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Strategy for Conserving a Connected California. Prepared for California Department of Transportation, California Department of Fish and Game, and Federal Highways Administration.
Stallcup, J.A., M.D. White, J.R. Strittholt,and W.D. Spencer. 2003. Conservation Assessment of Tejon Ranch. Unpublished report prepared by Conservation Biology Institute for the Resources Legacy Fund Foundation.
White, M.D., J.A. Stallcup, C.R. Cabanero,and K.L. Penrod. 2006. Proposed Reserve Design for Tejon Ranch A Threatened California Legacy. Unpublished report prepared by Conservation Biology Institute and SC Wildlands.
White, M.D., J.A. Stallcup, W.D. Spencer, J.R. Strittholt and G.E. Heilman. 2003. Conservation Significance of Tejon Ranch: A Biogeographic Crossroads. Unpublished report prepared by Conservation Biology Institute for Environment Now.

Wildlife Corridors in the Udzungwa Mountains of Tanzania

Francesco Rovero (Tropical Biodiversity Section, Museo delle Scienze, Via Calepina 14, 38122 Trento, Italy and Udzungwa Ecological Monitoring Centre, Udzungwa Mountains National Park, P.O. Box 99, Mang'ula, Tanzania, francesco.rovero@mtsn.tn.it) and Trevor Jones (Udzungwa Elephant Project, P.O. Box 99, Mang'ula, Tanzania and Animal and Environmental Research Group, Anglia Ruskin University, East Road, Cambridge, UK, trevor.udzungwa@gmail.com)

It is widely accepted that maintaining, restoring, and protecting wildlife corridors is a critical conservation intervention at times of unprecedented habitat fragmentation (Gilbert-Norton et al. 2010). Corridors serve primarily to maintain viability of isolated populations while ensuring ecosystem functionality and harmonizing conservation and development needs (Beier and Noss 1998). Despite this importance, designing effective conservation corridors remains a challenge, and there are critical gaps between conceptual corridor research and actual corridor design and implementation (Beier and Gregory 2012). In this context, framing practical ways to design, assess functionality, and manage corridors is of priority habitat restoration relevance.

Here, we review research conducted during 2005–2010 on corridors in the Udzungwa Mountains of Tanzania. The country is one of the few for which a detailed compilation of known wildlife corridors is available at national level (Jones et al. 2009). In addition, Tanzanian wildlife policy is conducive to corridor restoration, as the 2009 Wildlife Act authorizes the Government to designate wildlife corridors and migratory routes (United Republic of Tanzania 2009). Wildlife corridors in Tanzania are classified into 5 categories, based on knowledge of wildlife movements and type of connecting habitat (Caro et al. 2009, Jones et al. 2009). The classification includes, at its extremes, 'known animal movement between two protected areas' (threatened wildlife movement criterion) and 'potential connectivity of important habitats' (fragmented habitat restoration criterion). The first type (herein Category 1) applies predominantly to large animals, often elephants (*Loxodonta africana*), moving across protected areas, while the second (Category 2) applies to fragmented habitat, usually highland forests, containing populations of endangered or range-restricted species.

Both of these categories of corridors have been identified in the Udzungwa Mountains. The area covers 10,000 km², comprising moist forest blocks interspersed with areas of woodland, human settlements, and agricultural areas. As the largest block of the Eastern Arc Mountains (Burgess et al. 2007), the Udzungwas hold unmatched levels of biological endemism, which are under increasing threats (Rovero et al. 2012). To the southeast of the Udzungwas, the Selous Game Reserve spans over 50,000 km² and hosts the largest population of elephants in East Africa (Figure 1). Category 1 corridors are those routes used by elephants and other large mammals to move between Udzungwa and Selous ecosystems across the Kilombero valley. Only 2 remaining routes linking these major ecosystems were identified in 2005: the Nyanganje Corridor and the Ruipa Corridor (Jones et al. 2007; Figure 1). These corridors were classified as those of 'critical urgency' by the national assessment (Jones et al. 2009), meaning that they were predicted to be closed in < 2 yrs. Remarkably, connectivity between these ecosystems is critical at a national level because the Tanzanian elephant metapopulation consists of major populations genetically interconnected via individuals moving through corridor areas (Mduma et al. 2011). The Udzungwa-Selous connection is recognized as a vital link in this network, as it is predicted to facilitate gene flow between the major western population of Ruaha-Rungwa (up to 25,000 elephants) and the major Selous-Mikumi population (up to 38,000 elephants).

