**Online Resource**

**Title:** Supporting conservation with biodiversity research in sub-Saharan Africa's human-modified landscapes

**Journal:** Biodiversity and Conservation

**Authors:** Morgan J. Trimble[a] & Rudi J. van Aarde[b]

**Affiliation:** Conservation Ecology Research Unit, Department of Zoology & Entomology, University of Pretoria, Private Bag X20, Hatfield Pretoria 0028, South Africa

**Email:** [a] morgantrimble@gmail.com, [b] rjvaarde@zoology.up.ac.za

**Online Resource Table 1 Summary of studies investigating biodiversity of grazing landscapes in sub-Saharan African rangelands**

| Reference | Country | Habitat | Taxa | Land use variable | Control [a] | Biodiversity variable | Finding | Conclusion |
|---|---|---|---|---|---|---|---|---|
| (Bergström and Skarpe 1999) | Botswana | xeric shrubland | large herbivores | gradient of cattle density with distance to village | NA | abundance | large herbivores not found near villages; some species more sensitive than others | heavy cattle and goat grazing near villages probably excludes wild herbivores |
| (Blaum et al. 2007a) | South Africa | semiarid savanna | 5 rodent species | increasing levels of shrub encroachment as proxy for grazing intensity | NA | abundance, diversity, community composition | increasing shrub cover affects rodents differently | overall species richness decreased with increasing shrub cover |
| (Blaum et al. 2007b) | South Africa | semiarid savanna | 10 mammalian carnivores | increasing levels of shrub encroachment as proxy for grazing intensity | NA | abundance | species react disparately | intermediate shrub cover is best |
| (Blaum et al. 2009a) | South Africa | semiarid savanna | ground-dwelling arthropods | increasing levels of shrub encroachment as proxy for grazing intensity | NA | abundance, diversity, community composition | mixed results for different groups: abundance trends were mixed; richness showed bell-shaped pattern; composition definitely changes | can use some species for indicators of bush encroachment |
| (Blaum et al. 2009b) | South Africa | semiarid savanna | 12 small and medium mammalian carnivores | gradient of stocking rates with and without predator control | NA | abundance | abundance of all species lowest on farms with high stocking rate; predator control affected species differently | need to expand research and monitoring |
| (Colville et al. 2002) | South Africa | Succulent Karoo | monkey beetles | contrasting grazing histories | NA | abundance, richness, composition, plant turnover | higher abundance in disturbed sites generally but higher richness in undisturbed sites, with distinct assemblages at each site | monkey beetles useful indicators of overgrazing |
| (Davis et al. 2012) | South Africa | savanna | dung beetles | communal grazing | Kruger National Park | abundance, richness, biomass, structure | higher richness, abundance, and biomass in PA than communal grazing and different structure | higher mammal diversity in the PA allow for a more complex beetle community despite higher mammal density in the communal land |
| (Fabricius et al. 2003) | South Africa | xeric succulent thicket | terrestrial arthropods, reptiles | commercial and subsistence rangeland with varying grazing intensity | Great Fish River Reserve Complex | richness, community similarity | greater richness generally in nature reserve; snakes and lizards twice as abundant in communal grazing; locations generally housed 2/3's of total diversity | nature reserves important, but mixed land-use mosaic supports greater gamma diversity |
| (Georgiadis et al. 2007) | Kenya | savanna | large herbivores | commercial ranches, communal ranches, transitional properties | NA | density, trends | many herbivores can thrive when sharing with moderate livestock densities, but only few when livestock densities are high | maintaining high wild species diversity at landscape scale depends on network of unfenced areas with low or zero livestock densities |
| (Gregory et al. 2010) | Kenya | savanna | birds | traditional pastoral practices (i.e. burn patches, abandoned bomas) | undisturbed matrix | species richness, abundance, community | greater density of birds and unique species assemblages on burn and boma patches than undisturbed | disturbances caused by traditional pastoralism may be critical to maintaining avian diversity |

