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Action: Creating Corridors to Influence Ecosystem Services

Key Messages

- Studies incorporating reducing emissions from deforestation and forest degradation (REDD+) aim to uplift poverty-stricken communities by repurposing and protecting local land to create corridors, forested areas, riparian zones, etc. that help to reduce carbon emissions. The money generated from investors in these projects is reinvested into community projects that help to provide services, resources, educational experiences, and employment opportunities to community members. These corridors increase biodiversity, improve natural resources, and help to sequester carbon. (supporting evidence 1-4)
- Bodies of water often provide community services including aquaculture, transportation avenues, watersports etc., but often suffer from the negative consequences of human impact. Studies conducted on corridors within bodies of water display that restorative structures implemented for marine organisms improve marine environments, water quality, and biodiversity while still allowing community services and recreational activites. (supporting evidence 5-7)
- Experimental studies conducted in Savannah River Site, South Carolina, demonstrate that corridors promote interpatch movement and pollination, promote prescribed understory fires that restore woodlands, and do not increase disease spread/prevalence between patches. (supporting evidence 8-10)

Background Information

Wildlife corridors are passageways that connect two separate areas of land while simultaneously increasing species migration, biodiversity, and mitigating fragmentation and deforestation effects (Newmark, 1993). These corridors provide ecosystem services while protecting native plant and animal species (Samways, 2009). Ecosystem services are positive benefits that the earth can provide for humans and other organisms ("Ecosystem Services", NWF). There are four types of ecosystem services provisioning services, regulating services, cultural services, and supporting services. Provisioning services include benefits that can be extracted from nature such as water, timber, oils, wood fuel etc. Regulating services include benefits that moderate natural phenomena such as pollination, erosion, decomposition etc. Cultural services are non-material benefits that help to improve community development and daily life. Sustaining services allow earth to sustain life and include photosynthesis, nutrient cycling, and the water cycle. This paper presents evidence that corridors aid in providing ecosystem services to the communities that surround them and to the larger surrounding environment.

Supporting Evidence

1. The Monte Pascoal-Pau Brazil Ecological Corridor which is located in the Central Corridor of the Atlantic Rainforest, in the Caraíva River Basin, is part of a project

focused on restoring forest areas and riparian woods (Paiva, 2014). This project is part of the voluntary carbon market and has received the seal climate community and biodiversity. The involvement of the corridor in the carbon market has attracted contracts with Kraft, Natura Cosmetics, and COELBA and has resulted in the planting of seeds and saplings from native plant species which are expected to reduce 316 thousand tons of CO2. Through collection of primary sources (visits and interviews) and secondary sources (reports of institutions on themes and references) researchers drew conclusions about corridor use and benefits. Due to corridor restoration and a newly balanced surrounding ecosystem, the local community has benefited from a decrease in land erosion, improvement of natural water resources, increase of birds and mammals in the area, and a decrease in plague occurrences on plantations. These benefits have led to decreased use of artificial plague control which has reduced the cost of maintenance for plantations and surrounding area. This corridor has encouraged improvement, protection, and efficient use of natural resources. Additionally, the project has fostered community involvement in the establishment of forest governance. The local community was enriched by the project through technical training of the residents to handle the forest resources in a sustainable way, which provided jobs and income associated with the project. This corridor has provided cultural services through educational training, forest governance and job creation, regulating services through pest regulation and decrease in land erosion, support services through carbon sequestration, and enhanced provisioning services through improvement of natural resources for community use.

2. The Umiam sub-watershed is a community conservation forest and wildlife corridor along the banks of the Umiam River gorge that is linked to a larger forest area in the upper watershed; these areas are part of a an initiative to reduce deforestation, increase reforestation, and reduce emissions in the Indian state of Meghalaya (Poffenberger, 2015). This wildlife corridor is protected and managed by a local governance organization and is registered as an Indigenous Community Conserved Area with the United Nations. Yearly forest plot inventory data shows considerable increases in biomass levels and carbon sequestration within inventory plot categories that are being actively reforested. According to 10 plots sampled in 2014, the increase was 2.7 tC/ha year on year, compared to 0.28 tC/ha for areas not involved in assisted natural regeneration activities. This higher rate of sequestration may be due to better fire control, thinning, weeding, enrichment planting, better soil, and altered moisture conditions. Additionally, by 2015, approximately 54% of the carbon offset certificates created by the project were sold generating $140,439 in revenue. This revenue is being used to support fire control, fuel efficient stove distribution, finance management and monitoring, and support for community development grants. In 2014, 15.8 kilometers of fire lines were created to limit the extent of annual forest burn; as a result, average annual forest fire area fell from 82.8 ha from 2010–2012, to 62.3 ha from 2013-2015. A historical formation of a “Federation” by ten indigenous governments occurred to coordinate forest management plans and activities. This governance system creates a permanent framework for inter-village action focused on resolving natural resource management problems. This project has delivered benefits to local communities and has met REDD+ goals. This corridor

