HUMANS AND ELEPHANTS ALTER VEGETATION STRUCTURE IN SAVANNA WOODLANDS

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Humans are an integral and ancient part of savanna structure and function. Up to a third of the global human population resides in savannas, forming the majority of the global agropastoralism. This growing land-use pressure in savannas is bound to alter savanna vegetation structure as humans mediate woody cover. This occurs directly through removal of wood for building materials and wood fuel, and indirectly, through altering fire regimes.

In this respect, humans are similar to another iconic savanna change agent, the African elephant. Elephants alter woody structure in savannas through breaking branches and pushing trees over. But elephants also have a synergistic relationship with fire on tree mortality in savannas. Trees that have been damaged by elephants (e.g. by gouging trees or bark stripping) that are subsequently exposed to fire are more likely to die and topple over than undamaged trees. Elephant effects on tree mortality and the changes they create to savanna structure have been the focus of much research. Yet far less work has been done on the effects of humans as “functional megaherbivores” on savanna woody cover.

In most of Africa, elephants and humans co-exist, making drivers of treefall unclear. But here in South Africa, elephants are fenced creating a macroscale experimental opportunity to look at vegetation dynamics in the presence and absence of two major disturbance agents in savannas, humans and elephants.

To measure change in treefall dynamics over landscapes, our research collaboration (University of the Witwatersrand (WITS), the Council for Scientific and Industrial Research (CSIR), the Global Change and Sustainability Research Institute (GCSRI), and the Carnegie Institution for Science) used airborne laser scanning technology collected by the Carnegie Airborne Observatory (CAO: https://cao.carnegiescience.edu/). This remote sensing technique generates incredibly high resolution three-dimensional models of vegetation (Figure A).

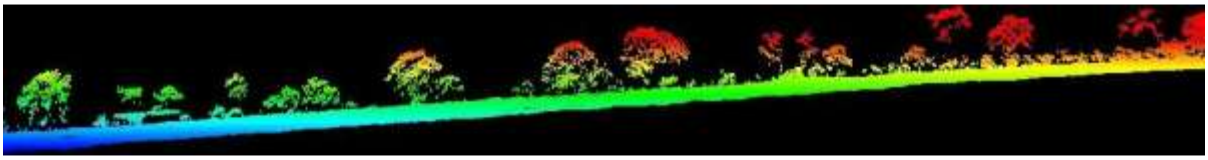

Figure A: High resolution, three-dimensional data for savanna woodlands from airborne laser scanning.

The CAO flew field campaigns in 2010 and 2012 over portions of the South African Lowveld. We used data from four sites: Andover Nature Reserve (Reserve$_0$), Sabi Sand Wildtuin (Reserve$_e$), Justicia communal land (Communal land$_A$) and Welverdiend communal land (Communal land$_B$) (Figure B). Reserve$_0$ was fenced off from both humans and elephants, Reserve$_e$ contained elephants but no humans, and the Communal lands contained humans but not elephants. Communal land$_B$ had higher human population pressure on their communal land than Communal land$_A$, allowing us to examine the effects over a usage gradient. Previous research had described elephants as the dominant agent in treefall and demonstrated further that treefall rate is strongly related to elephant density but mediated spatio-temporally by the abiotic template. We wondered if human-mediated vegetation dynamics were similarly affected by geology and fire and whether intensity of communal land use was evident in treefall rates and patterns.

We monitored over 450 000 geotagged trees over 6'812 ha between 2010 and 2012, and if the maximum height across the canopy decreased by 75% or more, it was classified as 'treefall'.