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| | | | | | | composition | control | |
| (Haarmeyer et al. 2010) | South Africa | Succulent Karoo | plants | different grazing intensities | farm with no grazing | abundance, species richness, composition, dynamics | endemic richness and abundance decreased with grazing, but grazed and ungrazed plots harbor unique species | no or moderate grazing necessary to preserve plant diversity and vegetation patterns |
| (Hejcmanová et al. 2010) | Senegal | savanna | plants | grazing and wood collection, 15 year fenced, 5 year fenced | NA | abundance, richness, % cover, functional diversity | shift towards woody species with time in sites where grazers excluded | enclosures may prove useful management strategy in degraded rangelands |
| (Hendricks et al. 2005) | South Africa | Succulent Karoo | plants | gradient of grazing intensity | little-grazed areas of Richtersveld National Park | species richness, cover | species richness and cover lowest at high intensity grazing | livestock in conservation areas may not be compatible with conservation goals |
| (Kinnaird and O'Brien 2012) | Kenya | savanna | large mammals | livestock management gradient | wildlife sanctuary with no livestock | occupancy, abundance, richness | fenced and group ranches had lower richness and occupancy than sanctuaries and conservancies | landowners need to be provided with incentives for tolerating wildlife |
| (Mayer et al. 2006) | South Africa | Succulent Karoo | monkey beetles | livestock grazing intensity (communal versus commercial) | NA | abundance, richness, composition | grazing intensity does not determine abundance and richness; composition varies | changes in vegetation affects composition of beetle assemblages; thus, grazing affects pollinator diversity |
| (Mohammed and Bekele 2010) | Ethiopia | savanna | plants | open hay-fields and grazed woodlands | NA | diversity, biomass production, range condition | higher diversity in wooded grazing land than open grassland, biomass production follows quadratic relationship with range condition | management of hay-fields may reduce diversity |
| (Morris et al. 2009) | Kenya | savanna | game birds | heavy grazing, seasonal grazing, abandoned grazing | wildlife sanctuary | abundance, richness, composition | doves most abundant in moderate grazing; francolin, spurfowl, and quail in sanctuary; abandoned landscape has highest richness | maintaining a mosaic of wildlife and livestock grazing with patches of ungrazed habitat will support diverse population of game birds |
| (Monadjem and Garcelon 2005) | Swaziland | savanna | 3 vulture species | government cattle ranches (no wildlife protection), cattle ranches (with protection for wildlife) | conservation areas | nest densities | nest densities highest in conservation areas, less on cattle ranches, and negligible on gov't ranches | vultures do not breed on intensive ranches although structurally, vegetation appears similar |
| (O'Connor et al. 2011) | South Africa | grassland | plants | grazing management (stocking rate, cattle-to-sheep ratio) | NA | abundance, richness, composition | mixed results for different trials and groups; increaser and decreaser species identified | trials suffer from lack of baseline data and limited replication |
| (Reid and Ellis 1995) | Kenya | arid savanna | 1 tree species | livestock corrals | non-corral sites | abundance of seeds and seedlings, size class of older trees | seedling emergence, growth, and survival better in corrals; older tree survival not significantly different outside corrals | contrary to popular belief, pastoralism may enhance recruitment of trees |
| (Rutherford and Powrie 2010) | South Africa | Succulent Karoo | plants | low and high grazing intensity | NA | % cover, richness, abundance | total number of species declines with heavy grazing while annuals and geophytes increase | beta diversity across disturbance regimes increases gamma diversity at a landscape level |
| (Rutherford and Powrie 2011) | South Africa | grassland | plants | heavy grazing | Tsolwana Nature Reserve | richness, diversity, composition | grazing led to higher richness at plot scale, but plots were more similar to each other | overall richness was similar between grazed and ungrazed |
| (Rutherford et al. 2012) | South Africa | savanna | plants, termites | grazing gradient | NA | abundance, | cover was reduced in high grazing | increased grazing in mopane savanna |

