Climate change complexity: repeat landscape photographs of the Pro-Namib and Namib Desert

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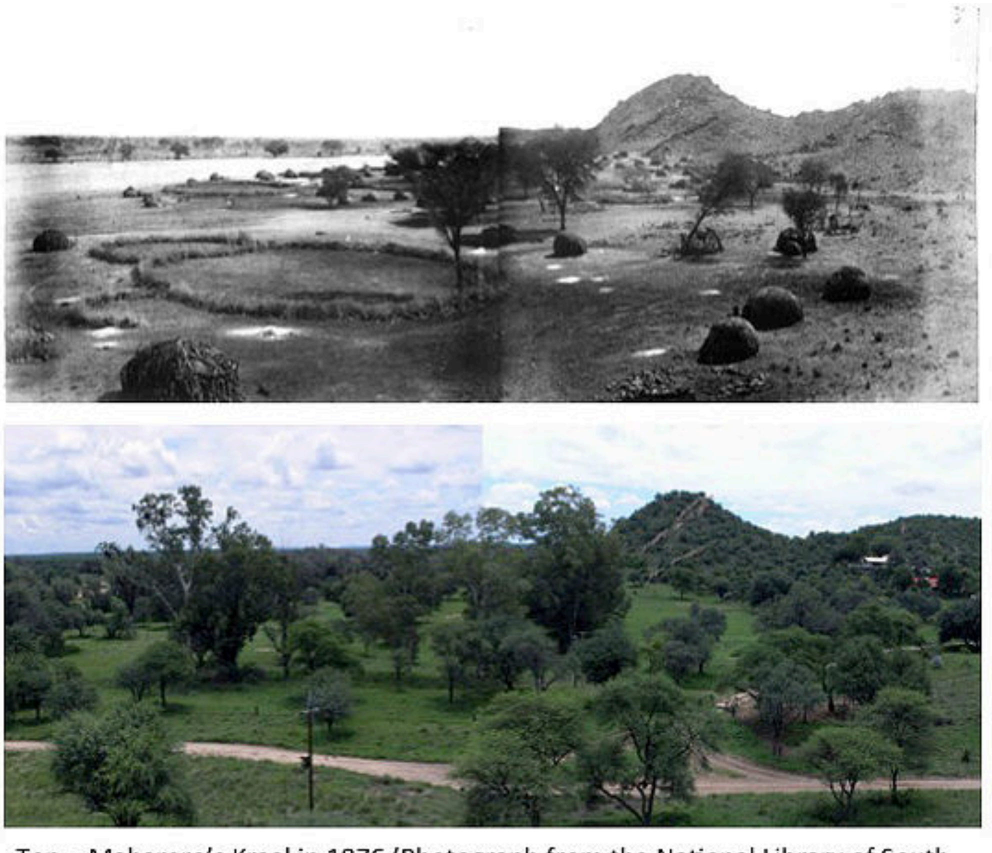
Rick Rohde, Timm Hoffman, Sam Jack and Sian Sullivan

The above composite image illustrates a key method we are drawing on in *Future Pasts* for exploring environmental change in west Namibia. This photograph depicts the Mirabeb rocky outcrop in Namib-Naukluft Park at three different times. The first view (the small black and white photo) is a still from the film *2001: A Space Odyssey* in which director Stanley Kubrick used Mirabeb for some of the opening scenes. The film's still photographer, John Jay, took this shot here in 1965. This image was then matched in 1995 with a retake (the image on the clip board) by University of Cape Town geomorphologist Frank Eckardt; followed by a third retake in 2015 by Rick Rohde and Timm Hoffman.

The *Future Pasts* research project draws on repeat landscape photography to explore and juxtapose different cultural and scientific understandings of environmental change and sustainability in west Namibia. Change in the landscape ecology of western and central Namibia over the last 140 years has been investigated based on archival landscape photographs that have been located and re-photographed or 'matched' with recent photographs.

This part of our project builds on a large dataset of images brought together since the 1990s by Rick Rohde and University of Cape Town ecologist Timm Hoffman. Each set of matched images for a site provides a powerful visual statement of change and/or stability that can assist with understanding present circumstances at specific places. They help us to contextualise projected and predicted environmental futures.