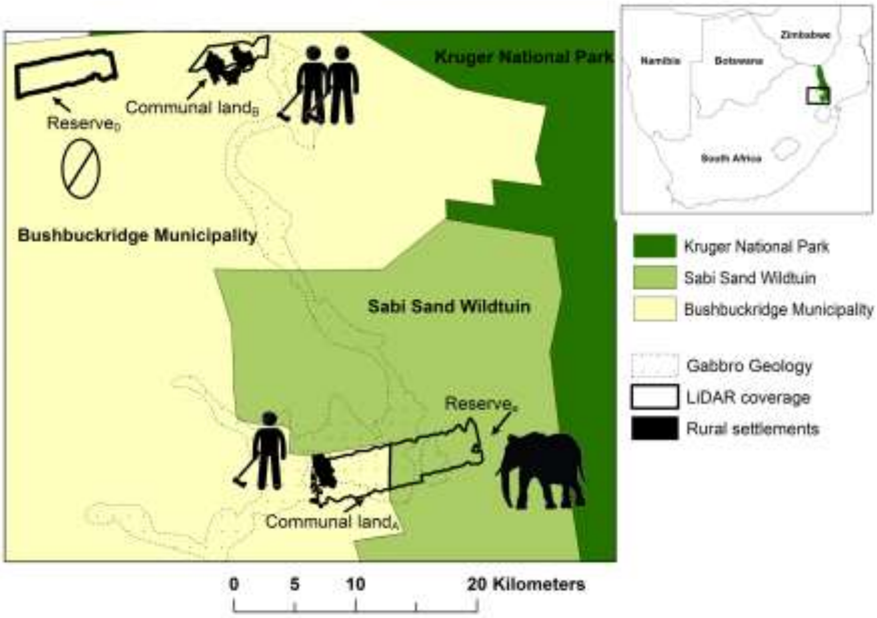

Figure B: Comparing the locations of the four surveyed areas, monitored in 2010 and 2012. The inset map shows the location of the Sabi Sand Wildtuin and Bushbuckridge Municipality in South Africa's north-east corner.

Human-mediated biennial treefall rates were 2 – 3.5 times greater than the control site (Reserve$_0$: 1.5% treefall ha^{-1}), while elephant-mediated treefall was 5 times higher (7.6% treefall ha^{-1}) than the control site (Figure C). However, patterns of human and elephant effects on treefall were spatially variable with elephant effects concentrated around surface water and on nutrient rich soils (Figure D). Treefall events in human-mediated areas were related to perceived ease of access to wood harvesting areas, as well as settlement-associated expansion - or on communal land boundaries to reinforce land ownership under perceived land claim threats (Figure D). Both humans and elephants utilise all height classes of trees.

Fire frequency was important in both elephant- and human-mediated landscapes and interactively increased treefall occurrences. However, treefall cannot be equated with tree mortality as many savanna species will resprout, demonstrating vegetation resilience in response to disturbance events.

We also demonstrate that concerns about elephant-related shrubland conversion and the subsequent effects on biodiversity and ecosystem function are just as applicable in human landscapes. Loss of large trees coupled with low seedling recruitment, interactive effects with fire and continued herbivore browsing or wood harvesting are precursors to woodland decline with implications for natural resource use sustainability and ecosystem function.

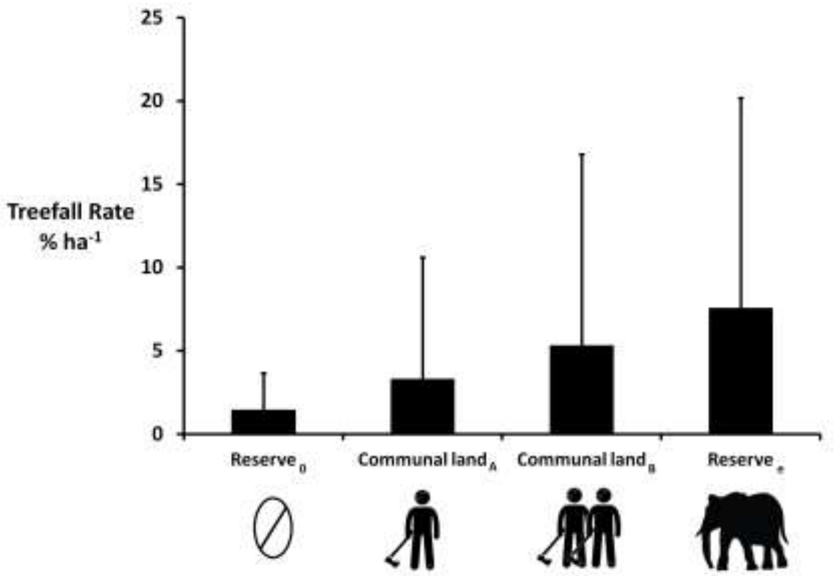

Figure C: Comparing biennial treefall rates (% ha^{-1}) ± standard deviation over: Reserve$_0$, a nature reserve containing neither elephants nor humans; Communal land$_A$, a moderately utilised communal land; Communal land$_B$, a heavily utilised communal land; and Reserve$_e$, a private reserve containing elephants.