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| | | | | | | richness, composition, cover | but no difference in richness or diversity of plants or termites although composition changed | would result in different species assemblages and physiognomy |
| (Savadogo et al. 2008) | Burkina Faso | savanna-woodlands | herbaceous plants | grazing, fire, and selective tree cutting | undisturbed sites | abundance, richness | different groups respond differently | site-specific and group-specific responses require landscape approach |
| (Seymour and Dean 1999) | South Africa | Succulent Karoo | invertebrates | moderate and high intensity grazing | NA | abundance, richness, composition | abundance higher with high grazing but richness greater at moderately grazed sites | high abundances at severely degraded areas may compound effects of overgrazing |
| (Shackleton 2000) | South Africa | savanna | plants | communal grazing areas | PAs | abundance, richness, beta diversity | fewer plant species in PAs | communal land maintains high diversity, but more work should be done to ensure persistence |
| (Smart et al. 2005) | South Africa | savanna | lizards | communal rangelands | PAs | abundance, richness, vegetation | communal lands have different vegetation; lizard richness higher in communal lands, but different assemblage than in PAs | Species used by people may not persist beyond PAs |
| (Todd and Hoffman 2009) | South Africa | Succulent Karoo | plants | commercial and communal rangelands | NA | % cover, richness, community composition, dynamics | divergence of communities maintained despite vegetation changes in both land uses | longevity of shrub species prevent quick recovery from overgrazing in contrast to shorter lived grassland species |
| (Vaudo et al. 2012) | South Africa | thicket/savanna | bees | livestock grazing | game farms | colony density, colony strength | land with indigenous herbivores may have greater colony density but are not healthier | more research is needed to confirm patterns |
| (Wasiolka and Blaum 2011) | South Africa | xeric shrubland | plants, reptiles | livestock grazing | Kgalagadi Transfrontier Park | abundance, richness, composition, plant cover | plant and reptile richness and abundance higher in PA than farmland | livestock farming leads to significant changes in vegetation composition and resources for the reptile community |

[a] NA indicates no control; PA stands for protected area.

**Online Resource Table 2 Summary of studies investigating biodiversity of agricultural mosaic landscapes in sub-Saharan African rangelands**

| Reference | Country | Habitat | Taxa | Land use variable | Control [a] | Biodiversity variable | Finding | Conclusion |
|---|---|---|---|---|---|---|---|---|
| (Anadón et al. 2010) | Mauritania, Mali | savanna | raptors | settlement gradient, cultivation | grassland | abundance, richness, composition | richness relates positively to cultivation, but resident species relate negatively to human population | resident species may be negatively affected by habitat degradation |
| (Caro 1999) | Tanzania | savanna | large and medium mammals | gradient of human presence from seasonal pastoralism to permanent settlements and cultivation | Katavi National Park | densities, composition | densities higher in low intensity use; some mammals still occur seasonally in high intensity use | illegal hunting is the main cause of lower mammal densities |
| (Caro 2001) | Tanzania | savanna | small mammals | cultivation, pastures, settlements, little used areas | Katavi National Park | abundance, diversity, community composition | diversity and abundance greater outside than inside park | large mammals may not be effective umbrellas for small mammals |
| (Devineau et al. 2009) | Burkina Faso | savanna | plants | agricultural mosaic | PAs | abundance, richness, composition, species traits | effect depends on land type and plant group but generally favors widespread species outside PAs | plants are not sufficiently protected in the agricultural landscape, so PAs are necessary |
| (Eilu 2003) | Uganda | savanna | plants | cultivation, fallow, plantation | natural woodland/ grassland | abundance, richness, composition | natural habitats support highest diversity; banana crops and some annual crops supported substantial diversity | farmers should be advised how to maintain plant diversity in agricultural landscapes |
| (Fritz et al. 2003) | Zimbabwe | savanna | mammals | river segments bordered by fields of various sizes, settlements, and grazing | uninhabited river segments | abundance, richness | field area affects abundance and occurrence of species | agricultural mosaics affect most species but especially when fields are larger than 3.2 ha |
| (Gardiner et al. 2005) | Burkina Faso | savanna | butterflies | cultivation, fallow, grazing | 30-year fallow | abundance, richness, composition | no difference in richness; abundance highest in cultivation yet more even in fallow | changes in species groups relate to vegetation changes |
| (Gardner et al. 2007a) | Tanzania | savanna | small mammals, amphibians, birds, butterflies, trees | gradient of human presence from seasonal pastoralism to permanent settlements and cultivation | Katavi National Park | abundance, richness, composition | richness does not decline with land use gradient but composition in different management areas is distinct | PAs are crucial but human-modified landscapes can have vital and complementary conservation value |
| (Happold and Happold 1997) | Malawi | savanna | mammals | tobacco farm with mix of intense cultivation, remnant vegetation, plantations, fallow | NA | abundance, richness | 66% of species known to occur in region occur on the farm; large remnants are especially important | farms that contain remnants of natural vegetation can play an important role in mammal conservation |
| (Hoare and Du Toit 1999) | Zimbabwe | savanna | elephants | gradient of settlement and cultivation coverage | NA | density | elephant density declines with increasing human transformation | elephants coexist in human agricultural matrix up to a threshold of transformation |
| (Konecny et al. 2010) | Senegal | savanna | small mammals | cultivation, pastures, fallow | Niokolo Koba | abundance, richness, | diversity and abundance greater outside than inside the park | traditional agriculture may support species not found in less disturbed |