At times, the images tell us something about settlement patterns and the lasting impact of historical episodes in the past. Given the dramatic events that have shaped the present socio-economic landscape of west Namibia – which over the last 150 years have included the establishment of colonial enterprise, a genocidal colonial war, seven decades of apartheid rule, and the ushering in of broadly neoliberal policies since independence in 1990 – it is not surprising that traces of past impacts are inscribed on the landscape. These traces create layered landscape 'palimpsests' in which past influences can be read and deciphered in the present.



Top = Maharero's Kraal in 1876 (Photograph from the National Library of South Africa, WC Palgrave Album. ALBX 5, i.e. 'Palgrave collection'); Bottom = Okahandja suburb in 2009 (Photo – R. Rohde & M.T. Hoffman).

In the top image above, for example, we see the kraal of Maherero, the first Paramount Chief of the OvaHerero who controlled Central Namibia prior to German colonization in the 1880s. The image was taken by a photographer who accompanied British colonial magistrate W.C. Palgrave as he travelled from Cape Town to central Namibia in the 1870s. What was then a pastoral scene of grassland savanna with umbrella acacias (*Acacia tortilis*) providing some shade for mud dwellings and animals, is now a cluster of 21st century German houses built like Bavarian castles on high square stone or concrete plinths, surrounded by electric fences and barbed wire (see houses to the right of bottom image). The vegetation changes are astonishing. Where once there was an open, wide sandy river bordering the receding Namibian grasslands (to the left of top image), now there is hardly an opening in the thornveld canopy. Some of the riverine *Fairherbia albida* trees in the bottom image are now gigantic – like old grandparents care-worn and haggard surrounded by a new generation of hungry dependants. The lush flowering grasses in the bottom image are breast-high in some places.

Assessing climage change

In order to assess the impacts of climate change in west Namibian landscapes *Future Pasts* research is extending a dataset of repeat landscape images compiled over the past 25 years by Rick Rohde. This dataset now consists of over 170 sites in western and central Namibia. One hundred of these sites are located in the western Pro-Namib and Namib Desert landscapes, and it is these sites that we focus on in this post. These arid and hyper-arid areas have been less impacted by human development and historical events than many of the more mesic parts of Namibia. For each site an archival image has been located exactly, re-photographed, and matched as shown in the pair of images above.

Doing repeat photography. M.T. Hoffman and R. Rohde near Gungachoab in the Namib, 2016 (photo: T. Wassenaar).

One focus of our project thus asks: how can repeat landscape photographs help us to understand environmental change, the construction of environmental pasts, and the visioning of environmental futures? In this post we share some preliminary findings of this aspect of *Future Pasts* research.

Some of the western Pro-Namib and Namib Desert landscapes sites noted above comprise two or more landform or vegetation 'units'[1], which thereby takes our dataset up to 124 units amalgamated into 4 main vegetation types, as shown in the Table below.

Class	Amalgamated vegetation types	sample size (n=124)
1a	Azonal Dunes	10
1b	Azonal Large Ephemeral Rivers	26
2	Fogbelt Shrublands	17
3	Grasslands & Rocky Shrublands	32
4	Savanna & Savanna Transition	39

Each site was surveyed using standard ecological monitoring techniques, and then analysed for changes in four vegetation growth forms: grass, succulent shrubs, shrubs and trees. Two components of the dataset have been left out of the subsequent quantitative analysis, as follows:

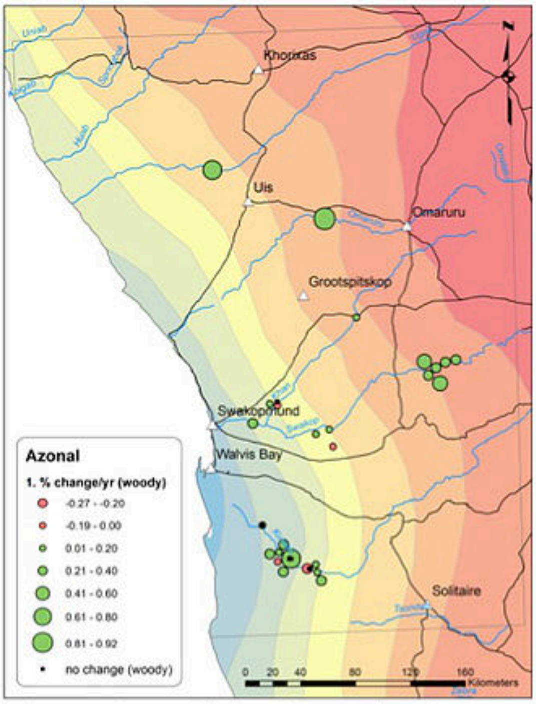
1. Grasses, because their presence is so highly dependent on the unpredictably varying rainfall of the region. This means that it is very difficult to ascertain trends over time in the presence or absence of grasses – many a researcher has observed a complete lack of grasses and assumed apocalyptic vegetation decline, only to have to completely revise this narrative in the face of significant grass growth following a year of above-average rain;