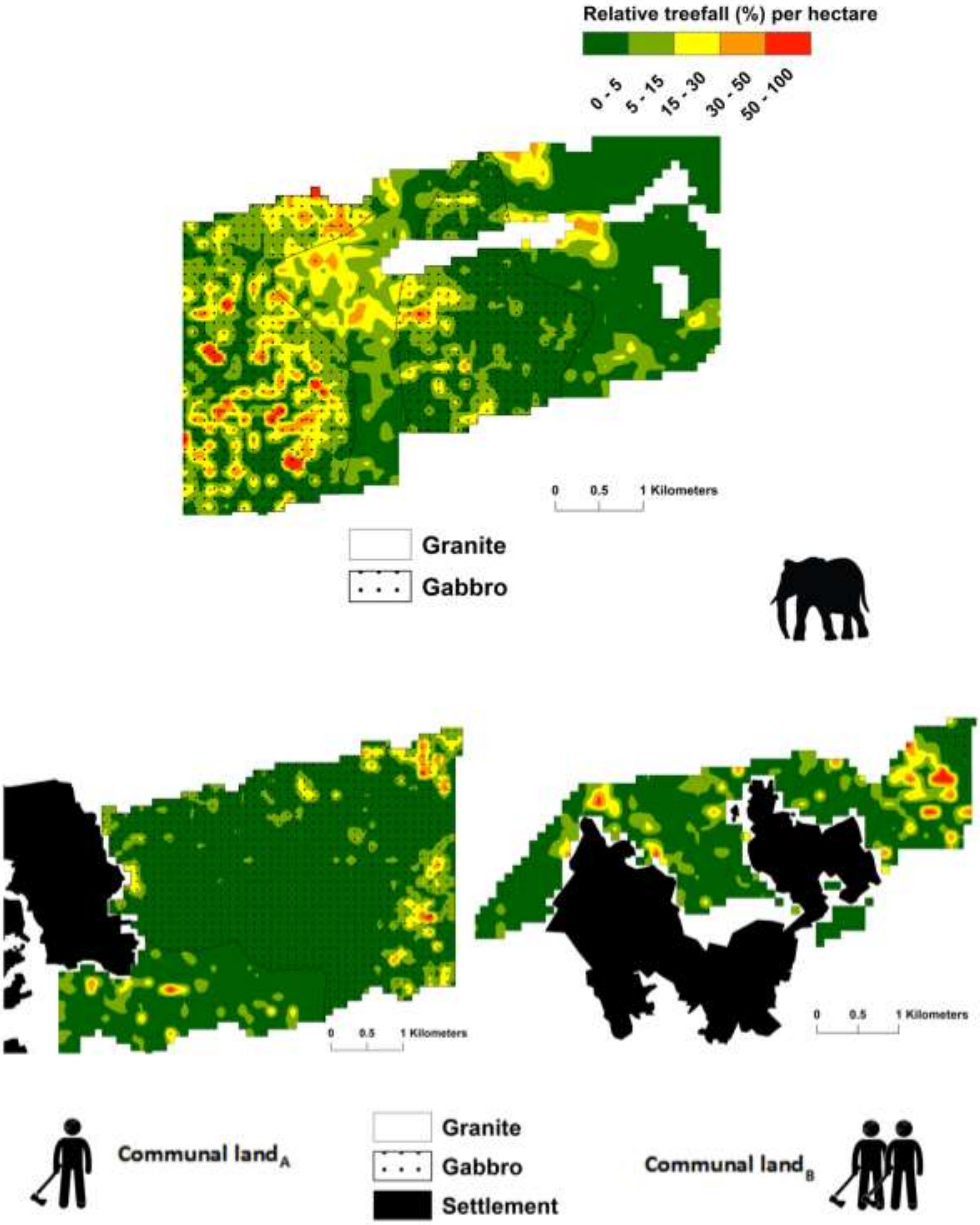

Figure D: Relative biennial treefall rates (treefall % ha^{-1}) between 2010 and 2012 for elephant- and human-mediated landscapes.