenos o para los usuarios de bienes predeterminados ha sido propuesta por los economistas como una forma eficiente de mitigar los impactos sociales negativos del desplazamiento humano de las áreas protegidas. Los cálculos empíricos conjuntos de la conservación y los impactos sociales del establecimiento de áreas protegidas que involucran los pagos de compensación son escasos. Sintetizamos los estudios sociales*

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y biológicos relacionados con el establecimiento del corredor boscoso Derema en las biodiversas montañas de Usambara Oriental en Tanzania. Este largo proceso de conservación involucró la apropiación de ~960 ha de dosel de agrobosque nativo y pendientes empinadas para el corredor y compensaciones monetarias para más de 1100 demandantes en las aldeas alrededor. Las metas dominantes al inicio fueron conservar los procesos ecológicos a la vez que no se causaba daño a las comunidades locales. Evaluamos si estas metas se lograron al analizar 3 indicadores de éxito: el mejoramiento de la conectividad forestal, la mejoría de la condición forestal y la mitigación de los impactos negativos sobre el bienestar de los locales. Los indicadores de la conectividad y las condiciones forestales mejoraron por medio de las reducciones en la pérdida forestal y de especies exóticas y el aumento en las especies nativas y el cierre del dosel. A pesar de los grandes esfuerzos hechos por organizaciones nacionales e internacionales, la intervención falló en la mitigación de pérdidas del bienestar, especialmente entre los habitantes pobres. El caso Derema ilustra los retos de diseñar e implementar esquemas de compensación para el desplazamiento de personas por causa de la conservación.

Palabras Clave: Arco Este, áreas protegidas, biodiversidad, compensación, corredor, Usambara Oriental

Introduction

Fragmentation is one of the most detrimental anthropogenic processes that affects forested ecosystems, and it results in substantial environmental and biogeographic changes (Saunders et al. 1991). Forest fragmentation occurs simultaneously with reduction of forest area and results in smaller forest patches, isolation of noncontiguous forest patches, and adverse changes to species composition (Bierregaard et al. 2001). The maintenance of habitat corridors can provide dispersal opportunities for a wide variety of species between protected areas (Simberloff et al. 1992; Gilbert-Norton et al. 2010). Corridors of natural land cover are being developed widely across the world, with the aims of sustaining the ecological health of increasingly fragmented forest landscapes (Hilty et al. 2006) and enhancing the conservation role of protected areas in the face of climate change (Hannah 2008), especially in mountain areas (Loarie et al. 2009).

Protected areas around the globe positively affect species (Rodrigues et al. 2004) and forest conservation (Andam et al. 2008), ameliorate land-use change (Joppa & Pfaff 2011), and benefit mammal populations (Craigie et al. 2010). However, the social impacts of the creation of new protected areas have been subjected to much debate. Attention has been drawn to negative impacts on local livelihoods, such as impoverishment and marginalization from displacement and reduced access to productive resources (e.g., Brockington & Igoe 2006; Agrawal & Redford 2009; Lasgorceix & Kothari 2009). Subsequently, there has been a shift from fully exclusionary models of conservation to approaches involving various degrees of local participation and mitigation of negative impacts as well as the creation of social benefits from conservation. In 2003, the IUCN World Parks Congress and in 2008 the Convention of Biological Diversity (CBD COP9) adopted principles to ensure that protected areas do no harm to local people. The CBD COP9 created guidelines "to ensure that conservation and development activities in the context of protected areas contribute to the eradication of poverty and sustainable development" and that the benefits "from the establishment and management of protected areas are fairly and equitably shared . . . "

Direct payments as compensation for the taking of resource rights and opportunities from local people have been hailed an efficient way to advance environmental conservation while addressing concerns of the affected populations (Ferraro & Kiss 2002). Although empirical evidence of the positive ecological benefits of protected areas is available (Geldmann et al. 2013), there is little evidence of the social impacts of compensated displacement from developing countries, save for a few studies from southern Asia (McLean & Straede 2003; Kabra 2009).

Tanzania's Derema Corridor was the first gazettement process in East Africa to attempt to follow the World Bank's 2001 Resettlement Safeguards Policy of do no harm. The gazettment process involved government, donor, NGO, and academic actors seeking to achieve positive outcomes for biodiversity and people. We analyzed this process from late 1990s to 2013. We determined whether the process was successful at balancing conservation and livelihood outcomes. With increasing interest in financial conservation mechanisms within the frame of payments for environmental services. The lessons which arise from this case study have broad relevance to the biological conservation and development communities who are applying monetary solutions to conservation challenges.