2. The 10 sites located in 'Azonal' (i.e. not restricted to any single climate zone) Dunes are all located along the Kuiseb River and exhibit the same pattern – namely a large increase in dune grass (*Stipagrostis sabulicola*). This pattern is shown in the images below and is probably due to high Namib rainfall subsequent to 2009.

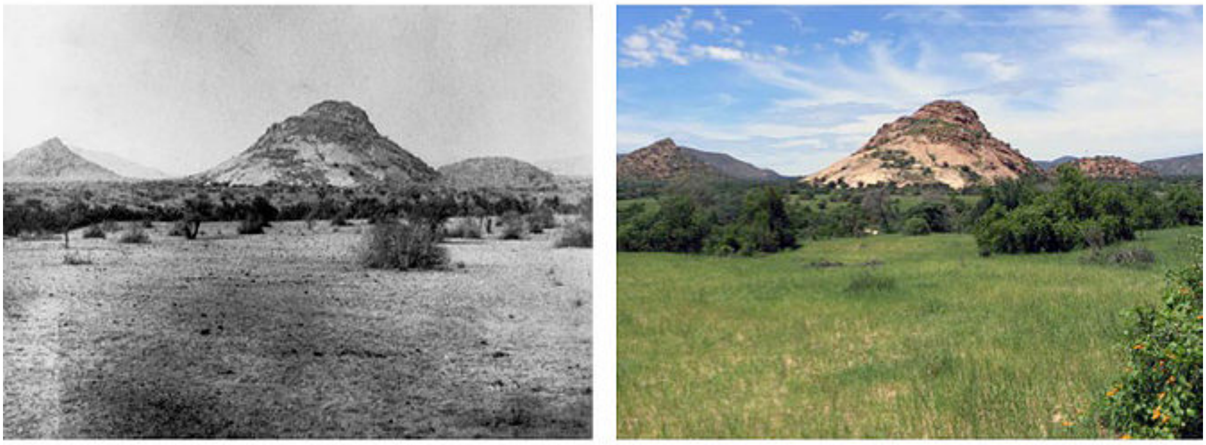
Azonal Dunes from Gobabeb looking east across the Kuiseb River. Left = 1963 (Photographer unknown). Right = 2015 (photo: R. Rohde)

The repeat photograph sites in the remaining four vegetation types – 1. Large Ephemeral Rivers, 2. Fogbelt, 3. Grasslands and Shrublands, 4. Savanna – are illustrated in the four maps below and accompanying images. These maps and images show changes in cover through time for each site falling within each of the four vegetation types identified above. The larger the green circles on the maps, the greater the increase in vegetation observed through time, as indicated by the repeat photographs. Red circles on the maps indicate that there has been a decline in amount of vegetation. The underlying map in each image is based on the Atlas of Namibia (2002)[2] number of fog days in the western land areas close to the Atlantic coastline per year.