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| | | | | | National Park | composition | | locations |
| (Mapinduzi et al. 2003) | Tanzania | savanna | plants | pastoral settlement, agro-pastoral settlement | NA | richness, erosion risk | greater diversity and less erosion risk in pastoral than agro-pastoral settlements | traditional ecological knowledge provides a valuable basis for assessing rangeland biodiversity |
| (Moreira 2004) | South Africa | grassland | 4 bird species | cultivation, grazing, plantation, fallow | NA | occurrence | relationship between occurrence and land use differs by species | afforestation and agricultural intensification threaten bustard species |
| (Mworia et al. 2008) | Kenya | savanna | large mammals | small-scale ranches, small-scale farms, communal grazing | PAs | abundance, richness, composition | wildlife density peaks at intermediate cattle grazing; small-scale agriculture not an important factor | management must maintain heterogeneous landscape and maintain access to water |
| (Nacoulma et al. 2011) | Burkina Faso | savanna | plants | communal cultivation, fallows, remnants | W National Park | abundance, composition, structure, traits | elevation and soil determine vegetation type; traditional land-use does not necessarily lead to loss of species | combination of communal management and PAs best for conservation |
| (O'Connor 2005) | South Africa | grassland | plants | plantation, commercial and communal cultivation/pastures | protected grasslands | abundance, richness, composition | plantations have more indigenous species than other land-uses; no effect of grazing intensity on richness, only composition | conservation should focus on species only found on unprotected rangelands |
| (Ratcliffe and Crowe 2001) | South Africa | grassland | birds | farms with various compositions of cultivation and pastures | NA | abundance, richness | species characteristic of variegated landscapes are lost with intensive farming | population declines due to intensification of agriculture so re-creation of a habitat mosaic with lots of edge habitat necessary |
| (Reid et al. 1997) | Ethiopia | grassland/ woodlands | trees | small- and large- holder fields and pastures | riparian woodlands, wooded grasslands | abundance, diversity, cover | cover and diversity high in riparian woodlands, moderate in small-holder and wooded grasslands, and low in large-holder farms | small-holder farms may be compatible with conservation, but riparian woodlands are key |
| (Russell and Downs 2012) | South Africa | grassland | frogs | plantations, sugar cane | PAs | richness, diversity, composition | lower richness in plantations and cultivation | land use should be considered for frog conservation |
| (Soderstrom et al. 2003) | Burkina Faso | savanna | birds | cultivation, fallow, grazing | NA | abundance, richness, composition | richness highest on actively disturbed land and decreases with fallow age; many species only found on cultivated land | woody vegetation should include many different species, and large trees should be maintained |
| (Stoner et al. 2007) | Tanzania | savanna | larger mammals | gradient of resource use restrictions | PAs | population trends | declines common in all land use categories, but least common in strict PAs; species commonly fared poorly in unprotected landscapes | PAs may fail some species and more monitoring is necessary |
| (Tabuti 2007) | Uganda | savanna | 16 tree species | cultivation, fallow, homestead, seasonally flooded, Bush | NA | abundance, occurrence, population structure | most species rare, but few widespread; some not able to persist in some land-uses | growing human population threatens species persistence |
| (Thiollay 2006) | Burkina Faso | savanna | non-passerine birds | traditional cultivation and fallow | PAs | abundance, composition | some bird groups maintain substantial populations in cultivated areas, but raptors and large game birds mostly absent | hunting, habitat degradation, and grazing cause extinctions and declines of large birds |
| (Wessels et al. 2011) | South Africa | savanna | trees | communal pastures, cultivation | Kruger National | cover, height | more large trees in the communal areas but few small trees | large trees are probably protected by people, but regeneration may be |