East Usambara Mountains and the Forest Connectivity Plan

The biodiverse humid forests of the East Usambara Mountains support 7 endemic animals and 42 strictly endemic plant species (Burgess et al. 2007; R.E.G., unpublished data). Most local people in the East Usambaras rely on subsistence agriculture. The mean farm size ranges from 2 to 3.5 ha (Reyes 2005; Bullock et al. 2011). Many forest areas were gazetted as national forest reserves to maintain timber production, water catchments, and reduction of soil erosion (Hamilton & Bensted-Smith 1989; Newmark 1993). These forests are valued by national to global actors for their biodiversity values and by local communities for their role in providing fuel wood, building materials, medicinal plants, and an overstory for growing cardamom, a lucrative cash crop (e.g., Hamilton & Bensted-Smith 1989; Rantala & Vihemäki 2011). Forest land is also valued by local communities as a source of future farmland, and many local people have resisted government efforts to protect remaining forests (e.g., Jambiya & Sosovele 2001; Vihemäki 2009).

As forests became increasingly fragmented in the East Usambaras, researchers noted that isolated populations of forest-dependent species were declining (Newmark 1991; 2006; Newmark & Stanley 2011). Connectivity between forest patches is regarded as essential for the maintenance of biological values in the East Usambaras (Cordeiro & Howe 2003; Newmark & Stanley 2011).

An East Usambara Forest Connectivity Plan was developed in the early 1990s by the government and advisors on a Finnish funded forest conservation project and was implemented from 1991 to 2008. In the early 1990s, the largest patch of unprotected forest remaining was a forested ridge named Derema (Johansson & Sandy 1996). Less than 1000 ha of exploited but still biodiverse forest remained on the ridge, stretching between the Amani Nature Reserve and the Kambai Forest Reserve in the north. This area acts as a corridor to 5 other forest reserves, including Nilo Nature Reserve (Fig. 1). Conservation scientists argued that if the forest on the Derema ridge continued to be encroached upon, then the biodiverse Amani and Nilo Nature Reserves would become forever isolated and that this isolation would jeopardize the ecological integrity of this part of a global biodiversity hotspot (Newmark 1993).

Gazettement Process

Gazettement of the Derema forest as a national forest reserve started in the 1990s through the efforts of the government of Tanzania and with funding from the government of Finland and the European Union. The first action was a forest baseline survey (Johansson & Sandy 1996) and an ex ante social impact assessment (Jambiya & Sosovele 2001), and they were followed by assessment of crops existing on the planned reserve boundary. The boundaries were planned purposefully to include only forest and farmland, so as to avoid the cost and political challenges of resettlement of residences. Over 1000 farmers from 5 villages claimed land within Derema forest, and many of them initially resisted the gazettement plan (Jambiya & Sosovele 2001). After the government of Tanzania promised financial compensation and the provision of alternative farmlands, representatives of the local communities formally accepted the gazettement plan, although the degree of communitywide participation in the decision appears to have been limited (Rantala & Vihemäki 2011).

In 2001 the boundaries of the new reserve were cleared and affected farmers were compensated for lost land at a rate of US$24/adult cardamom plant (U.S. dollar values given in 2010 values) (Table 1). This generated an expectation for high compensation rates across the remaining land. Consequently, hundreds of hectares of forest understory were hastily cut and new crops planted just before the crops could be surveyed within the reserve boundaries (URT 2006; Rantala & Vihemäki 2011). Valuation of crops in 2002 was calculated on the basis of a sliding scale due to lower farm per plant production quality found in the corridor. Based on their initial expectations from the boundary compensation, many farmers were disappointed with the final proposed compensation (Rantala & Vihemäki 2011).

Financial compensation promised in 2002 was only partially obtained by 2005 because of the complex process of securing funds from various international donors and the Tanzanian government (Table 1). In 2005 the Ministry of Natural Resources and Tourism requested an alteration to an existing forestry loan provided by the World Bank in order to fund remaining compensation payments. This request fell under the World Bank's resettlement safeguards policy and required the development of a resettlement action plan (RAP) to avoid deleterious impacts on local communities (URT 2006). In the RAP it was argued that changes in Tanzanian land legislation called for an increase in the projected costs of the compensation program. The World Bank's acceptance of this plan in 2007 allowed the Tanzanian government to use $2.1 million of its forestry loan to make payments to 1128 farmers in 2008 (Table 1). The delay in the compensation and limited, and sometimes hearsay, information on the process further fueled already negative feelings in the villages (Rantala & Vihemäki 2011). Formal complaints related to the devaluation of the cardamom compensation rates resulted in additional payments of $13,600 in 2008 (Shemdoe 2009). The reserve was officially declared on 9 July 2010 in the *Government Gazette* of Tanzania as Government Note 255.

Methods

We evaluated the achievements of the Derema gazettement process on the basis of 3 indicators of success: increase in forest connectivity, enhancement of forest condition for biodiversity, and mitigation of negative impacts on local livelihoods through compensation. To evaluate these outcomes, we conducted land-cover change and connectivity assessments across the landscape, completed new biological and social field work, and synthesized existing field studies on biodiversity and livelihood changes.