1. Large Ephemeral Rivers:

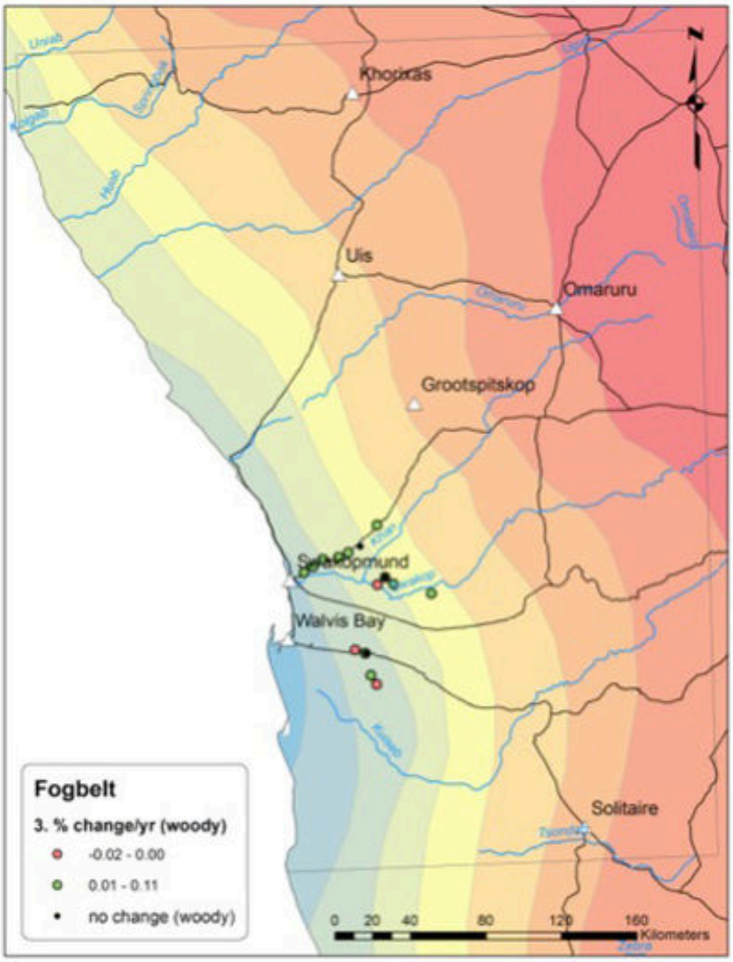


The Azonal Large Ephemeral Rivers show large increases in woody vegetation across virtually all of our repeat photograph sites.

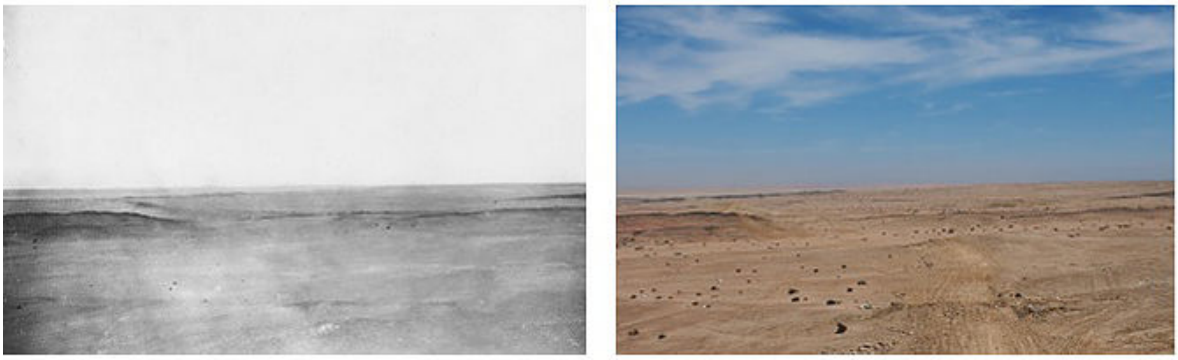


Azonal Swakop River upstream from Otjimbingwe. Left = 1876 (Palgrave Collection, see above). Right = 2015 (R. Rohde).