assists in providing cultural services through the creation of the Federation governance organization and income that is used to support community initiatives, regulating services by decreased fire occurrences, support services through carbon sequestration, and provisioning services through improved natural resources.

3. The Central Corridor of The Brazilian Atlantic Forest along the coast of Bahia State is involved in a "Restoration of The Atlantic Forest and Protection of Water Resources" project (Mesquita, 2010). Local communities were heavily involved in the process and were asked to designate which areas would be reforested. Communities chose to focus on riparian zones, basins, and establishing an ecological corridor connecting Pau Brazil and Monte Pascoal National Park. A local governance group was created called the "The Cooperative of Malta Atlantica Reforestation Workers of Far Southern Bahia (COOPLANTAR)", they focused on learning about forest restoration technologies and cooperative management techniques. This project has provided opportunities for work, income generation, workshops for new skills, and an increase in professional. COOPLANTAR was able to restore over 200ha of forest, local farms, and corridor projects, while simultaneously becoming active in all stages of forest restoration. Being part of this project has increased an individual's social autonomy within their community and has increased community awareness and prioritization of global environmental issues. This corridor has provided cultural services through education opportunities for the community and job creation, and provisioning services through improvement of natural resources.

4. The Kasigau project is a REDD+ project located in Kasigau, Kenya that focuses on protection and conservation of a dryland forest spanning 500,000 acres, and is a corridor for wildlife, linking Tsavo East and Tsavo West National Parks (Atela, 2013). Conserving the local dryland forest for carbon increases the land's value and creates opportunities and income for local communities. This project encourages local community participation in management of resources as well as sharing of benefits. This project links carbon benefits to local vulnerabilities including low value dryland, illiteracy, and water scarcity. Phase I of the REDD project covered conversion of 70,000 acres of the Rukinga ranch, private forested land, community owned group ranches, and community trust lands into protected conservation areas. The first phase of the project will sequester 300,000 tons of CO_2, while the second stage will sequester 49,000,000 tons. Ranch shareholders benefit from the carbon revenue and community projects funded by carbon revenue. Various community groups are supported in creation of their own tree nurseries and can sell their seedlings. The project increases diversity of seedlings including indigenous species, exotic species, and grafted fruit trees. Seedlings from the community mature in a local greenhouse and are then supplied to community members, schools and churches. About 400 local people are employed through this project as community wardens, extension staff, and clerks. The share for community projects is managed through a trust fund and has raised Ksh24 million (US$300,000) to

be directed towards community projects. This project provides cultural services through educational opportunities and job creation, provisioning services through growth of seedlings and improvement of natural resources, and support services through carbon generation.

5. The Kiel Fjord is classified as a heavily modified water body according to the EU WFD; however, there is valuable marine life in the fjord that has encouraged a number of habitat reconstructions in Germany (Krost, 2018). Physical changes have altered the waterside area of the Fjord, which had been urbanized to be used for waterfront development and sealed by seawalls and sheet piling. Additionally, the total area of the inner fjord has decreased, large portions of shallow areas have disappeared, bottom topography has been altered, and hard substrates may have disappeared. Dredging and harbor construction have decreased marine area and have necessitated habitat restorations to increase biodiversity. Examples of restorations include a stone reef fostering a diverse community of macroalgae, other artificial reefs, transplanted eelgrass shoots, and transplanted hard substrate. Small patches of these restoration areas are "stepping-stones" for the southern tip of the eastern wildlife corridor at Mönkeberg. Several biotypes have been observed using these restoration areas including *Zostera marina, Fucus vesiculosus, Syngnathus typhle, Entelurus aequoreus, Nereis pelagica,* and *Delesseria sanguinea.* Activities including research, surfing, aquaculture, use by military, and use by industrial facilities have been shown to foster positive compatibility with most biotope types. Corridors within the fjord offers community services through shipping, shipbuilding, navy activities, aquaculture, beaches, and water sports, provide regulating services through increased biodiversity that assists in keeping water environments balanced, and provisioning services through aquaculture opportunities.