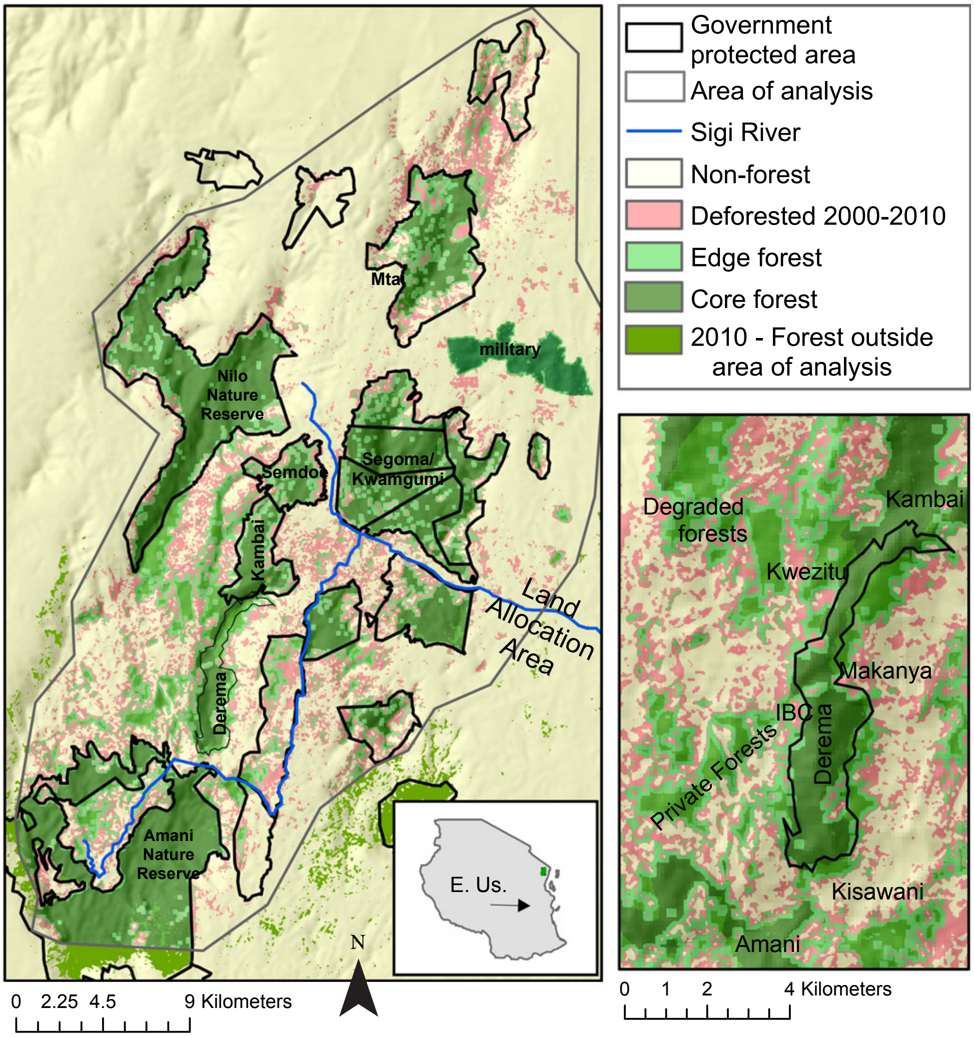

Figure 1. Forest cover in 2010 and forest loss 2000–2010 in the East Usambara Mountains, Tanzania. Smallest inset shows the Eastern Arc Mountains and the location of the East Usambara Mountains. Named are key villages around the Derema Forest Reserve that were involved in the Derema Forest Reserve compensation process.

Table 1. Funding used to complete the compensation of farmers for land lost due to the gazettement of the Derema Forest Reserve.

Year	*Source of funds*	*Funds raised*	*U.S. dollar equivalent in relevant year*	*U.S. dollar equivalent in 2011*	*Activity targeted*
2002	Government of Finland, European Union	127,746,446 Tsh	141,940	171,000	boundary clearance compensation payments
2004	Ministry of Natural Resources and Tourism	100,000,000 Tsh	100,000	115,000	compensation payment to affected farmers
2004	Government of Finland	160,000 Euro	200,000	229,000	compensation payment to affected communities
2005	Global Conservation Fund	US$350,000	350,000	389,000	compensation payment to affected communities
2006/08	World Bank	US $2,100,000	2,100,000	2,260,000	compensation payment to affected communities
2008/09	World Bank	US$274,661	274,661	281,000	implementation of Resettlement Action Plan (RAP)
2008/09	Critical Ecosystem Partnership Fund (CEPF)	US$150,000	150,000	153,000	boundary consolidation, map production, facilitation of RAP process
2009	CEPF	US$20,000	20,000	20,200	biological and socioeconomic survey and final lessons-learned report
Total			3,336,601	3,618,200	

Forest Connectivity

To estimate the impact of protection on forest condition, we determined the area of protected core forest and assessed if local biodiversity was regenerating. Core forest is essential to the ecological integrity of the East Usambaras because edge forest is degraded due to increased light, wind, desiccation, and influx of weedy generalist species (Muricia 1995) and because edge effects have led to ecosystems shifts in community composition and species diversity (Barlow et al. 2007).