2. *Fogbelt:*

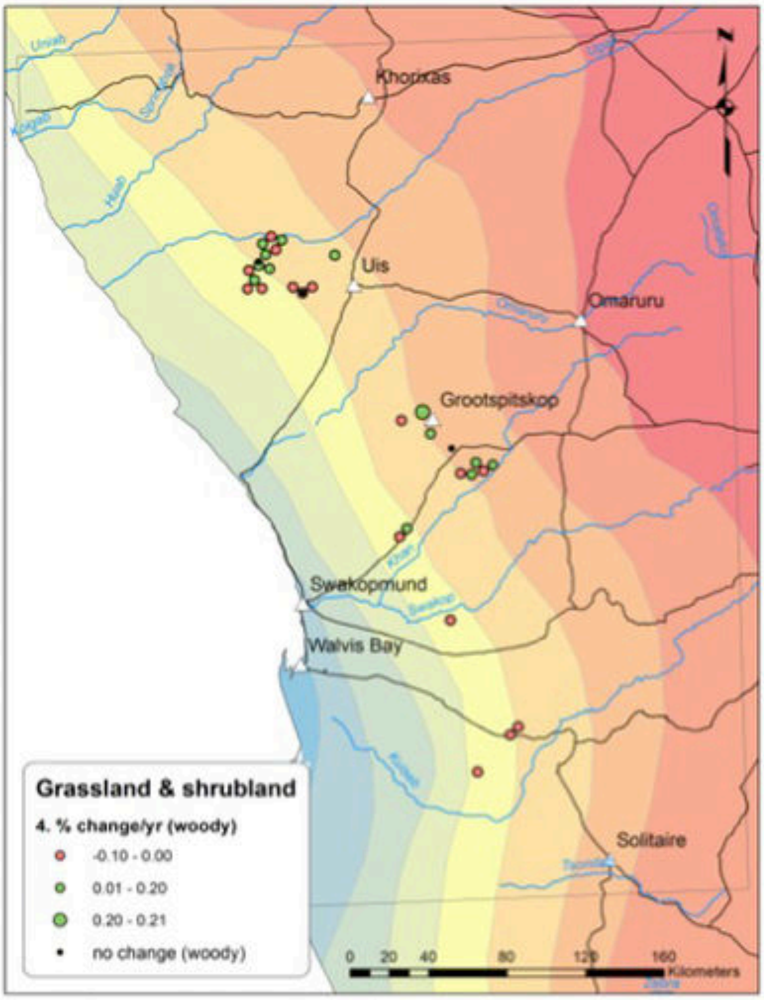


14 of 17 Fogbelt sites show an increase in woody vegetation.

