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Journal

Conservation Biology, 21(3)

ISSN

0888-8892

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Publication Date

2007

Peer reviewed

Published in **Conservation Biology** 10(6): 544-551 (2007).

The role of research in evaluating conservation strategies in Tanzania: the case of the Katavi-Rukwa ecosystem

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Running Head: Conservation strategies in Katavi-Rukwa

Key words: comanagement, community outreach, conservation strategies, ICDP, protectionism

Word count: abstract to end of acknowledgements 6494; refs 1336; total 7720

Abstract: Strict protectionism, resource extraction, protected-area community outreach, ecotourism, an integrated conservation and development program, comanagement schemes, and citizen-science initiatives are all being used to help conserve the remote Katavi-Rukwa ecosystem in western Tanzania. Biological and social research shows that protectionism is successful in the conservation of large mammals but fails to capture diverse species communities; extractivism is appropriate for some resources but not for others; that protected-area outreach can be effective for some communities; and devolved control over wildlife, in conjunction with ecotourism and citizen science, has considerable potential in the area. The long-term nature of the research provides the necessary time frame to evaluate outcomes of different conservation strategies; uncovers dynamics within communities that affect attitudes and responses to conservation initiatives; provides impartial recommendations because changing research personnel offer different viewpoints; and, probably most importantly, enhances trust among stakeholders. Currently, there are limited institutional mechanisms for ensuring the input of biological and social science in shaping conservation practice in Tanzania and long-term research can help informally bridge the gap.

Introduction

Different methods are marshaled to conserve ecosystems, including protectionism, where local community members are excluded from an area; extractive reserves, where people harvest wildlife resources from semiprotected areas; protected area outreach, where people living adjacent to protected areas are offered compensation for foregoing use of natural resources; ecotourism, where the government and/or local communities benefit financially from tourism in protected areas; integrated conservation and development projects, built on the premise that conservation cannot occur without local development; and comanagement schemes, in which local communities and government authorities share responsibility for the design and implementation of conservation strategy. Additional strategies include community-based protected areas, direct payments for conservation, private reserves, citizen-science initiatives, and conservation education (Borgerhoff Mulder & Coppolillo 2005).

There is heated debate among conservation biologists and managers as to the usefulness and practicality of these differing methods for preserving biodiversity. For example, there is argument over the efficiency of protection through utilization (Bruner et al. 2001; Brooks et al. 2006), uncertainty over the extent to which decision-making and implementation of conservation measures should be devolved to local levels (Wyckoff-Baird et al. 2002), and divisions over whether conservation ends can be served by development and market access (Wunder 2001). In theory, long-term interdisciplinary research should play a role in determining a suitable course of action for any particular site (McShane & Wells 2004). We examined how long-term research can shed light on the successes and failures of different conservation strategies at one location in Tanzania. Qualitative overviews, such as this, are key complements to more quantitative and comparative approaches to evaluation of conservation initiatives (Brooks et al. 2006).

Study site

In contrast to many conservation researchers who choose to work on endangered species or disappearing habitats, we selected the Katavi-Rukwa ecosystem because of the diversity of active conservation initiatives in the area. In 1995 we started to examine the ecological and social ramifications of long-term protection for four specific reasons. First, this was an area of the country for which baseline biological knowledge was lacking (e.g., Broadley 2006). Second, the ecosystem was protected under various forms of nationally recognized land-use regulations, ranging from strict protectionism to light restriction, which offered potential for comparison. Third, rapidly growing multiethnic populations lived within the Katavi-Rukwa ecosystem, and the people had a diverse array of livelihoods, which rendered the issue of conservation outreach particularly complex and interesting. Fourth, there was momentum at various junctures, from the traditional chief to the national assembly (albeit with opposition), to double the size of Katavi National Park (Sommerlatte 1995) that was reflective of the broader expansionary policies favored by Tanzania's protected-area managers (Bergin 2001) and was therefore of considerable interest.

Katavi National Park in the Rukwa Valley of Mpanda District, western Tanzania (latitude $6^{o}45'$ to $7^{o}05'$S, longitude $30^{o}45'$ to $31^{o}25$E) is the fourth largest national park in the country. It consists principally of miombo woodland, dry forest habitat characterized by *Markhamia*, *Grewia, Terminalia, Syzygium, Acacia,* and *Combretum* tree species (Rodgers 1996; Schwartz et al. 2002; Banda et al. 2006a). Rainfall is highly seasonal with a single wet season from November to April, when approximately 900-1000 mm of rain falls (Lewison 2002). The park contains several floodplains (Katisunga, Katavi and Chada) that support concentrations of

wildlife in the dry season. More broadly, together with the adjacent Rukwa Game Reserve to the southeast, it is an important part of a network of protected areas across the Miombo-Mopane biome of south-central Africa.

Historical and contemporary background

The Katavi-Rukwa ecosystem lies in "a forgotten corner" of East Africa (Tambila 1981:261). In precolonial times, prior to German military occupation in 1893, the area was fairly prosperous. Indigenous peoples engaged in mound-based horticulture (*chitimene*), cooperative hunting, fishing, and honey production and forged iron and traded salt. During the nineteenth century, social organization in western Tanzania was focused around chiefs, who maintained pallisaded royal villages (Willis 1966) for protection against Ngoni raiders from the south and Arab traders from the east. It is not clear whether chiefdoms were of significance in the lightly populated Rukwa Valley beyond that based at Maji Moto (Fig. 1).

Late nineteenth-century explorers were followed by missionary settlements. In 1880, wildlife and livestock populations crashed following the rinderpest outbreak, and famine and smallpox outbreaks became widespread. Between 1893 and 1940 the area had a low human population density ($<0.9/km^2$) and minimal colonial development, primarily because of military insecurity resulting from competing Belgian, British, and German interests, disease, conscription, and taxation.