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| | | | | | Park | | | problematic |

[a] NA indicates no control; PA stands for protected area.

**Online Resource Table 3 Summary of studies investigating biodiversity of cropping landscapes in sub-Saharan African rangelands**

| Reference | Country | Habitat | Taxa | Land use variable | Control [a] | Biodiversity variable | Finding | Conclusion |
|---|---|---|---|---|---|---|---|---|
| (Ayuke et al. 2011) | Malawi, Burkina Faso | savanna | termites & earthworms | management leading to high- and low-carbon soils | fallow | abundance, diversity | higher richness and abundance under field management that results in high-carbon; higher worm richness but not termite in fallow | management that increases soil carbon supports diversity |
| (Carvalheiro et al. 2010) | South Africa | savanna | pollinators | orchard | distance to natural habitat | abundance, richness | pollinators decline in abundance and richness with distance to natural habitat | need to make farmland more suitable for pollinators by maintaining remnants of natural habitat throughout |
| (Carvalheiro et al. 2011) | South Africa | savanna | plants & pollinators | sunflower fields differing in weed occurrence | distance to natural habitat | abundance, richness, composition | weed diversity increased pollinator diversity | natural habitat patches should be conserved and flowering plants maintained within fields to maximize productivity and conservation |
| (Fitzherbert et al. 2006) | Tanzania | savanna | butterflies | cultivation | areas with little human impact, e.g. Katavi National Park | abundance, richness, composition | abundance and richness low in cultivation | increased cultivation could reduce butterfly diversity |
| (Gardner et al. 2007b) | Tanzania | savanna | amphibians | cultivation | Katavi National Park | abundance, richness, composition | cultivation decreases diversity | transformation of miombo could threaten amphibian species |
| (Midega et al. 2008) | Kenya, South Africa | savanna | ground-dwelling spiders | monoculture maize, maize intercropped with 'push-pull' crops | NA | abundance, richness, composition | abundance higher in the intercrop; diversity not generally greater | 'push-pull' intercropping may provide valuable pest control in maize agro-ecosystems |
| (Mponela et al. 2010) | Malawi | savanna | plants | marginal land within cultivated landscape | marginal land in uncultivated landscape | abundance, richness, composition | fallow areas in cultivated landscapes were rich in disturbance tolerant species; uncultivated areas had high conservation value species | marginal land in uncultivated areas should be spared for conservation |
| (Pryke and Samways 2012) | South Africa | grassland | arthropods | plantations, grassland remnants | PAs | abundance, richness, composition | Interior of grassland remnant networks similar in arthropod assemblage to PAs | provided they are wide enough, grassland remnant ecological networks have conservation value in human-dominated landscapes |
| (Sinclair et al. 2002) | Tanzania | savanna | birds, insects | cultivation | PAs | abundance, richness, composition | bird abundance in agriculture much reduced; half of insectivorous and granivorous species not recorded in cultivation; consistent with drop in insect abundance | many species will become relegated to PAs unless restoration of cultivation is achieved |
| (Tchabi et al. 2008) | Benin | savanna | abuscular mycorrhizal fungi | cultivation | natural savanna, long fallow | density, richness, composition | spore density and species richness higher in natural savanna and yam cultivation, intermediate in fallow, and low in cotton | agricultural practices decrease richness; it is not quickly restored by fallow which could harm soil fertility |

[a] NA indicates no control; PA stands for protected area.