We used remote sensing to generate land-cover maps and to calculate forest area fragmentation and changes to connectivity of forest patches in the East Usambaras over 35 years. We focused on changes from 2000 to 2010. Forest area was determined from a series of Landsat images: MSS 27 August 1975; TM 4 June 1992; ETM+ 23 February 2006; and SPOT images 17 January 2000, 17 February 2007, and 23 January 2010. Pixels <30 m resolution were resampled to 30 m with bilinear interpolation resampling. Land-cover classifications were produced using a hybrid supervised-classification and rule-based approach. Ground truthing was performed during the summers of 2005 and 2007 by J.H. Ninety-five ground truthing locations were within natural humid and dry forest. Images were geometrically and topographically corrected using a modified cosine-correction algorithm. Ten land-cover classes were recognized: humid forest, dry forest, eucalyptus, teak, tea, thicket, bushes or fallow, water, grass, and bare. Further, land-cover change analysis was performed for the 2 natural forest classes only.

To demonstrate the conservation impact of protecting the Derema landscape, we determined core forest, forest area change, forest fragmentation, and forest connectivity. A variety of metrics exist to measure how a patch is related to other patches. They range from straightforward metrics based on basic principles of island biogeography (e.g., distance to nearest patch, number or area of patches within a buffer) to statically based approaches (e.g., cohesion, connectance). We used connectance, which measures connectivity of habitat structure within the entire landscape based on the number of functional joined patch pairs. It measures whether a forest patch is connected to other patches (accepting a gap in patches of <100 m as still connected) (McGarigal & Marks 1995). Connectance represents the percentage of forest patch pairs in the landscape that are connected either directly or through other patches and relates to the ability of an organism to traverse or disperse through the forest. Connectance calculations were performed on forest cover from 1975, 1992, and 2010. A neighborhood function was used to determine the area of all forest that was edge in the landscape. Edge is designated in the Eastern Arc forests as approximately 100 m from the forest margin (Newmark 2006). Core habitat versus edge area was measured for every forest patch in 1975, 1992, and 2010.

Forest Condition: Botanical and vertebrate surveys were conducted in 2006–2010, several years after farming activities were halted in 2002. Changes in the floral species composition and regeneration within the Derema forest before, during, and after the reserve compensation process were measured through field surveys in 2006 (Hall et al. 2010) and 2010 (Mtango & Kijazi 2011), and in 2012 the same plots were remeasured by the same researchers for maximum comparability (J.H., unpublished). We determined species diversity for all trees >5 cm dbh (diameter breast height) in 10 0.5-ha plots. Mtango and Kijazi (2011) measured all trees >1.0 cm dbh from 22 nested plots of radius 15 m. In 2009 mammals and reptiles were trapped, birds were caught in mist nets, and direct observations of fauna were made to estimate species richness (Makonda & Njilima 2009).

Impacts on Local Livelihoods

Changes in access to land and changes in livelihood strategies among different social groups were tracked by Jambiya and Sosovele (2001), Shemdoe (2009), Mtango and Kijazi (2011), Rantala and Vihemäki (2011), and Rantala et al. (2013). The approach used by Rantala et al. (2013) was qualitative; they focused on 2 villages that were perceived by local key informants as the worst affected by displacement. Findings regarding the social impacts of the Derema corridor were based on a tracking of the affected people's livelihood strategies and outcomes over 2 years following the final compensation payments. Mtango and Kijazi (2011) returned to households sampled by Jambiya and Sosovele (2001) to compare changes in basic household characteristics. To convert compensation payments to 2010 prices, we obtained historical conversion rates for Tanzanian shillings to U.S. dollars (http://www.oanda.com/currency/historical-rates/) and then discounted the value to the 2010 value with an index tied to gross domestic product (http://www.measuringworth.com).

Results

Forest Cover and Connectivity

Since 1975 forest within the East Usambara landscape has undergone clearing and increasing fragmentation (Fig. 1; Table 2). In 2010, 28,750 ha of forest remained within government and community reserves, including Derema, and 10,698 ha of forest remained outside of formal reserves. Of the unprotected forest, some 2924 ha was moist upland forest (above 450 m) located on either smallholder plots or owned by the tea estates. Within the boundary of the Derema Reserve, there was no significant change in forest cover from 2000 to 2010. Outside the proposed reserve, there was continued agricultural

Table 2. Forest change in hectares within East Usambara landscape 2000 to2010.