The Category 2 corridor within the Udzungas is a stretch of habitat called the Mngeta Corridor, and it connects the northern forests of Udzungwa Mountains National Park and Kilombero Nature Reserve with the Uzungwa Scarp Forest Reserve (Figure 1). The latter is one of the largest (200 km²) and most threatened forests of the area, hosting many key species, particularly the Udzungwa-endemic monkeys, Sanje mangabey (*Cercocebus sanjei*) and Udzungwa red colobus (*Procolobus gordonorum*) (Rovero et al. 2012). From 2005–2010, in collaboration with various researchers, we identified, assessed, and proposed restoration measures for these corridors. The government of Tanzania has endorsed the resulting recommendations. Below is a description of these 3 corridors and the operational framework we propose for their restoration.

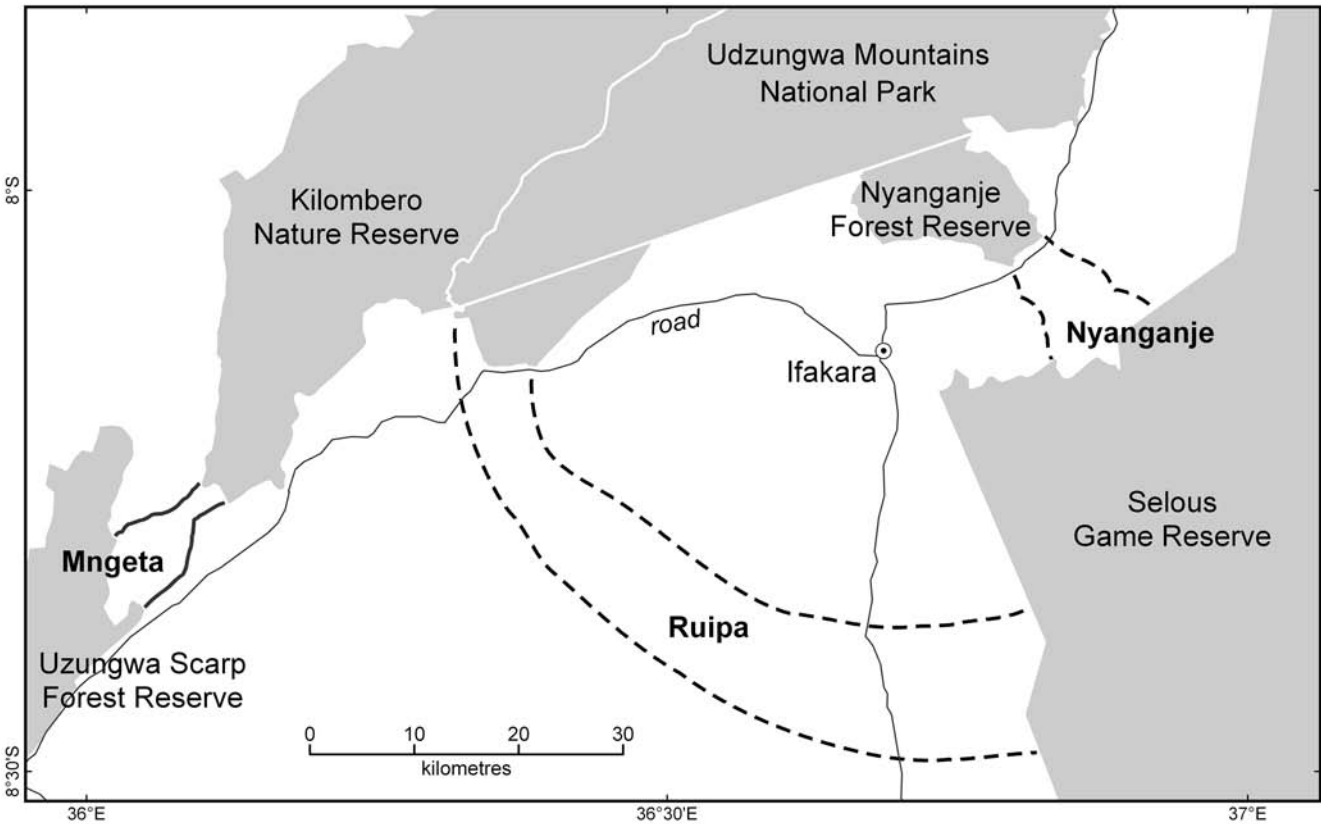

Figure 1. The 2 categories of wildlife corridors assessed and proposed for restoration within the Udzungwa Mountains. The Nyanganje and Ruipa Corridors (Category 1) are indicated as dashed lines and represent large mammal routes between the Udzungwa and Selous ecosystems. The Mngeta Corridor (Category 2) is represented by a heavy continuous line and is a stretch of habitat connecting the Uzungwa Scarp Forest Reserve to the Kilombero Nature Reserve.

The Nyanganje Corridor is approximately14 km long and 8 km wide, and the Ruipa Corridor is 20 km long and ranges in width from 0.5–6 km, crossing a mosaic of riverine forest, woodland, degraded pasture, swamp, and teak plantation in the Kilombero valley (Figure 1). We identified corridor area extent by combining aerial surveys, extensive ground mapping of animal signs, and interviews with local communities. Results indicated that in 2005 connectivity was vanishing, especially for elephants (Jones et al. 2007). Then in 2007–2010, we performed a more focused and systematic assessment to monitor corridor function (Bamford and Ferrol-Schulte 2010, Bamford et al. 2010, Hieronimo et al. 2010), and we discovered that by 2010 both corridor routes had become