6. The conditions of the Austrian Danube and its floodplains have changed considerably over the last 125 years especially with the creation of a hydroelectric water plant that has provided energy and has helped to control floods but has also led to restructuring of the area including shallow water areas, gravel banks, small permanent backwaters, temporary waters, and fragmentation (Chovanec, 2000). Water of the Danube channel is divided by Danube Island which was initially planned and constructed for flood control; however, the island has become a major recreational activity destination. Rehabilitation of inshore structures has occured through the Danube Island Monitoring Program. This program has assisted in measuring of corridor usage, water quality, functionality of a fish bypass, macrovertebrate assemblages, functional integrity, indicator species, and re-establishment of key processes and structures in the areas surrounding Danube Island. Monitoring displayed 16 plant species at the investigation sites, 14 in the monitoring plots. Newly constructed inshore zones were colonized by 24 dragonfly species. Zygopteran species who have shorter migration distances display that Danube Island acts as a long-distance corridor through Vienna. The appearance of I. pumilio displays the corridor function of installed inshore structures of the Danube Island. This was the first record of I. pumilio

on the Danube Island, it has previously only been found in floodplain areas north and south of Vienna. Reptiles and amphibians are considered to be the best indicators to determine functional integrity of corridors and connectivity of breeding sites; 12 of 20 amphibian species inhabiting Austria were recorded on Danube Island. 9 of 13 reptile species occurring in Austria have been found in the floodplain areas in or near Vienna and two have been found on the Danube Island. At the Danube, New Danube, and Old Danube, 40 waterfowl species were recorded, which nearly encaptures the total number of waterfowl species in Central Europe during winter. Populations at various sites on the island indicate exchange between new habitats and floodplain areas. This corridor provides cultural services through use the island for restaurants, bathing, sports arenas, and open-air events, and provides regulating services through increased biodiversity that assists in keeping water environments balanced.

7. Three constructed fish passes in the rivers Nassach and Reidbach in Northeast of Bavaria, a major drainage system in southern Germany, have been assessed for conservation value of stream habitat restoration by nature-oriented fish passes (Pander, 2011). The continuity of natural fish communities and river systems are considered to be biological and hydromorphological quality elements that are essential to stable and flourishing environments. Fish passes may act as compensation habitats for rheophilic fish species and corridors for fish passage. 17 fish species from 7 different families were found in the corridors through electrofishing surveys. In the Nassach, 15 species were detected. In the Reidbach, 14 species were detected. Fish aggregations were dominated by 11 species of cyprinids. In Nassach, species richness and biomass were higher, while in Reidbach the number of individual fish observed was higher. All three semi-natural fish passes were used for both upstream and downstream movements. Researchers recorded 438 total fish movements. These corridors are important habitats for rheophilic species, juveniles, and small fish. Well-designed corridors have positive effects on overall fish and habitat diversity and restore good ecological status. This corridor provides provisioning services by increasing the number of fish found in various areas of rivers and regulation services through increase of fish biodiversity.

8. In the Savannah River Site, National Environmental Research Park in South Carolina, researchers created 1-ha “central patch” locations surrounded by four peripheral patches 150 m away from the central patch, in eight separate 50-ha patches (Tewksbury, 2002). A 25-m-wide corridor was created to connect the central patch at each location to one peripheral patch at each location (the “connected” patch). Movement rates of animals, pollen, and seeds from the central patch to the four surrounding patches was measured. Overall, movement from the center patch to patches connected by corridors was higher than movement to the unconnected patches for all taxa. The Common Buckeye (butterfly) was 3-4 times more likely to migrate from center patches to connected patches than to unconnected patches. The Variegated Fritillary (butterfly) was twice as likely to move through corridors than through forest when moving from the center patch. Pollen