**Online Resource Table 4 Summary of studies investigating biodiversity of agroforestry landscapes in sub-Saharan African rangelands**

| Reference | Country | Habitat | Taxa | Land use variable | Control [a] | Biodiversity variable | Finding | Conclusion |
|---|---|---|---|---|---|---|---|---|
| (Augusseau et al. 2006) | Burkina Faso | savanna | trees | fallows, cultivation | NA | density, size, richness, composition | farmers modify species diversity towards dominance of a few useful species | new techniques in agroforestry management are needed to encourage tree conservation |
| (Bayala et al. 2011) | Burkina Faso | savanna | trees | home, village, and bush parklands | NA | abundance, richness, size, composition | diversity was related to farming system and many species were rare | domestication and conservation strategy are key to maintaining parklands and threatened species |
| (Djossa et al. 2008) | Benin | savanna | 1 tree species | fallow, cropland, villages | W National Park | abundance, size | regeneration problem in crops, villages, and fallows | baobabs can withstand harvesting of NTFPs, but future intensification may lead to problems |
| (Fandohan et al. 2010) | Benin | savanna | 1 tree species | farmlands, fallow | gallery forest | abundance, size | trees less common in farmland and fallow and more vulnerable | introduction of seedlings to farmlands may be necessary |
| (Fifanou et al. 2011) | Benin | savanna | trees | farms of different size | NA | abundance, richness, composition | small land holdings had higher richness; people plant trees for food and medicine | traditional agroforestry supports tree species richness |
| (Kindt et al. 2008) | Burkina Faso, Mali, Niger, Senegal | savanna | trees | village fields, bush fields, sylvo-pastoral zone | forest reserves | abundance, size, richness, composition | low richness in village fields, intermediate in bush fields and sylvo-pastoral zone, highest in forest reserves | projects to encourage farmer assisted maintenance and regeneration of trees may be necessary |
| (Ouinsavi and Sokpon 2008) | Benin | savanna | trees | farms | NA | richness, abundance, regeneration | density and composition depend on socioeconomic and environmental factors | more evenness should be promoted in farmlands by encouraging management of rarer species |
| (Pote et al. 2006) | South Africa | savanna | 1 tree species | fields, villages | plains and rock outcrops | abundance, size | villages and fields have low recruitment | population is stable due to low mortality, but seedlings are not well protected in human-modified areas |
| (Raebild et al. 2007) | Burkina Faso | savanna | trees | fallows, cultivation, plantations | gallery forest | density, size, richness, composition | richness highest in fallow; regeneration low in parklands | fallow important for keeping tree diversity |
| (Schreckenberg 1999) | Benin | savanna | trees | cultivation, fallow, bush | gallery forest | abundance, size, composition | many trees valuable to people are maintained in fields and fallows | changes in the agricultural system may result in declining importance of valuable species and incentive to maintain them |
| (Schumann et al. 2011) | Burkina Faso | savanna | 1 tree species | fallows, crops | W National Park | harvest intensity, abundance, sprouting | healthy stands in fallows and park but no saplings in croplands | stands are well preserved despite harvest due to life history traits |
| (Venter and Witkowski 2010) | Benin | savanna | 1 tree species | farmland | NA | abundance, size | largest individuals found in farmed land but juvenile recruitment low | sporadic recruitment probably enough to maintain population due to low mortality |

[a] NA indicates no control; PA stands for protected area.

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