closed. For a set of sites within the corridors, Bamford and others (2010) counted tracks and other signs of large mammals along 0.5–1.5-km long transects in both 2007 and 2010. Results indicated that species richness decreased dramatically between 2007–2010, while signs of cattle increased. High human immigration into the corridor area and conversion of land to farming or grazing appear to be the main causes. However, the documented continued attempts by elephants to cross by both routes indicate that connectivity can still be restored.

The Mngeta Corridor is approximately 9.2–15.2 km long and 2.1–6.8 km wide, for a total area of 63 km² (Figure 1), composed mainly of riverine forest, mixed shrubby and grassland vegetation along steep slopes, and regenerating vegetation on abandoned farms. Corridor assessment was based on habitat type (extent of natural vegetation), presence of human settlements, and land use ownership, as assessed by aerial and ground surveys (Rovero 2007, St. John 2008). The corridor area supports approximately 90 households, of which 17% are seasonal farmers and 83% are permanent residents, with increasing encroachment pressure from nearby villages. However, less than 2% of the area was permanently used by farmers. The extent of remaining habitat led us to recommend conservation of the Mngeta corridor.

Corridor restoration, for both categories, fundamentally entails a process of harmonizing the needs of several different land owners and stakeholders. While the Mngeta Corridor is entirely in public, central Government land, the Udzungwa-Selous corridors cross human-dominated landscapes with differing land management regimes and legal status (e.g., village lands, Wildlife Management Areas, Game Controlled Areas, and private lands, including teak plantations). Accordingly, the Mngeta Corridor can be restored by creating a protected area, and indeed, it is currently under the process of being gazetted by the central Government as a Nature Reserve, effectively extending the northern Kilombero Nature Reserve to join the southern