The ecosystem surrounding Lakes Katavi and Chada was gazetted as a game reserve by the German authorities in 1912 and perpetuated under the Game Preservation Ordinance passed by the British administration in 1921. It was regarded as a prime hunting ground in Tanganyika Territory in the 1920s and, in 1927, people were concentrated in villages, ostensibly for sleeping

sickness control. The game reserve was extended westward in 1957 and upgraded to national park status in 1974 (Sommerlatte 1995). In 1997 Katavi National Park was extended eastward and effectively doubled in size from 2253 km^2 to 4300 km^2 , and the adjacent Rukwa Game Reserve (4100 km^2) was established (Ministry of Natural Resources and Tourism 2002). Wildlife densities are second only to the Serengeti (Caro et al. 1998a).

The park and game reserve (Fig. 1) are surrounded by Bantu populations. To the south live Pimbwe hunter horticulturists, who have been displaced from the park at various periods, and Sukuma agropastoralist immigrants, who began arriving from the Shinyanga region in the 1970s. To the north live the Bende, although, as elsewhere in Tanzania, most villages are ethnically mixed. Rapid population growth characterized Mpanda District between 1978 and 1988 (5.7% pa), reflecting arrival of Sukuma and refugees from the political struggles in the interlacustrine region, and this generated annual population growth rates as high as 8.4% and 20.9% in some wards adjacent to the park (Sommerlatte 1995). The most recent census shows continued but slower growth, 3.4%/year for the district (Tanzania National Census 2002). Indigenous villages and the belts of outlying Sukuma homesteads are nevertheless increasingly surrounded by protected areas to which the people have no legal access.

Human impacts on the Katavi-Rukwa ecosystem are multiple, as evidenced by our research in Mpimbwe Divison. Although land is not yet in short supply, Pimbwe and Sukuma are clearing forest at a considerable radius from each village to plant subsistence crops (maize, millet, peanuts, cassava, sweet potato) and cash crops (sunflower, tobacco, rice) and for establishing new settlements. Women are traveling ever-greater distances to procure firewood (Holmes 2005); preferred timber for construction and carpentry is no longer locally available; and people foraging far from their homes are occasionally threatened by the staff of commercial

hunting operations. Coppolillo (2000) showed that Sukuma prefer to graze their cattle adjacent to cultivated areas and make only rare incursions into the park, but recent cattle epidemics have shifted the economic endeavors of the Sukuma toward rice cultivation in the low-lying floodplains adjacent to protected areas. Given the key role of cultivation in determining the central-place foraging strategies that govern grazing patterns (Coppolillo 2001), the shift to rice may render pastoralism more ecologically damaging than in the past.

Our observations on health, nutrition, and demography indicate that wealth differentials, poverty, and seasonal food insecurity are the prime drivers of human agricultural expansion in Mpimbwe and are the potential drivers of changes in the prevalence of local hunting. Rukwa is a relatively poor and undeveloped area of Tanzania (United Republic of Tanzania 2005), and Mpimbwe Division is underdeveloped even by Rukwa standards. Acute seasonal food insecurity exists, particularly among the Pimbwe (Hadley et al. 2007). The dynamics of this insecurity have lasting poverty-reinforcing effects as Pimwbe turn to wage labor on Sukuma farms and thus abandon their own subsistence crops. As the Pimbwe become poorer some Sukuma get richer, and they use Pimbwe labor to expand cultivation, increase livestock holdings, and experiment with flood-plain rice cultivation in increasingly marginal habitats. Material evidence of this social divide lies in marked ethnic differences in children's growth. Six percent of Sukuma children and 28% of Pimbwe children classed as underweight, and 8% of Sukuma children and 37% of Pimwbe children are classed as stunted. These anthropometric measures respectively indicate short-term and chronic malnutrition (Hadley 2005), and adult women show similar ethnic differences (C. Hadley & M.B.M., unpublished data).

Current conservation strategies

The Katavi-Rukwa ecosystem is characterized by a number of different conservation strategies (see Introduction). Full or partial protection is afforded through the heavily protected national park under the Tanzania National Parks authorities (TANAPA) and the game reserve administered by the Wildlife Division, where the main activity is expatriate hunting. Extractivism is also occurs in the lightly protected Mlele Game Controlled Area to the east, where, under the permitting system of the district government and Wildlife Division, resident and tourist hunting is allowed, and in the Msaginia Forest Reserve to the northeast, where selective logging is sanctioned (again under local government). The area outside these management designations is the open area, where people live, farm, fish, and keep livestock, and resident hunting is allowed (Fig. 1). Protected-area community outreach is practiced by TANAPA through financing of small community projects. An international organization, Deutsche Gesellschaft fur Technische Zusammenarbeit (GTZ), recently completed an integrated conservation and development project (ICDP) to improve the livelihoods of villagers in the vicinity of the park. A community-based protected area has been established in a buffer zone in the open area to the south of the national park. High-end ecotourism within Katavi National Park and tourist hunting outside have been operating for nearly 20 years, and citizen-science initiatives are underway. Developments related to conservation education and comanagement are in their infancy. Here we show how long-term research is shedding light on the successes and failures of these varied conservation schemes.

Protectionism and large mammal fauna

Zonal planning allowing full protection, partial protection, and extractivism enabled us to evaluate the conservation effects of traditional protectionism in comparison with other land uses.