	Forest 2000 (ha)	*Forest 2010 (ha)*	*Change (ha)*
Landscape			
landscape area[a]	91,706	91,706	0
forest area	40,164	35,180	−4,984
core forest		18,943	
edge forest		16,237	
Protected area coverage			
area of reserves	27,840	28,750	910
protected forest area	23,058	28,750	
area of forest outside reserves	15,020	10,698	−4,322
forest cleared inside protected areas (2000–2010)			−2,588
forest loss outside of protected			−4,322
harvest in Longuza teak plantation			−642
Derema Reserve			
area of forest in Derema[b]	855	855	0
1-km buffer of Derema			
forest area	1,664	1,345	−319
forest area lost 2006–2010			−81

[a] *For this analysis we used a landscape area that is a function of satellite image obstruction (clouds) and image coverage. This landscape border has been used for analysis in the East Usambaras in the past and allows amount of forest area to be compared through time. The landscape boundary is shown in Fig. 1.*
[b] *Forest cover in Derema has not changed within the boundaries of the corridor because the boundaries were placed far within the forested area in order to leave forest area outside for continued use by local people.*

conversion of the forest edge from 2000 to 2006 (Fig. 1), whereas after the compensation process began, 2006–2010, little additional forest loss was detected.

Forest connectivity in the East Usambara Mountains continued to decline as forest edges were encroached upon by local small holders and smaller fragments were cleared completely. Connectance was reduced by 62% from 1995 to 1992 and declined an additional 28% from 1992 to 2010 (Fig. 2). The unprotected forests along the Derema ridge between the Amani Nature Reserve and other protected forests were also encroached upon by small holder farmers. Following the protection of the Derema Corridor, the protected area system contained one gap (approximately a 500-m gap of mature eucalyptus silvopastoral land) at the southern end of the Derema Forest Reserve.

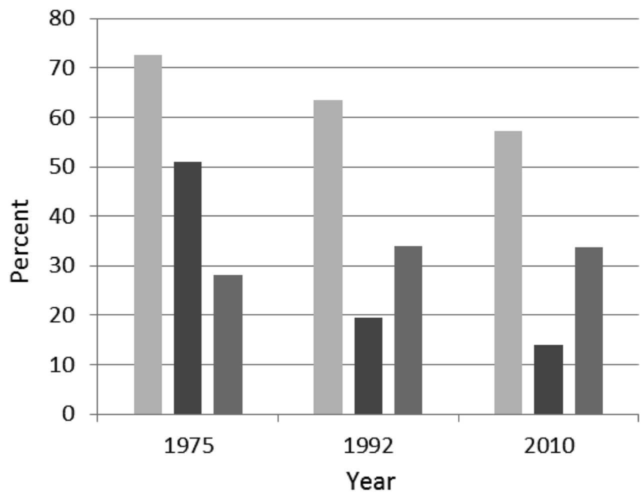

Figure 2. East Usambara Mountains upland (>450 m elevation) forest condition 1975–2010 as indicated by percentage of forested landscape (light gray bars), percentage of connected forest patches in the landscape (dark gray bars), and percentage of forest that is edge (approximately 100 m) (medium gray bars).

Forest Area and Condition

Between 1975 and 2010 the area of core forest in the East Usambaras progressively declined (Fig. 2) due to direct clearing of core forest and increased fragmentation of forest patches outside protected areas. The number of forest patches increased from 230 to 650 from 1975 to 2010 due to fragmentation of larger patches. The remaining patches were smaller and the proportion of edge habitat increased in 1992 (Fig. 2). By 2010, the number of patches decreased because smaller patches were cleared completely. After the protection of Derema Forest Reserve, the total area of protected core forest in the uplands increased by 592 ha.

The number of small- and medium-sized trees increased greatly, and the once degraded forest was still dominated by the Eastern Arc and Coastal Forests endemic species *Cephalosphaera usambarensis* and *Allanblackia stuhlmannii*, other native species, and the nonnative species *Maesopsis eminii*. *Cephalosphaera usambarensis* and *Allanblackia stuhlmannii* composed approximately 50% of all stems ≤5 cm dbh. The now protected agroforests contained 3 times more medium and small trees and 7 times more endemic trees than nearby active agroforests (Hall et al. 2010). The resurvey in 2012 of 5 plots first surveyed in 2006 showed that tree species richness had increased from an average of 38 (SD 8) species per plot to an average of 55 (SD 7) species. These 5 plots contain 115 of the 194 tree species documented in the entire earlier 2006–2007 survey of 42 plots throughout the landscape, demonstrating that seedling dispersal and regeneration occurred. The number of small trees (<20 m) also increased dramatically (400% increase; J.H. et al., unpublished). The proportion of small nonnative trees decreased from 0.1 to 0.04; thus, canopy cover of native trees had increased and was shading out light-demanding invasive nonnative species.

Species Protection

Data from The Missouri Botanical Garden's TROPICOS database indicated that 15% of plant species endemic to the Eastern Arc Mountains occur in the Derema forest, including 69% of the endemic plants of the East Usambaras and 59% of plants endemic to the East and West Usambaras (Supporting Information). A substantial number of Eastern Arc and Coastal Forest endemic animal species also occurs in the Derema forest (Makonda & Njilima 2009) (Supporting Information). This includes 4 near-endemic mammals, Zanzibar galago (*Galago zanzibaricus*), lesser pouched rat (*Beamys hindei*), eastern tree hyrax (*Dendrohyrax validus*), and the Zanj elephant shrew (*Rhynchocyon petersi*), which is listed as vulnerable on the IUCN Red List (Rathbun & Butynski 2008), and 16 endemic or near-endemic herpetofauna. Seven near-endemic, and 5 threatened bird species were recorded, including the critically endangered Long-billed Apalis (*Orthotomus moreau*; new locality) and the endangered Amani sunbird (*Hedydipna pallidigaster)*.