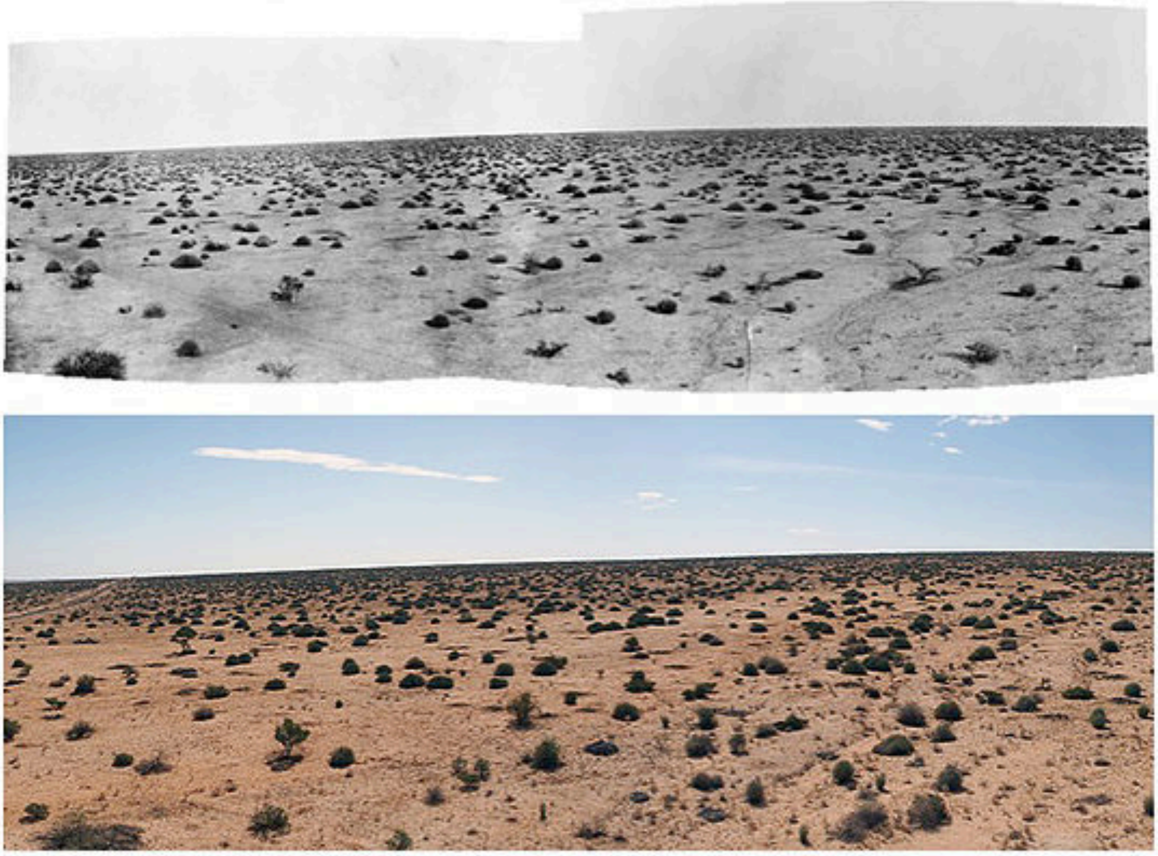


Nonidas, Fogbelt - 9 km from coast. Fog dependent plants have increased 10-fold. Top = 1919 (Pole-Evans). Bottom = 2016 (R. Rohde & M.T. Hoffman)

3. Grasslands and shrublands

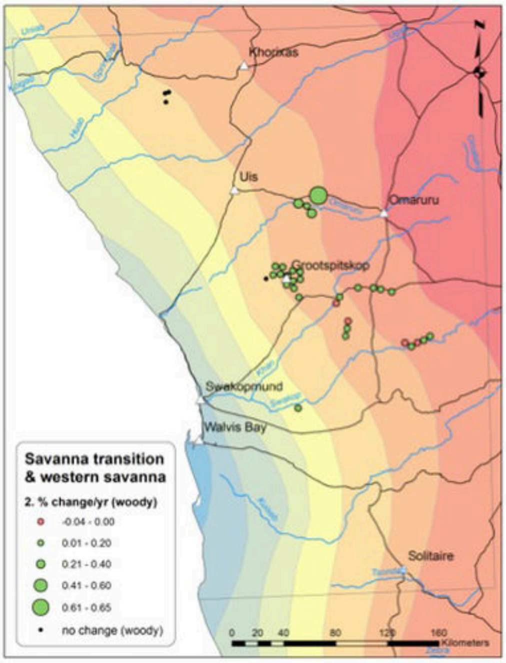


16 of the 32 Grass/Shrubland sites show a decrease in vegetation cover; 13 sites show an increase in cover; 3 show no change.