During 1995 and 1996, T.C. drove 3000 km along minor tracks inside and outside the park to estimate densities of 25 species groupings of large mammals under different types of protection. Densities of large mammals (Caro 1999a) were uniformly higher in the national park, moderately high in the game controlled area, but very low in the forest reserve and open area (Table 1). This showed quantitatively that stringent legal restrictions backed up by irregular patrolling foster large mammal populations; subsequent interview data indicate that illegal (unlicensed) hunting is responsible for low densities outside the park (T.C., unpublished data). Nonetheless, the possibility that the national park was originally set up in an area of high mammal density cannot be excluded (Caro 2003). For example, Katavi National Park is centered on three seasonally flooded areas that host large mammals throughout the dry season. Fortuitously, the game controlled area transects were established in an area that is now part of the national park extension and T.C. has continued to conduct annual dry-season surveys there. Thus we are amassing data on densities of large mammals collected both before and after the instigation of full protection allowing us to determine whether national park status really enables populations of large mammal to flourish and hence whether conservation money should be targeted at national parks as presently occurs. In addition, data collected in 1995 and 1996 show that most large mammals, with the exception of elephants (*Loxodonta africana*), do not migrate out of the old park borders during the wet season as was previously thought, suggesting that the park is relatively self-contained (Caro 1999c).

Protectionism and small vertebrates and invertebrates

In East Africa, national parks and game reserves were originally set up to protect large mammals before the word *biodiversity* was coined. Now we demand that reserves protect all the varied

components of biodiversity, including smaller, less charismatic species, habitat types, and biological processes (Redford & Richter 1999). Therefore, in 1998-2000, T.C. sampled rodent and insectivore diversity inside the national park and outside, in the open area (Caro 2001). Surprisingly, rodent diversity and abundance were consistently lower inside than outside the park across seasons (Table 2). Reasons are unclear but reduced food availability, possibly resulting from competition with large ungulate herbivores (Keesing 1998) (an effect not mirrored by interactions with domestic livestock outside) or else disruption of competitive interactions within the small mammal community due to feeding on agricultural crops outside the park, are both possibilities. The conservation message is that heavily protected areas provide a conservation service for some taxonomic groups but not others.

To determine the efficacy of national parks in protecting other taxa, we trapped and surveyed small mammals (Fitzherbert et al. in press), amphibians (Gardner et al. 2006), butterflies (Fitzherbert et al. 2006), and birds (P. Lalbhai et al., unpublished data) across 41 sites distributed equally across the national park, game controlled area, forest reserve, and open area in wet and dry seasons of 2002 and 2003. Findings show that species richness of most taxa is similar under different forms of protection but that species composition differs markedly (T. Gardner, T.C., E. Fitzherbert, T. Banda, P. Lalbhai, unpublished data; see also Sinclair et al. 2004). The message from these findings is that areas outside national parks that allow limited economic activities, and are often less well protected, may possess distinct communities and additional species, indicating that the existing strictly protected area network is insufficient for the successful conservation of biodiversity and ecosystem processes. Parallel data on tree species show that the national park does not harbor greater species diversity than other areas, which

brings into question the importance of strict protectionism in conserving trees in Miombo-Mopane habitats (Banda et al. 2006a).

Extractivism and trees

Katavi National Park is one of a string of reserves in Tanzania, Zambia, and Zimbabwe that protects miombo, a fire-climax dry forest that burns annually. Miombo is under assault from local hardwood cutters who, in western Tanzania, primarily fell two species of trees, *Pterocarpus angolensis* DC (known locally as mninga) for furniture and *Sterculia quinqueloba* (Garcke) K. Schum. (msawala) for rafters and door frames. Around the national park, trees are cut by hand and trunks are cut into beams, carried to the roadside, collected by trucks, brought to the railhead, and shipped to Dar es Salaam or used locally.

We examined tree distribution and regeneration of *Pterocarpus angolensis* and found that standing trees in Katavi National Park are much larger than in the forest reserve, where most large trees have been cut (Fig. 2). *Pterocarpus angolensis* produces a small seed with an enormous seed coat that is very difficult to crack. In the field, germination rates are extremely low both inside and outside the park (Caro et al. 2005). In the nursery, naturally burned seeds have only a 10% germination rate (Banda et al. 2006b). These results are troubling because models reveal that the species will be commercially extinct within a few years at current cutting rates (Schwartz et al. 2002). In addition, compensatory recruitment of trees of any species to replace logged trees is not occurring (Schwartz & Caro 2003). Thus, selective exploitation of *Pterocarpus angolensis* is not sustainable; furthermore, strict protection is not necessarily a solution for this species when ungulate browsing and human-caused fires are frequent.

Extractivism and large mammals

Hunting in Tanzania takes three forms – tourist trophy hunting, hunting with a license (resident hunting), and unlicensed hunting for meat (local hunting). Tourist and resident hunting that formerly occurred in the national park extension when it was a game controlled area had relatively little effect on the densities of most species of ungulate (Table 1), although tourist hunting may currently impact lion (*Panthera leo*) populations in the Katavi-Rukwa ecosystem (Kiffner 2006). Across Tanzania, game reserves that allow only tourist hunting exhibit large mammal populations similar to those in national parks (Caro et al. 1998b). Resident hunting quotas set for game controlled areas and open areas around Katavi National Park are reasonable given the size of ungulate populations (Caro 1999b), assuming they are adhered to in the field.

Exploitation from local hunting has a much larger effect on many mammal populations especially in open areas (Table 1), and increasingly through illegal incursions into the park itself (T.C., unpublished data). Under persistent conditions of food insecurity in Mpimbwe (Hadley et al. 2007), families have always supplemented their diet with fishing and hunting. In 2004, C. Hadley and M.B.M. (unpublished data) found that Pimbwe families were eating bushmeat 0.74 times/week, and Sukuma (who eat more domestic meat) ate bushmeat only 0.04 times/week (mean 0.39). Increased unlicensed hunting likely reflects both increased food insecurity contingent on a rapidly growing rural population and new opportunities for selling bushmeat to a growing middle class in urban areas (T.C., unpublished data).