Livelihoods Outcomes

Following the Derema conservation intervention, average landholdings of the affected farmers were halved (Mtango & Kijazi 2011; Rantala et al. 2013). A majority of the affected people thought the compensation they received was insufficient to reinvest in land (Rantala et al. 2013). When the final compensation was eventually received after a long delay, many farmers used the money on things other than land because they had been promised alternative farmland. Continued delays in allocating alternative farmland further compounded the negative attitudes toward the compensation process (Rantala & Vihemäki 2011). By January 2014, plans were in place for 1128 members of Derema to be allocated parcels of the abandoned Kibaranga sisal estate, which is approximately 50 km east of where a majority of those affected live. Successful farming in this area will require transportation, knowledge of drier-land farming, and financial resources.

Total financial assistance received by farmers from the compensation process ranged from <\$20 to nearly \$10,000. (All monetary units are U.S. dollars unless otherwise stated.) Access to this compensation money varied among social groups characterized by gender and wealth status (Rantala et al. 2013). The median compensation in the lowest wealth class was \$193 ($n = 36$), while in the middle class it was \$307 ($n = 82$) and in the highest class \$1370 ($n = 16$). The median compensation received by women was smaller (\$256) than the amount received by men (\$547). Although similar proportions of interviewed men and women were affected by loss of access to similar areas of farmland, all the men received compensation, whereas one-third of women received compensation. The operationalization of the compensation intervention failed to address gender discrepancies in local cultural practices related to land tenure, despite the early documentation in the social impact assessment that this was a concern (Jambiya & Sosovele 2001, Rantala et al. 2013). The lower and middle wealth classes had numerous other priorities for expenditures, were not provided with funds sufficient for reinvestment, and had hoped for allocation of alternative land by the government. As such, they used most of their compensation money on immediate household necessities and for home building and repair (Table 3 & Supporting Information). Investing in substitute farmland or business activities was concentrated in the highest wealth classes, people in which also received larger compensation sums. New business activities included shops, trading activities, and building rental houses in a nearby town (Rantala et al. 2013).

Mtango and Kijazi (2011) found that the majority of respondents across all affected villages considered themselves worse off following gazettement due to loss of main livelihoods and fewer livelihood options (Table 3). Only 4.8% of the surveyed farmers stated they were better off, and 10.5% considered their livelihoods the same. Rantala et al. (2013) reported that only the minority of the wealthiest farmers were content with the compensation intervention, while the middle and lowest class farmers experienced a strong negative impact.

Discussion

Our results showed the gazettement process of the Derema Corridor was successful. In the newly protected area, species richness and abundance increased, and the area appeared to be functioning as an ecologically important corridor. Within a few years a diversity of endemic forest trees regenerated and the once degraded canopy began to close. Forest connectivity in the landscape was enhanced, and core habitat containing rare and threatened species was conserved. Without gazettement the encroachment and clearing of forest would have continued and the forest's function as an ecological corridor would ultimately have been greatly reduced.

Table 3. Main uses of the land compensation funding as stated by 248 people from 5 village surrounding the Derema corridor (Mtango & Kijazi 2011); according to 53 households in different wealth groups (Rantala et al. 2013); based on livelihood consequences of the reserve gazettement (Mtango & Kijazi 2011); and based on use of funds by gender (42 men and 10 women) (Rantala et al. 2013).

Overall use of funds	*Number of farmers*		*Percentage*
no answer	97		39.1
invested in children's education	38		15.4
made house improvements	34		13.7
alternative incomes or non-farm activities	25		10
buying or building house	22		8.9
acquire land in village	17		6.9
acquire land outside village	14		5.6
spent on healthcare	1		0.4
Total	248		100
	Wealth group		
Use of funds	lowest (%, $n = 10$)	middle (%, $n = 33$)	highest (%, $n = 10$)
consumption	70	45	30
building	60	42	50
farmland	10	27	70
children's education	0	15	20
livestock	10	12	10
saving	0	12	0
Change in livelihoods	Number		Percentage
worse off	97		78.2
same	13		10.5
no answer	8		6.5
better off	6		4.8
Total	124		100
Reasons for livelihood decrease			
loss of main livelihoods	49		39.5
fewer livelihood options	49		39.5
no answer	21		16.9
low (compensation) payments	5		4.1
Total	124		100
Use of funds	Men (%) ($n = 42$)		Women (%) ($n = 10$)
consumption	52		27
building	52		18
farmland	38		27
children's education	7		36