movement replicated trends seen in butterfly movement. Higher proportions of flowers produced fruit in connected patches compared to unconnected patches. Fruit sets increased on average by 69% in connected patches compared to unconnected patches. Flowers in the patches were visited by flies, wasps, bees, and butterflies. Corridors are used preferentially by some of the aforementioned insects, which resulted in higher fruit set for connected patches. *I. vomitoria* seeds were more than twice as likely to be found in connected patches compared to isolated patches; additionally, a significantly greater proportion (increase of 18%) of fecal samples in connected patches contained fluorescent powder (sprayed on seeds in the center patches) compared to unconnected patches. These results show that corridors increase seed movement by birds, increase movement of disparate taxa, increase plant-animal interactions, increase fruit set, and increase seed dispersal. Increased fruit set and seed movement by corridor have postive effects on gene flow and population dynamics. Plants producing more fruit are likely to attract more frugivores; as a result, plants in connected patches have greater contributions to gene flow within and between patches. This is due to increases in pollen movement, fruit removal, and seed movement through corridors. This study demonstrates that corridors provide benefits associated with increase in habitat area and interpatch movement that enables key mutualisms between plants and animals. This corridor provides regulating services through pollination and support services through promoting primary production.

9. In the Savannah River Site, National Environmental Research Park in South Carolina, researchers created six experimental landscapes (each 50 ha) that represented a single statistical block (Bridvig, 2012). Each block contained one central patch (100 x 100 m) surrounded by four peripheral patches 150 m from the central patch One of the peripheral patches (100 x 100 m) was connected to the central patch by a corridor (25 x 150 m), which was also composed of open habitat. Other peripheral patches were isolated from the central patch by 150 m of matrix habitat. Six burns were conducted in this study between January and March 2009, on days supporting a predetermined set of environmental conditions. Half of the locations were ignited by hand and the other half were ignited aerially. All landscapes burned with similar probability. Corridors elevated fire temperatures by increasing connectivity and edge effects. Higher temperature plots supported higher bunch grass cover after burning. Corridors may aid in promoting plant species coexistence though the promotion of bunchgrasses following fire. Prescribed understory fire is vital to the management/restoration of longleaf pine woodlands; increased fire temperature by corridors may be beneficial. Understory fire maintains understory plant diversity by encouraging coexistence of herbaceous plants and shrubs. Corridors provide regulating services through promoting prescribed understory fires that restore woodlands which in turn provides support services through promoting plant biodiversity and bunchgrasses after fire.

10. In the Savannah River Site, National Environmental Research Park in South Carolina, researchers created experimental landscapes (each 50 ha) that represented a single

statistical block (Hess,1994). Each block contained one central patch (100 x 100 m) surrounded by four peripheral patches 150 m from the central patch One of the peripheral patches (100 x 100 m) was connected to the central patch by a corridor (25 x 150 m), which was also composed of open habitat. Increased spread of infectious disease is often cited as a potential negative effect of corridors; as a result, a plant-pathogen system was tested in a large-scale habitat corridor experiment. This experiment displayed that corridors do not encourage the movement of wind-dispersed plant pathogens. Connectivity of patches does not increase levels of plant disease, rather edge effects seem to be the cause of plant disease. Sweet corn (Zea mays) and southern corn leaf blight (Cochliobolus heterostrophus) were used as model plant-pathogen systems. Over time, less edgy patches had greater proportions of diseased plants; distance of plants to habitat edges was the determining factor in disease development. The results show that concerns over harmful effects of conservation corridors on disease spread are incorrect. Corridors due not negatively impact plant health.

Conclusions and Recommendations

These studies have displayed that corridors positively impact ecosystem services. All four services (community services, regulating services, supporting services, provisioning services) have been provided by human made corridors. Corridors have increased biodiversity, increased carbon sequestration, increased gene flow, increased pollen movement, decreased land erosion, maintained key mutualisms between plants and animals, improved natural resources, improved environmental conditions, etc. They have also provided jobs, educational experiences, resources, recreational potential, governmental organization, and revenue to local communities. Communities and governments should implement corridors to help their local ecosystem and provide services to their people.

Supporting Studies

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