Protected-area outreach

The principal form of outreach around Katavi National Park is TANAPA's Community Conservation Service, which supports small village projects, such as financing the construction

of a classroom or dispensary. Safari hunting companies, GTZ, and local politicians also contribute to such projects, with the result that many parties claim credit for bringing development that is technically the responsibility of the district government. What are the impacts of such protected-area outreach?

Holmes (2003a) interviewed 240 Pimbwe and Sukuma households, randomly selected from Kibaoni, Manga, and Mirumba villages about attitudes toward the park, perceived levels of TANAPA outreach, and type and extent of wildlife problems. Individuals who perceived TANAPA as providing active extension services held more positive attitudes toward the park than those who did not, a result independent of confounding socioeconomic and ethnic effects. Perceived number of visits of TANAPA personnel to the village was also associated with positive attitudes (as elsewhere in Tanzania; Newmark et al. 1993), although this result was not independent of ethnicity. Pimbwe, who live in villages and along the road, were more cognizant of TANAPA visits and less in favor of degazetting Katavi National Park. Unexpectedly, a family's experience with wildlife-related damage caused by elephants and bushpigs (*Potamochoerus porcus*) did not create negative views against the park. Despite indications that TANAPA outreach is not effective in northern Tanzania (Igoe 2003) our findings point to the importance of the Katavi National Park's Community Conservation Service and the need to target certain activities to the more-dispersed homesteads of the Sukuma. Unresolved, as yet, is the question of whether attitudinal change contingent on outreach is associated with behavioral change (Borgerhoff Mulder & Coppolillo 2005; Holmes 2005).

Community-based protected areas

In 1998 a local environmental community-based organization, MIMAKI (Kibaoni Ward Environmental Conservation Society), was set up by the local parliamentary representative. Although this organization was inactive for several years, in 2002 villagers began to explore its potential for protecting a 3-km buffer strip immediately south of the park for honey production, to attract Katavi National Park outreach, and to draw direct benefits from the limited tourist market to the park. This initiative occurred prior to outside funding becoming available and revealed environmental concerns among villagers themselves. With the support of the member of parliament, M.B.M., and O.A.M., MIMAKI initiated a community-based conservation scheme of honey production in the buffer zone, drawing technical support from a local beekeeping cooperative (GoldApis) and financial support from UN Development Programme and The Peoples of Mpimbwe Fund (Cultural Survival, Boston).

The MIMAKI was only partially successful. The initially strong and democratically elected leadership team was duplicitously replaced in early 2004 by a set of corrupt but well-connected individuals. By mid 2004, although a MIMAKI office and equipment store had been successfully built to budget, project-owned honey-making equipment and bicycles were privately sold off, and all other activities halted.

Community activists have now successfully transformed this ward-level initiative into a broader organization (MIMAMPI) for the whole of Mpimbwe. The MIMAMPI was registered in 2006, with the dual objectives of environmental conservation and community livelihood protection. Distributing authority among the multiple institutions of a division rather than a small ward can simultaneously both preserve the grassroots nature of an organization and provide greater institutional oversight and support (e.g., Barrett et al. 2001), at least if the benefits of a

broader base and more top-down scrutiny are not outweighed by additional risks of corruption. The larger scale of MIMAMPI compared with its predecessor will also extend much-needed buffer-zone protectionist activities along the hard boundaries between the park and open area within Mpimbwe Division (see below). To strengthen its law-enforcing responsibilities in the community protected areas MIMAMPI might ultimately be able to call on the *sungusungu*, a resilient Sukuma institution that regulates interpersonal behavior and punishes crime. Although this national-level vigilante institution has been misused in other parts of Tanzania, it is particularly robust, uncorrupted, and well-organized in Mpimbwe (Paciotti & Borgerhoff Mulder 2004), and could serve as a potential tool for advancing development and conservation needs.

Ecotourism

Ecotourism can be a useful tool for conservation if a sufficient cut of profits is equitably distributed among community members and not captured by local elites. Without such benefits, villagers are unlikely to respect the conservation measures that are ultimately responsible for drawing tourists – in this case intact forests, annual filling of floodplains, and populations of large mammals. Shares too must go to the appropriate government organizations that are responsible for enforcing such regulations. In Katavi National Park there are four high-end photographic tourist camps around seasonal lakes, and other tourist sites are planned (Ministry of Natural Resources and Tourism 2002). Tourists arrive by air, as do many of their supplies. As a result local communities and the district government receive no benefits, other than park fees paid directly to TANAPA.

Some ecotourist operators are increasingly keen to purchase local products and, more importantly, to involve villagers in tourist enterprises. One operator has worked directly with

MIMAMPI to build a day lodge in the buffer strip south of the park and to develop a honey museum and craft shop that tourists can visit. It also purchases local produce and is beginning to use local labor. This is cost-effective for the tourist company and perhaps increases market appeal. It also has the potential to enhance incomes for farmers and herders in the community, although researchers are monitoring local prices to ensure that the new market does not inflate food prices for villagers, a common negative impact of ecotourism. With possible decentralization in the control of wildlife and wildlife related businesses (discussed below), local communities should become more-active stakeholders in such ecotourist initiatives.

Integrated Conservation and Development Projects

The GTZ established the Katavi-Rukwa Conservation & Development (KRCD) Programme in 1998. It had a good opportunity to initiate large-scale integrated ICDPs in the Katavi-Rukwa ecosystem because, with substantial funding and a secure institutional basis, it could work directly with the national government, TANAPA, and the Wildlife Division.