However, a balance between conservation and livelihood objectives during the Derema gazettement was not achieved. As of January 2014, the social outcomes of corridor's protection have been more negative than positive, in spite of efforts to apply the World Bank resettlement safeguards policy and the considerable compensation funds provided by various agencies to mitigate the social impacts. Moreover, the strongest negative impacts were experienced by the most vulnerable groups, the poorest and women. The winners of this conservation and compensation process tended to be the privileged, who were able to diversify their livelihoods and business activities and acquire new farmland. The experience and outcomes of the Derema case mirror the poor planning and implementation of compensation schemes elsewhere (e.g., development-related displacement) and illustrate the challenges of successfully applying monetary compensation for lost access to resources, particularly among the most disadvantaged groups (Cernea & Mathur 2008). These findings are based on tracking outcomes over 2 years following the final compensation payments within affected villages. We recognize we did not have comparable control information from similar, but unaffected, villages. This would be a productive avenue for further research.

Our Derema Corridor case study demonstrates that protection of degraded forests may constitute an ecologically effective tool in tropical forest conservation. At the same time, it reminds us that the planning and implementation of such interventions must be done carefully, be done in a timely manner, and be socially inclusive to ensure equity of outcomes and ultimately the long-term sustainability of conservation efforts. Compensating the loss of a renewable resource with a dispensable one (cash alone) may not always be the best method. All people do not have the same capacities to turn cash compensation to their advantage, especially the poorest. Now that land allocation is planned to start, it remains to be seen whether solving this issue will resolve remaining problems and mark the end to this long and complex process.

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Supporting Information

Preliminary information on the botanical importance of the Derema forest in comparison with Eastern Arc Mountains and East Usambara Mountains (Gereau et al. 2013) (Appendix S1); endemic, near-endemic, and threatened vertebrate species recorded in the Derema Forest Reserve (Appendix S2); changes in houses in a sample of 124 households in 5 villages before and after the gazettement of Derema and the payment of compensation, 2002 and 2010 (Appendix S3); and provision of alternative land in the lowlands based on responses from 124 households across 5 surrounding villages (Appendix S4) are available online. The authors are solely responsible for the content and functionality of these materials. Queries (other than absence of the material) should be directed to the corresponding author.

Literature Cited

Agrawal, A., and K. Redford. 2009. Conservation and displacement: an overview. Conservation and Society **7:**1–10.

Andam, K. S., P. J. Ferraro, A. Pfaff, G. A. Sanchez-Azofeifa, and J. A. Robalino. 2008. Measuring the effectiveness of protected area networks in reducing deforestation. Proceedings of the National Academy of Sciences, USA **105:**16089–16094.

Barlow, J, et al. 2007. Quantifying the biodiversity value of tropical primary, secondary, and plantation forests. Proceedings of the National Academy of Sciences, USA **104:**18555–18560.

Bierregaard, R., C. Gascon, T. E. Lovejoy, and R. Mesquita, editors. 2001. Lessons from Amazonia. Pages 96–145 in the ecology and conservation of a fragmented forest. Yale University Press, New Haven, Connecticut.

Brockington, D., and J. Igoe. 2006. Eviction for conservation: a global overview. Conservation and Society **4:**424–470.

Bullock, R., D. Mithöfer, and H. Vihemäki 2011. A comparative financial analysis of current land use systems and implications for the adoption of improved agroforestry in the East Usambaras, Tanzania. WP 125. World Agroforestry Centre, Nairobi.

Burgess, N. D. et al. 2007. The biological importance of the Eastern Arc Mountains of Tanzania and Kenya. Biological Conservation **134:**209–231.

Cernea, M. M., and H. M. Mathur, editors. 2008. Can compensation prevent impoverishment? Reforming resettlement through investments. Oxford University Press, New Delhi.

Cordeiro, N. J., and H. F. Howe. 2003. Forest fragmentation severs mutualism between seed dispersers and an endemic African tree. Proceedings of the National Academy of Sciences **100:**14052–14056.

Craigie, I. D., J. E. M. Baillie, A. Balmford, C. Carbone, B. Collen, R. E. Green, and J.M. Hutton. 2010. Large mammal population declines in Africa's protected areas. Biological Conservation **143:**2221–2228.

Ferraro, P. J., and A. Kiss. 2002. Direct payments to conserve biodiversity. Science **298:**1718–1719.

Geldmann, J., M. Barnes, L. Coad, I. Craigie, M. Hockings, and N. Burgess. 2013. Effectiveness of terrestrial protected areas in reducing habitat loss and population declines. Biological Conservation **161:**230–238.

Gilbert-Norton, L. R., J. Wilson, R. Stevens, and K. H. Beard. 2010. A meta-analytic review of corridor effectiveness. Conservation Biology **24:**660–668.

Hall, J. M., T. W. Gillespie, and M. Mwangoka. 2010. Comparison of agroforests and protected forests in the East Usambara Mountains, Tanzania. Environmental Management **48:**237–247.

Hamilton, A. C., and R. Bensted-Smith, editors. 1989. Forest conservation in the East Usambara Mountains, Tanzania. World Conservation Union, Gland, Switzerland.