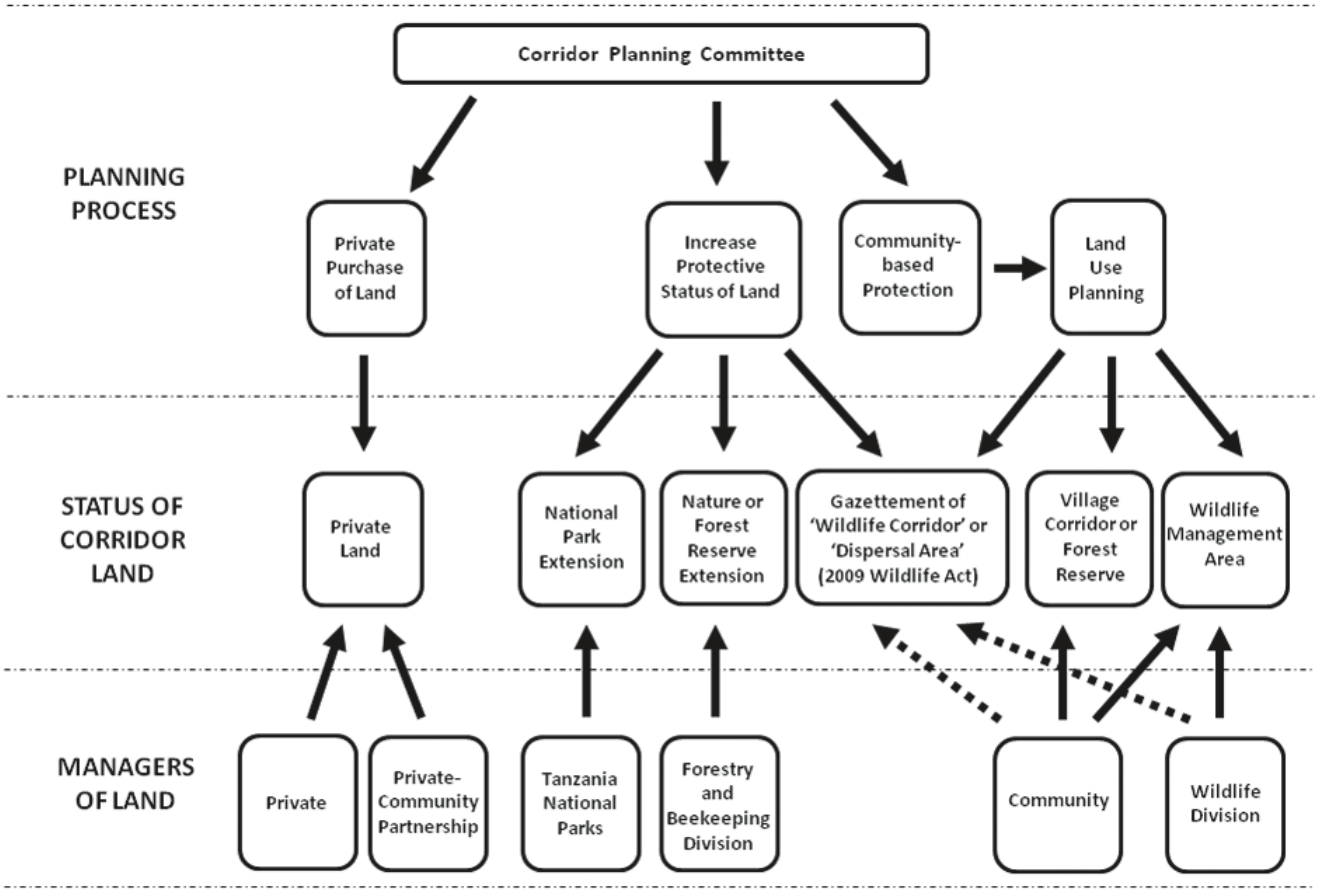

Figure 2. Proposed planning and management options for conserving threatened corridors in Tanzania, showing the various options that the multiple stakeholders and land owners can take to ensure protection of corridor land. The process should be coordinated by a corridor planning committee formed by representatives of the stakeholders themselves. (From Jones et al., *in press*).