The main thrust of activities was to build park infrastructure to support the extended national park. This included marking park boundaries, improving roads for antipoaching control, revitalizing airstrips, and censusing wildlife. Also important was the development of a comprehensive management plan (Ministry of Natural Resources and Tourism 2002) that sets out locations for tourist use areas, road networks, and ranger posts; it marks a productive and unprecedented level of cooperation among TANAPA and Wildlife Division in western Tanzania. The flagship of the ICDP was the construction of a new joint Katavi National Park and Rukwa Game Reserve headquarters. This has bolstered the effectiveness of poorly funded Wildlife Division personnel and established a new locus for antipoaching activities. Unfortunately, the

chosen location is extremely remote, making the whole plan unpopular among TANAPA staff; indeed the TANAPA board formally decided in 2006 not to move the headquarters to the new location. Whether a new headquarters will help control poaching is also uncertain because building new roads across wilderness areas generally jeopardizes conservation because it attracts wood cutting and poaching. At the close of the KRCD project, it is clear that the majority of effort was directed toward protectionism, park management, and capacity building, not community development, so integrated conservation and development never occurred.

Comanagement schemes

Comanagement, the sharing of power and responsibility between local resource users and government, offers a powerful management compromise that blends the strengths of state and communal regimes. Although devolution of natural resource management is no magic bullet to conservation (Agrawal & Gibson 1999), the challenge lies in finding an appropriate balance of centralized control and local initiative (Wyckoff-Baird et al. 2000).

At the national level GTZ was instrumental in revising wildlife policy to introduce a new land-use category, wildlife management areas (WMA), in which ownership and control over wildlife and other natural resources that occur on village lands is devolved to villagers (Baldus et al. 2004). The template for this policy comes principally from Zimbabwe, where CAMPFIRE programs were built on the legal rights of landowners (and custodians) to the wildlife.

Our monitoring of MIMAMPI's progress indicates that it is poised to become a WMA Authorized Association, a designation potentially appropriate for a region of Tanzania where most community members have fixed and not seasonally mobile homesteads. Indeed, unlike any of the pilot WMAs (Nelson 2006), MIMAMPI is already earning income, receiving grants, and

distributing monies to locally determined development and conservation initiatives. Furthermore, with legal rights over its land, it could operate as a stronger stakeholder in ecotouristic ventures, as observed in some cases in northern Tanzania (Igoe 2003). However, until there is genuine implementation of the currently stalled 1998 Wildlife Policy of Tanzania, the practical cooperation of the national government and local authorities characterized by the comanagement ideal remains elusive. With baseline research data on animal and plant populations we can monitor the effects of such legal changes, should they occur.

Citizen science

Researchers are in a strong position to encourage the new development of citizen science. Citizen science promotes the idea that knowledge is not confined to specialists, laboratories, or development programs (Irwin 1995). Motivated locals who start out as research assistants soon begin to shape research objectives, even methods. We have experienced this in Mpimbwe. Building on a workshop that we held in 1995 that was attended by TANAPA, Wildlife Division, and local government officials, we have tried to develop a tradition of citizen science.

Citizen science is being used to stimulate community interest in local history. Working with Mpimbwe elders, O.A.M., M.B.M., and T. Waters visited the sites of all the Pimbwe villages that existed prior to the 1927 village clearance campaign driven by British colonial interests. At each site we recorded the size of the settlement, GPS location, date of abandonment, vegetational and other evidence of human activity, and specifics of the settlements' histories, such as names of leaders and sites of religious significance. Invariably younger Pimbwe accompanied the expedition and learned about their history and connections to the land. This team has produced a map of the traditional chiefdom of Mpimbwe that is now available in each

of the 11 villages in Mpimbwe. Mapping stimulates awareness of the value, rights, and responsibilities associated with land, and promotes political awareness (Hodgson & Schroeder 2002), a sensibility that is complicated in places like the Rukwa Valley where there are many recent immigrants (see also Brockington 2001). This mapping initiative forms a bridge between local communities and TANAPA authorities and is leading to dialogue between the Sukuma and Pimbwe communities. Furthermore, in connection with community land use planning, members of MIMAMPI plan their own ecological monitoring of the effectiveness of their protected honey-production zone in attracting mammals and birds and affording regeneration of exploited tree species

Archeological investigations (directed by C. O'Brien in collaboration with the Antiquities Museum in Dar es Salaam) also entail citizen science. They focus on two sites, one in Kibaoni village and the other at the Maji Moto historical capital of Mpimbwe, where the royal lineage of the Pimbwe maintained a large defensive compound between the mid-nineteenth and early twentieth centuries. Bone fragments, pottery shards, pollen, and minor artifacts are collected and cataloged and lists are provided to the appropriate authorities in Tanzania. Analysis of the faunal and environmental data yielded by these sites will provide a long-term perspective on the nature of human-land interactions in the region, and provide educational material for villagers and school children.

Conservation education

Conservation education is an important tool in attaining wildlife habitat conservation but very little has occurred in our study area. The GTZ recognized the importance of conservation education, but focused primarily on district-level workshops, and capacity building among

professionals. Our ethnographic and attitudinal research indicates that the Sukuma, but not the Pimwbe lack, conservation awareness, and that both the Sukuma and the Pimwbe are economically constrained from adopting conservation practices (Holmes 2005). The community-based organization MIMAMPI aims to offer protection in buffer zones and achieve a reputation for improving aspects of local livelihoods before seeking to develop awareness of and solutions to environmental problems. When education becomes a priority, MIMAMPI will focus primarily on the Sukuma community. It will also target school children, with the aim of creating a new generation with heightened appreciation of the natural world and threats to it.

Implications of research for conservation practice in Katavi-Rukwa

Research plays an important role in shaping conservation practice in the Katavi-Rukwa ecosystem. Given the distinct effects of various sorts of protection on different aspects of biodiversity, conservation initiatives must occur at a landscape scale and conservation practices must be encouraged outside as well as within national parks and game reserves. Although this is not a new insight for conservation biologists, it has particular significance for Tanzania because most research occurs inside protected areas, and protected-area coverage is still expanding. Furthermore, use of large mammals as indicator species in areas such as Katavi-Rukwa can result in inappropriate recommendations for conserving less-charismatic species.