Hannah, L. 2008. Protected areas and climate change. Annals of the New York Academy of Science **1134:**201–212.

Hilty, J. A., W. Z. Lidicker, and A. M. Merenlender. 2006. Corridor ecology: the science and practice of linking landscapes for biodiversity conservation. Island Press, Washington, D.C.

Jambiya, G., and H. Sosovele. 2001. Conservation and poverty: the case of Amani Nature Reserve. Research on Poverty Alleviation (REPOA), Dar es Salaam.

Johansson, S., and R. Sandy. 1996. Protected areas and public lands. Land use in the East Usambara Mountains. East Usambara Catchment Forest Project, Technical paper 28, Tanga, Tanzania.

Joppa, L. N., and A. Pfaff 2011. Global protected area impacts. Proceedings of the Royal Society **278:**1633–1638.

Kabra, A. 2009. Conservation-induced displacement: a comparative study of two Indian protected areas. Conservation and Society **7:**249–267.

Lasgorceix, A., and A. Kothari. 2009. Displacement and relocation of protected areas: a synthesis and analysis of case studies. Economic and Political Weekly **44:**37–47.

Loarie, S. R., P. B. Duffy, H. Hamilton, G. P. Asner, C. B. Field, and D. D. Ackerly. 2009. The velocity of climate change. Nature **462:**1052–1055.

Makonda, F., and F. Njilima. 2009. Faunal and floral surveys of the Derema corridor, East Usambara Mountains of Tanzania. Report to WWF Tanzania Programme Office, Dar es Salaam. http://www.easternarc.or.tz/eusam

McGarigal, K., and B. J. Marks 1995. Spatial pattern analysis program for quantifying landscape structure. PNW-GTR-351. USDA, Forest Service.

McLean, J., and S. Straede. 2003. Conservation, relocation and the paradigms of park and people management. A case study of Padampur Villages and the Royal Chitwan National Park, Nepal. Society and Natural Resources **16:**509–526.

Mtango, N., and A. Kijazi. 2011. Impact of gazettement of Derema forest corridor on community livelihoods and forest conservation. REPOA, Dar es Salaam, Tanzania.

Muricia, C. 1995. Edge effects in fragmented forests: implications for conservation. TREE **10:**58–62.

Newmark, W. D. 1991. Tropical forest fragmentation and the local extinction of understory birds in the Eastern Usambara Mountains, Tanzania. Conservation Biology **5:**67–78.

Newmark, W. D. 1993. The role and design of wildlife corridors with examples from Tanzania. Ambio **22:**500–504.

Newmark, W. D. 2006. A 16-year study of forest disturbance and understory bird community structure and composition in Tanzania. Conservation Biology **20:**122–134.

Newmark, W. D., and T. R. Stanley. 2011. Habitat fragmentation reduces nest survival in an Afrotropical bird community in a biodiversity hotspot. Proceedings of the National Academy of Sciences **108:**11488–11493.

Rantala, S., and H. Vihemäki. 2011. Forest conservation and human displacement: lessons from the establishment of the Derema Corridor, Tanzania. 52–81 in I. Mustalahti, editor. Features of forestry aid: analyses of finnish forestry assistance. Ministry for Foreign Affairs of Finland, Helsinki.

Rantala, S., H. Vihemäki, B. Swallow, and G. Jambiya. 2013. Who gains and who loses from compensated displacement from protected areas? The case of the Derema Corridor, Tanzania. Conservation and Society **11:**97–111.

Rathbun, G. B., and T. M. Butynski. 2008. *Rhynchocyon petersi*. In IUCN red list of threatened species. Version 2013.2. International Union for Conservation of Nature, Gland, Switzerland.

Reyes, T. 2005. Socio-economic comparison between traditional and improved cultivation methods in agroforestry systems, East Usambara Mountains, Tanzania. Environmental Management **36:**682–690.

Rodrigues, A. S. L., et al. 2004. Effectiveness of the global protected area network in representing species diversity. Nature **428:**640–643.

Saunders, D. A., R. J. Hobbs, and C. R. Margules. 1991. Biological consequences of ecosystem fragmentation: a review. Conservation Biology, **5:**18–32.

Simberloff, D., J. A. Farr, J. Cox, and D. W. Mehlman. 1992. Movement corridors—conservation bargains or poor investments. Conservation Biology **6:**493–504.

Shemdoe, R. S. 2009. Participatory monitoring and evaluation of resettlement action plan for Derema forest corridor. WWF Tanzania Country Office, Dar es Salaam.

United Republic of Tanzania (URT) 2006. Resettlement Action Plan for farm plots displaced for biodiversity conservation in the Derema Forest Corridor. Ministry of Natural Resources and Tourism, Dar es Salaam, Tanzania.

Vihemäki, H. 2009. Participation or further exclusion? Contestations over forest conservation and control in the East Usambara Mountains, Tanzania. Interkont Books, University of Helsinki.