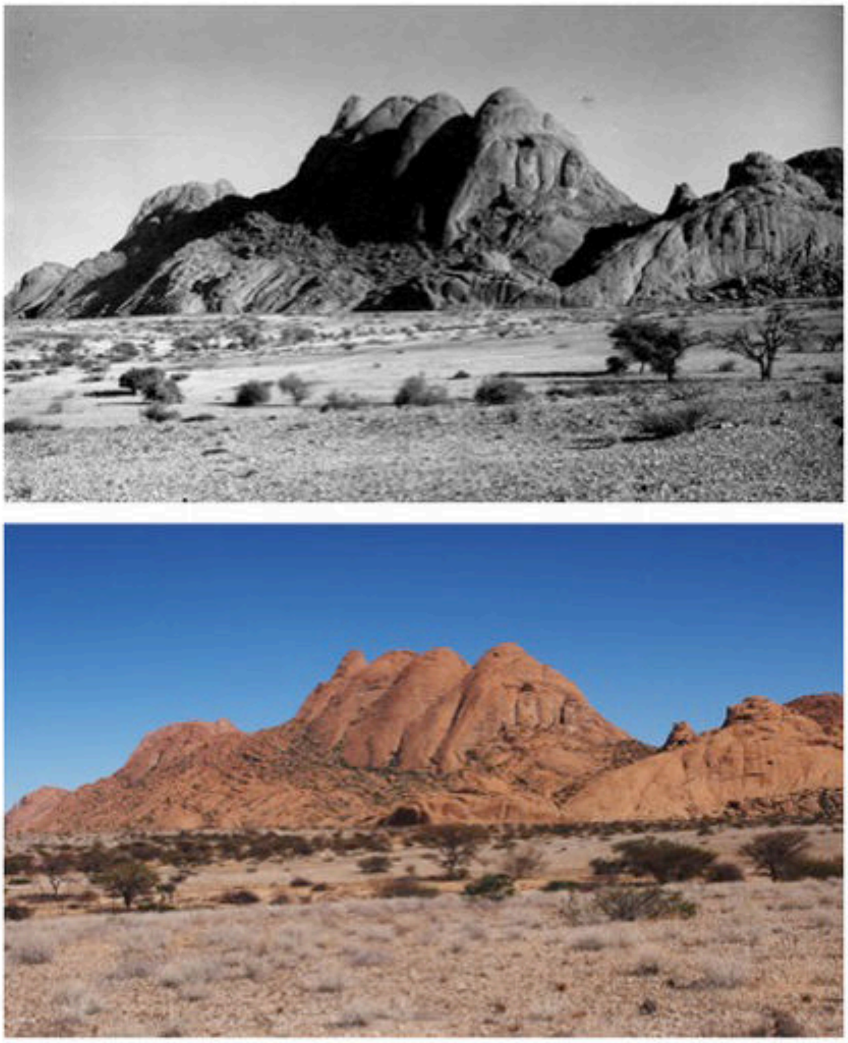


Grassland/ Shrubland at Aukas, panorama looking north. Very little change apart from a slight increase in non-succulent shrubs and a decrease in succulents (*Euphorbia damarana*). Top = 1919 (Pole-Evans). Bottom = 2016 (R. Rohde & M.T. Hoffman)

4. Savanna



Most of the Savanna Transition sites show an increase in woody vegetation with only 4 of the 39 sites showing a decrease.



Savanna Transition – Spitzkoppe showing a significant increase in shrubs and trees. Top = 1920 (photographer unknown). Bottom = 2016 (R. Rohde).

Reflections

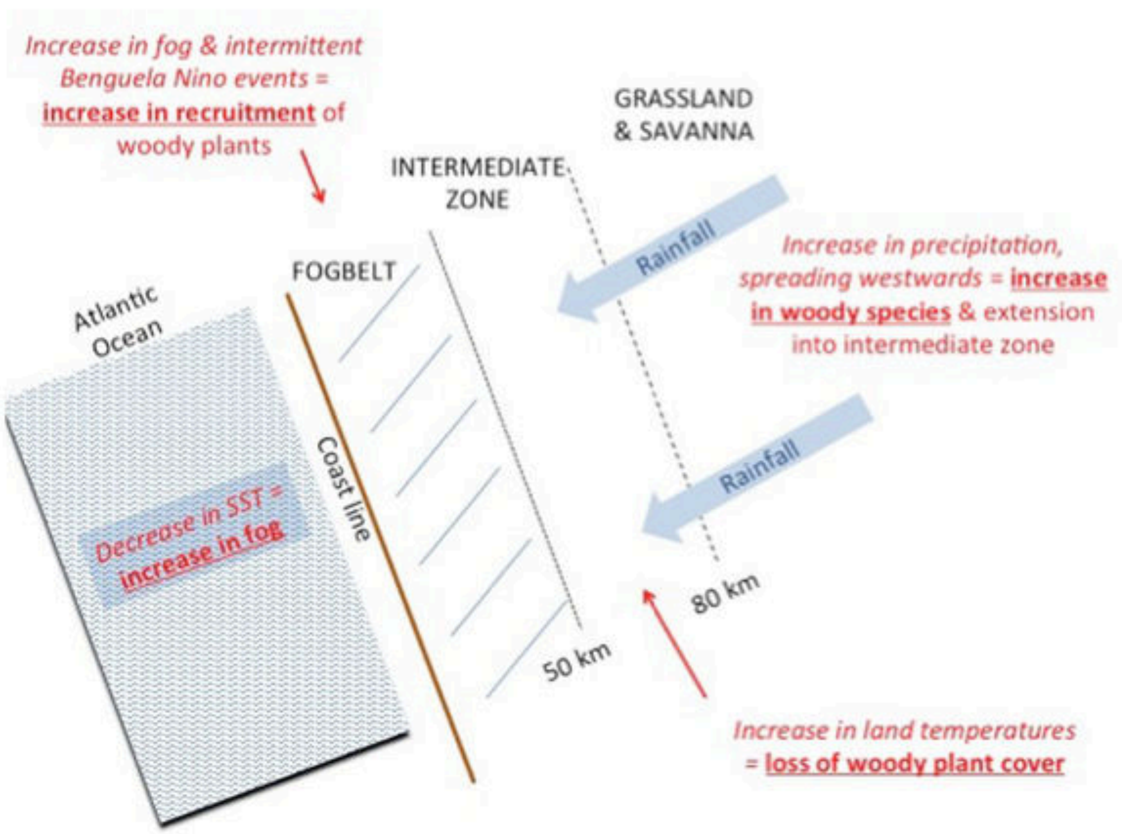
Preliminary analysis of the changes in woody vegetation lead us to the following four possible explanations, which we illustrate in the diagram below:

- That increased vegetation in the Fogbelt is possibly associated with a change to a colder, more intense Benguela current upwelling in the Atlantic ocean off the coast of Namibia. This cooling in turn generates more coastal fog, making more moisture available to plants in the coastal areas of west Namibia. This enhanced fog moisture has combined with recent increased occurrences of the Benguela Niño climate fluctuation (associated with desert rainfall events) that have supported population recruitment of coastal fog dependent woody vegetation species (*Arthraerua leubnitziae* and *Zygophyllum stapffii*).

- Further inland, increased temperatures in the Grasslands/Shrublands areas have instead resulted in the desiccation of woody vegetation and a consequent reduction in fog.

- The Savanna Transition areas again show increases in vegetation consistent with increased rainfall and atmospheric CO2 fertilisation in the more eastern landscapes.

- The large increases in woody vegetation along the Azonal Large Ephemeral Rivers may be due either to upstream dams, fewer recent large flood events (which can wash woody plants downstream), and/or increased carbon uptake due to higher levels of global CO2 associated with greenhouse gasses.



Hypotheses presented in diagramatic form (M.T. Hoffman).

These observations add to current debate regarding trends that are predicted or contradicted by various modelled future scenarios and that posit intensification (or weakening) of cold Benguela current upwelling, leading to increased (or decreased) fog near the coast and desiccation further inland.[3]

Researchers have described hypothetical scenarios based on the modeling of the climatic gradient in the Pro-Namib/Namib region. None have done so, however, by showing the relationships between the three climatic zones discussed here, or by using observations derived from historical sources in order to substantiate past and present trends. The research presented here thus offers rare empirical evidence for historical changes in the Namib's vegetation. Perhaps more importantly, it also has significant implications for understanding larger phenomena such as the trend in the intensity of the Benguela Eastern Boundary Upwelling System.

Notes

[1] Identified with reference to an extensive survey by Juergens, N., Oldeland, J., Hachfeld, B., Erb, E., and Schultz, C. 2013 Ecology and spatial patterns of large-scale vegetation units within the central Namib Desert. *Journal of Arid Environments* 93: 59-79.

[2] Atlas of Namibia Project 2002 Directorate of Environmental Affairs, Ministry of Environment and Tourism, Government of Namibia.

[3] More technically, these trends are associated with complex synoptic interactions between the Continental Thermal Low, the South Atlantic Oceanic High, the weakening of the Hadley Cell and changes in sea/land temperatures that steepen cross-shore pressure gradients driving upwelling winds. See: Snyder, M.A., Sloan, L.C., Diffenbaugh, N.S. and Bell, J.L. 2003 Future climate change and upwelling in the California Current. *Geophysical Research Letters* 30(15); Dinter, I. and Klaus, H. 2008 Epicuticular wax and anatomical features of *Arthraerua leubnitziae* (Kuntze) Schinz (Amaranthaceae) related to the ecological conditions in the Namib Desert. *Dinteria* 30: 1-18; Willians, C.J.R., Kiveton, D.R. and Layberry, R. 2008 Influence of South Atlantic Sea surface temperatures on rainfall variability and extremes over Southern Africa. *Journal of Climate* 21: 6498-6520; Haensler, A., Cermak, J., Hagemann, S. and Jacob, D. 2011 Will the Southern African west coast fog be affected by climate change? Results of an initial fog projection using a regional climate model. *Erdkunde* 65(3): 261-275; García-Reyes, M., Sydeman, W.J., Black, B.A. *et al*. 2013 Relative influence of oceanic and terrestrial pressure systems in driving upwelling-favorable winds. *Geophysical Research Letters* 40: 5311–5315; Bakun, A., Black, B.A., Bograd, S.J. *et al*. 2015 *Current Climate Change Report* 1: 85–93.