Timber extraction and unlicensed hunting currently occur at unsustainable levels, although trophy hunting generally appears sustainable. Timber extraction needs more governmental oversight. Unlicensed hunting inside Katavi National Park and Rukwa Game Reserve may be curbed through tighter policing and patrolling, whereas unlicenced hunting outside these protected areas could be restrained through devolution of power through the new

but currently stalled 1998 Wildlife Act that outlines WMA development. Buffer-zone land management should be brought under this new legal framework. Although devolution of power does not assure a positive conservation outcome for the Katavi-Rukwa ecosystem, with proper legal control over their village lands and natural resources, villagers will be better positioned to stem rapacious commercial enterprises based in urban centers and (often) sanctioned by corrupt mid-level government officials.

The community outreach program of TANAPA successfully influences the attitudes of villagers surrounding the park, although more for Pimbwe than Sukuma. Claims that TANAPA's community outreach program is ineffective in northern Tanzania cannot be generalized here. Community outreach can be guided by our findings that show that different sectors of the local communities need different forms of outreach – most Pimbwe families need food security, whereas most Sukuma families could benefit from conservation education.

Top-down attempts to combine ICDPs have not been effective. Whether this reflects funding constraints or a more fundamental incompatability of objectives is unclear. Decentralized initiatives that combine conservation and development through community-based organizations reveal the much-appreciated dangers of local-level corruption associated with devolution, as seen with MIMAKI. The decision to broaden the institutional basis of a community-based organization, specifically to create MIMAMPI, reflects a locally- conceived solution to the problem of corruption. Our recommendation is that MIMAMPI be carefully guided into becoming a WMA. Otherwise, villagers may become confused with a plethora of potentially competitive village-based institutions.

Ecotourism is a growing source of cash in the area, particularly with planned road development to the national grid. Although ecotourist and hunting operators appreciate the value

to their companies of providing stronger links (business or recreational) with local communities, such relationships are difficult to handle if the community does not have an authorized body to deal with the new demands and opportunities; again MIMAMPI should be encouraged to take this role.

Beneath these recommendations lurks a deeper question, pertinent to Katavi-Rukwa and to all of Tanzania. What is the mechanism whereby scientists' findings are incorporated into the development of contemporary conservation policy in Tanzania? There is a noticeable lack of institutional means at the district and national level for incorporating scientists' findings. For example, the annual TAWIRI conference is usually attended by only a few TANAPA and Wildlife Division officials, and scientists' views are not widely sought with respect to the ongoing debate over WMAs. Whether scientists' findings are heeded largely depends on extraneous considerations – such as personalities and nature of the findings. Fortuitously, because of generally transparent and productive relationships among scientists, nongovernmental organizations, TANAPA, and Wildlife Division personnel in Katavi-Rukwa, research findings have been shared informally, through impromptu workshops, exchange of drafts, and personal friendships. One solution to this problem might be establishing a more formal forum for discussing pressing issues in conservation within the country. Without such an institutional structure in place, scientists cannot be proactive and are limited to monitoring successes and failures of different conservation strategies.

Value of long-term research

We see four advantages to long-term research: longitudinal assessment of the ecological impacts of changing policies regarding land use; observation of the changing dynamics within

communities over a deteriorating natural resource base; acquisition of a balanced and impartial viewpoint on controversial issues; and the generation of local trust.

With respect to the effects of different levels of protection on species richness and abundance, protection in Tanzania was initially established in areas of hunting potential. Monitoring the effects of changing land-use patterns (e.g., the extension to the park and the establishment of a community-based protected area in Mpimbwe) over time, allows for difficult-to-obtain before and after comparisons. Long-term research also provides opportunities to document other poorly known taxonomic groups that TANAPA is mandated to protect. In this respect, long-term research allows rigorous monitoring, a component of conservation science that is still lacking (Agrawal & Redford 2006). We are accordingly in a position to determine through longitudinal study the impact of extending the park, of the community-based protected areas, and (if it occurs) of devolved wildlife management.

With respect to community dynamics, there has been increased wealth differentiation and an emergence of an effectively landless class (nonfarming Pimbwe) because of economic liberalization, retraction of local government services, interannual rainfall variation, and immigration. Our interdisciplinary research shows how these developments have had deleterious effects on family health, welfare, and labor allocation, driving an expansion of Sukuma farming into marginal areas adjacent to Katavi National Park through the use of Pimbwe labor. Long-term analyses show that the nature of inequities among heterogeneous communities in resource use and conservation potential can change over time (e.g., Agrawal & Gibson 1999). Such knowledge is critical to shaping conservation outreach. It is also key to finessing community-based institutions for the long-term management of local resources. For example, researchers brought observations gained from Mpimbwe and elsewhere on how shifting community

heterogeneity can undercut institutions for the management of natural resources to meetings at which MIMAMPI was designing its constitution. The result, after much brainstorming, was explicit provisions in the constitution to deal with these matters.

Long-term research programs encourage diverse forms of interrelated research: animal population monitoring, animal behavior, public health, evolutionary anthropology, demography, pastoral ecology, archaeology, and environmental history (e.g., Paciotti et al. 2005). Although not commonly acknowledged, it serves to "average out" personal viewpoints and expectations, guaranteeing a more objective and impartial form of monitoring, reporting, and recommendation. Accordingly researchers are not viewed locally as conservation biologists. We see this as a strength because our evaluations of conservation initiatives are considered nonpartisan, and our opinions and advice are sought locally on many issues. There is an additional benefit deriving from long-term interdisciplinary research – the inadvertent uncovering of information relevant to conservation. For example, we observed growing incidences of illegal hunting in a longitudinal survey of child growth patterns, the political significance of abandoned villages during a wildlife survey; and the emergence of an effectively landless class in a study of growth differentials between the different ethnic communities.