Uzungwa Scarp Forest Reserve. This process will entail relocation and compensation of permanent households, a potentially complex and long process as shown by the Derema Corridor, a strip of land in the East Usambara Mountains that is currently being protected by the Tanzanian Government to restore forest connectivity (United Republic of Tanzania 2006). The Derema Corridor, however, involved many more people, as over 1,100 farmers were financially compensated for their land and crop losses.

On the contrary, management of the Udzungwa-Selous corridors must be diversified in respect of the multiple land regimes. While compensation and creation of protected areas may be feasible for some portions of these corridors (including through private purchase of land), community-led land use planning for the areas where corridors cross village land is likely to be the primary long-term solution for corridor protection. This entails a well-established process of village land use planning, conducted with the inclusion of land allocation for corridors.

Operationally, we recommend that a corridor planning committee, consisting of representatives of all stakeholders, be established to coordinate land allocation and the various management options across the entire corridor area (Figure 2). When the legal and land use aspects are addressed, corridor functioning may be enhanced by fencing and/or agroforestry schemes (Bonnington et al. 2007, Bhagwat et al. 2008, Graham et al. 2009). With technical and financial support from the government, relevant NGOs, and interested parties in the private sector, the opportunity exists to restore connectivity through these and other conservation corridors in Tanzania.

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References

Bamford, A. and D. Ferrol-Schulte. 2010. The status of the Nyanganje wildlife corridor (Udzungwas to Selous) during the rainy season of 2010. Report to Frontier Tanzania, Dar es Salaam, Tanzania.

Bamford, A., D. Ferrol-Schulte and H. Smith. 2010. The status of the Ruipa Corridor between the Selous Game Reserve and the Udzungwa Mountains. Report to Frontier Tanzania, Dar es Salaam, Tanzania.
Beier, P. and A.J. Gregory. 2012. Desperately seeking stable 50-year-old landscapes with patches and long, wide corridors. *PLoS Biology* 10: e1001253. doi:10.1371/journal.pbio.1001253.
Beier, P. and R.F. Noss. 1998. Do habitat corridors provide connectivity? *Conservation Biology* 12:1241–1252.
Bhagwat, S.A., K.J. Willis, H.J.B. Birks and R.J. Whittaker. 2008. Agroforestry: a refuge for tropical biodiversity? *Trends in Ecology and Evolution* 23:261–267.
Bonnington, C., D. Weaver and E. Fanning. 2007. The use of teak (*Tectona grandis*) plantations by large mammals in the Kilombero Valley, southern Tanzania. *African Journal of Ecology* 47:138–145.
Burgess, N.D., T.M. Butynski, N.J. Cordeiro, N. Doggart, J. Fjeldså, K.M. Howell, F. Kilahama, S.P. Loader, J.C. Lovett, B. Mbilinyi, M. Menegon, D.C. Moyer, E. Nashanda, A. Perkin, F. Rovero, W.T. Stanley and S.N. Stuart. 2007. The biological importance of the Eastern Arc Mountains of Tanzania and Kenya. *Biological Conservation* 134:209–231.
Caro, T., T. Jones and T.R.B. Davenport. 2009. Realities of documenting wildlife corridors in tropical countries. *Biological Conservation* 142:2807–2811.
Gilbert-Norton, L., R. Wilson, J.R. Stevens and K.H. Beard. 2010. A meta-analytic review of corridor effectiveness. *Conservation Biology* 24:660–668.
Graham, M.D., N. Gichohi, F. Kamau, G. Aike, B. Craig, I. Douglas-Hamilton and W.M. Adams. 2009. The Use of Electrified Fences to Reduce Human Elephant Conflict: A Case Study of the Ol Pejeta Conservancy, Laikipia District, Kenya. Working Paper 1, Laikipia Elephant Project, Nanyuki, Kenya
Hieronimo, P., T. Jones and F. Rovero. 2010. Conserving the Nyanganje Wildlife Corridor (Udzungwa-Selous), Phase I. Final Report to WWF-Tanzania Programme Office, Dar es Salaam, Tanzania.
Jones, T., F. Rovero and J. Msirikale. 2007. Vanishing Corridors: A Last Chance to Preserve Ecological Connectivity between the Udzungwa and Selous-Mikumi Ecosystems of Southern Tanzania: a Feasibility Study. Final Report to Conservation International.
Jones, T., T. Caro and T.R.B. Davenport. 2009. Wildlife corridors in Tanzania. Report to Tanzania Wildlife Research Institute.
Jones, T., A. Bamford, D. Ferroll-Schulte, P. Hieronimo, N. McWilliam and F. Rovero. Submitted. Vanishing wildlife corridors and options for restoration: a case study from Tanzania. *Tropical Conservation Science*.
Mduma, S., A. Lobora, C.L. Foley and T. Jones. 2011. Tanzania National Elephant Management Plan 2010–2015. Tanzania Wildlife Research Institute.
Rovero, F. 2007. Conservation Status, Connectivity, and Options for Improved Management of Southern Forest Reserves in the Udzungwa Mountains, Tanzania: Urgent Need for Intervention.
Rovero, F., A. Mtui, A. Kitegile and M. Nielsen. 2012. Hunting or habitat degradation? Decline of primate populations in Udzungwa Mountains, Tanzania: An analysis of threats. *Biological Conservation* 146:89–96.
St. John, F. 2008. A corridor linking protected forests: meeting conservation and livelihood expectations. The Mngeta Corridor: Linking the Kilombero Nature Reserve and the Udzungwa Scarp Forest Reserve, Morogoro Region, Tanzania. MS Thesis, Bangor University, UK.
United Republic of Tanzania. 2006. Derema Forest Corridor: East Usambara Mountains. Resettlement Action Plan for farm plots displaced for biodiversity conservation in the Derema forest corridor.
United Republic of Tanzania. 2009. The Wildlife Act, 2009. United Republic of Tanzania, Ministry of Natural Resources and Tourism, Wildlife Division. Dar es Salam: Government Printer.