The most important outcome of long-term research is trust. A continued presence generates a sense of mutual confidence whereby researchers can serve as a liaison between different stakeholders – ecotourism operators, wildlife officials, politicians, government officials, farmers, herders, local business interests, even unlicensed hunters. Thus, researchers are in a position to facilitate projects on the ground by liaising between different parties, emphasizing links between conservation and development initiatives, advising in the pursuit of

funds, or providing practical, technical, and logistical services and training when they are needed.

Acknowledgements

We thank COSTECH, TAWIRI, TANAPA, and the Wildlife Division for permissions at the national level, Mr Qolli and Kitwara and their staff for support locally, and regional, district ward, and village officials for permissions and help at the local level. Our welcome at all levels has made research in Tanzania an unparalleled pleasure. We have had support from California State University Chico Faculty Research Grant, Friends of Conservation, Fulbright Foundation, Louis Leakey Foundation, National Geographic Society, National Science Foundation, Packard Foundation, and University of California at Davis. We thank Direct Relief International, Bush Hospital Foundation, Cultural Survival, Winters Rotary, the Nomad Trust and the Ultimate Travel Company for support of development projects in Rukwa region. We thank our collaborators, P. Abwalo, T. Banda, P. Coppolillo, T. Davenport, E. Fitzherbert, T. Gardner, C. Hadley, C. Holmes, P. Lalbhai, R. Lewison, F. Lyimo, C. O'Brien, B. Paciotti, A. Nyamora, M. Schwartz, and T. Waters. We are grateful to Mizengo, K.P. Pinda, R. Purcell of Nomad Safaris, and Katavi-Rukwa Conservation and Development project members (GTZ / ECO-AGEG) and especially to I. Games, H. Krishke, and B. Meyer. We also thank principal assistants B. Caro, C. Chumo, M. Evans, C. Garton, M. Kimisha, M. Moore, C. Middleton, L. Mwitwa, C. Natusch, J. O'Leary, A. Omari, J. Ponsiano, V. Sintala, M. Sungula, and O. Ulia. We thank P. Coppolillo, T. Gardner, C. O'Brien, M. Schwartz, S. Thirgood, and an anonymous reviewer for comments on the manuscript.

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Table 1. Mean densities per square kilometer of large mammals, people, livestock, and human activities measured over 14 months in four conservation areas in the Katavi ecosystem (Caro 1998b).[a]

Variable[b]	A NP	B GCA	C FR	D OA
Mammal biomass (kg/km^2)	22526	7106	152Ab	705ab
MAMMALS				
Elephant[b]	1.96	0.10a 0A	0a	
Hippopotamus[b]	5.15	0a 0a	0	
Giraffe[b]	2.17	1.78	0AB	0.55c
Buffalo[b]	21.15	12.30	0.05AB	0.03ab
Eland[b]	1.45	0.03a 0A	0a	
Roan antelope	0.19	0.04	0.13	0
Sable antelope	0	0	0	0
Burchell's zebra[b]	5.64	1.65	0Ab	1.33
Waterbuck[b]	4.28	0.58	0A	0a
Greater kudu	0.01	0.07	0	0
Hartebeest	0.35	1.30	1.04	0.08
Topi[b]	2.13	0.26	0A	0.05a
Bushpig[b]	0.07	0	0a	0
Warthog[b]	1.34	1.82	0Ab	0a
Reedbuck	0.39	0.26	0	0
Impala[b]	3.72	0a 0A	5.12bC	
Bushbuck	0.04	0	0.07	0
Small antelope[b,c]	0.06	0.91	0.35a	0.09
Lion[b]	0.07	0	0a	0

Spotted hyena[b]	0.19	0A	0A	0a			
Small carnivore[b,d]	0.04	0		0a	0		
Mongoose[e]	0.21	0.11		0.21		0	
Baboon	0.01	0.06		0.12		0	
Vervet monkey	0.47	0.06		0.05		0.24	
Small mammal[f]	0.01	0		0		0	
HUMAN PRESENCE							
Human[b]	0.01	1.33		1.52A	14.65Abc		
Livestock[b,g]	0	6.12		0		69.05AC	
Human activity[b,h]	0	0.03		1.92Ab	5.14Ab		

[a] Letter suffixes refer to significant differences between that column and earlier ones (as specified by the same letter at the top of the table) based on Mann-Whitney *U* tests; uppercase letters denote $p<0.01$, lowercase letters $p<0.05$. Mammals are arranged in order of descending body weight and taxonomic affiliation.

[b]Significant differences between ground transects comparing the national park (NP, $n=7$ transects/month);game controlled area (GCA, $n=4$); forest reserve (FR, $n=6$);open area (OA, $n=3$) based on a Kruskal-Wallis test.

[c] Bush duiker, klipspringer, oribi, and dik-dik combined.

[d] Leopard, wild dog, ratel, serval, and side-striped jackal combined.

[e] Banded, dwarf, black-tipped, and marsh mongoose combined.

[f] Hare and squirrel combined.

[g] Cow, goat, and donkey combined.

[h]Beehive, treecutter's camp, firewood pile, sawpit, grass pile, and pile of brocks combined.

Table 2. Mean values of measures of small mammal abundance and species richness inside Katavi National Park and outside in the open area to the south of the park (Caro 2002).

	1998 Aug-Sept dry season		1999 Feb wet season		2000 Jul-Oct dry season	
	in	out	in	out	in	out
Number of trap nights	1402	1704	1317	1722	2345	2380
Individuals/ 100 trap nights	0.7	15.8[a]	1.0	5.8[a]	0	3.0[b]
Species/ grid	0.6	1.9[a]	1.0	1.7	0.1	1.6[b]
Total number of species caught	3	7	5	6	1	8

[a] $p < 0.05$ with Mann-Whitney *U* tests.

[b] $p < 0.001$ with Mann-Whitney *U* tests.

Figure 1. Map of Katavi National Park (shown in light gray and bounded by a continuous line). Dark gray denotes floodplains; solid thin gray lines are roads; villages are shown as triangles; legally designated protected areas are shown in bold type. Katavi National Park is 150 km wide from west to east. Insert shows location in Tanzania

Figure 2. Size-class distribution of live and cut trees in the Msanginia Forest Reserve (MFR), where tree cutting isallowed and in Katavi National Park (KNP), where it is not allowed (from Schwartz et al. 2002).

Figure 1

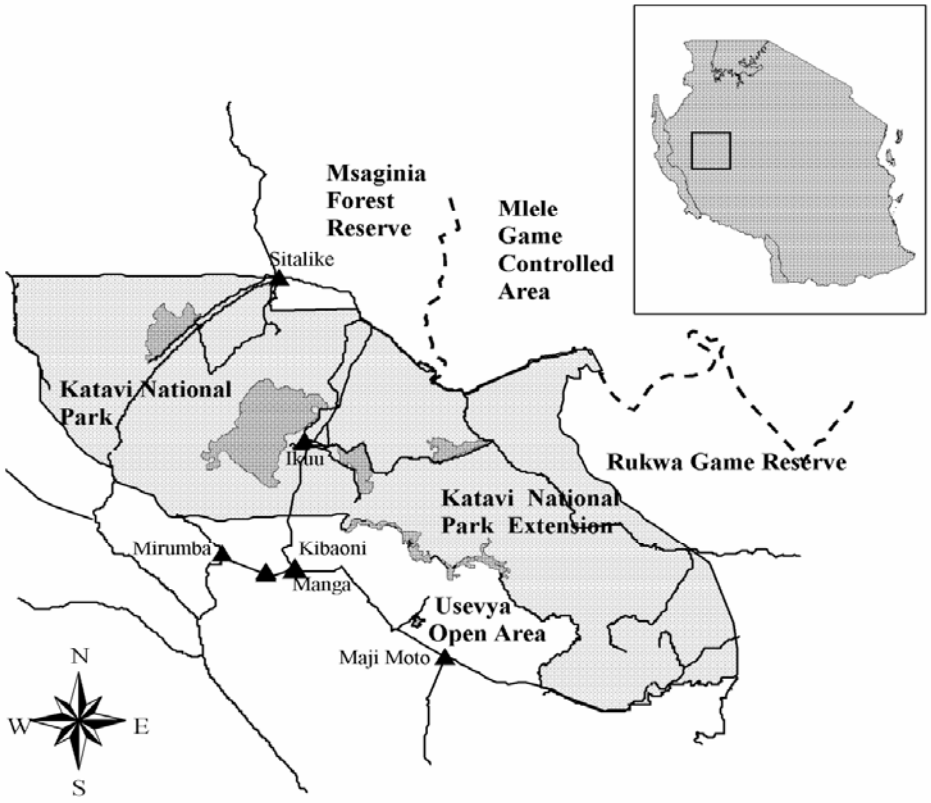
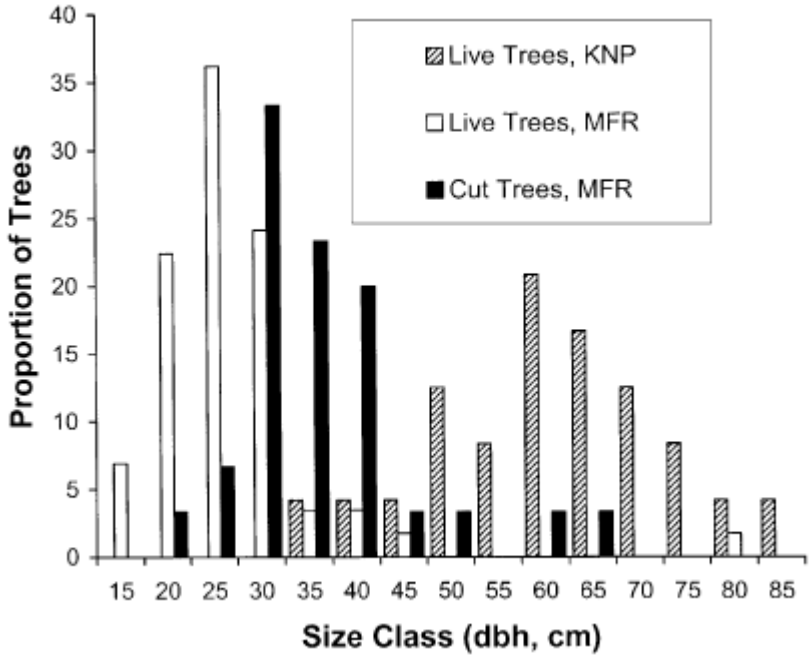

Msaginia
Forest
Reserve
Mlele
Game
Controlled
Area
Sitalike
Katavi National
Park
Ikuu
Rukwa Game Reserve
Katavi National
Park Extension
Mirumba
Kibaoni
Manga
Usevya
Open Area
Maji Moto
N
W
E
S

Figure 2


Live Trees, KNP
Live Trees, MFR
Cut Trees, MFR
Proportion of Trees
0
5
10
15
20
25
30
35
40
15 20 25 30 35 40 45 50 55 60 65 70 75 80 85
Size Class (dbh, cm)