Connecting Fragments of the Pine Rockland Ecosystem of South Florida: The Connect to Protect Network

Devon Powell (Center for Tropical Plant Conservation, Fairchild Tropical Botanic Garden, 11935 Old Cutler Rd., Miami, FL 33156) and Joyce Maschinski (Center for Tropical Plant Conservation, Fairchild Tropical Botanic Garden, 11935 Old Cutler Rd., Miami, FL 33156, jmaschinski@fairchildgarden.org)

Globally, critically imperiled pine rockland ecosystems occur only in south Florida, USA and the Bahamas (Snyder et al. 1990). Once encompassing 51,193 ha along the Miami Rock Ridge in south Florida, today Everglades National Park protects 8,029 ha, while outside the park approximately 920 ha remain as small fragments within the dense urban matrix of Miami-Dade County, FL (Bradley 2005, Florida Natural Areas Inventory 2010; Figure 1). Since the late 19th century, pine rocklands have been cleared for timber, agriculture, and urban development. This unique ecosystem evolved with a diverse mix of temperate and tropical plant and animal species. Of the 432 native plant species found within pine rocklands, 31 are endemic to Florida, 5 are federally endangered, and 5 are candidates for federal listing (Gann et al. 2002, Florida Natural Areas Inventory 2010). Realizing a sense of urgency in 1990, Miami-Dade County voters approved a property tax that created the Environmentally Endangered Lands Program (EEL), which has purchased 242 ha of pine rockland forest fragments for protection. On private lands small pine rockland parcels still exist in various stages of health.

Because the ability to move successfully from fragment to fragment and find new patches to colonize is critical for a species' persistence (Kindlmann et al. 2008), corridors and stepping stones can potentially connect isolated populations, increase seed dispersal, and provide areas for new colonization. In this spirit, Fairchild Tropical Botanic