Determining the changes in vegetation structure in three semi-arid savanna environments in Namibia over the past 60 years

Matthew Walters

Mini-thesis presented in partial fulfilment of the requirements for the degree of Bachelor of Natural Resource Management Honours (Nature Conservation) degree at the Namibia University of Science and Technology

Supervisor Name: Dr Ben Strohbach

Faculty: Faculty of Natural Resources & Spatial Sciences

Department: Department of Natural Resources and Agricultural Sciences

Date: April 2017

Contents

1. Introduction 1
2. Methods and study site 3
3. Results 5
   3.1 Weener 7
   3.2 Gamsberg 8
   3.3 Erichsfelde 9
4. Discussion 12
5. Conclusion 14
Acknowledgements 15
References 15
Appendix A: Guideline to Authors/Journal of Arid Environments 19
Appendix B: Photography Points 34

Figure 1: 5
Figure 2: 7
Figure 3: 7
Figure 4: 8
Figure 5: 9
Figure 6: 11
Figure 7: 11
Figure 8: 11
Figure 9: 11
Figure 10: 12
Figure 11: 14
Figure 12: 14

Table 1: 4
Table 2: 10

Declaration

I, Matthew Healey Walters, hereby declare that the work contained in the mini-thesis, entitled “Determining the changes in vegetation structure in three semi-arid savanna environments in Namibia over the past 60 years” is my own original work and that I have not previously, in its entirety or in part, submitted it at any university or other higher education institution for the award of a degree.

Signature: MHWalters

Date: 2 November 2016

Determining the changes in vegetation structure in three semi-arid savanna environments in Namibia over the past 60 years

Matthew H. Walters[1] and Ben Strohbach[2]

[1]Private Bag 13388 Windhoek, Namibia, 13 Storch Street Windhoek, Namibia, matthew.walters94@gmail.com

[2]Private Bag 13388 Windhoek, Namibia, 13 Storch Street Windhoek, Namibia, bstrohbach@nust.na

Abstract

Matched photography is a particularly resourceful method of determining vegetation change and determining the drivers of vegetation change for the purpose of informing decision making on a national scale. Fourteen photographs from 1956 were therefore utilized and matched to make comparisons between three farms in both the Highland Savanna and the Thornbush Savanna. Additionally, drone imagery along with aerial photographs were matched and compared to simulate the comparisons of the terrestrial photographs. Close inspection of the all fourteen terrestrial photographs and aerial photographs revealed that Erichsfelde showed the greatest amounts of change, whereas Gamsberg showed little to almost no change in most photographs; Weener showed moderate amounts of encroachment in lower gradient slopes and plains. All indications in climatological aspects and management of rangelands point to local drivers being responsible for the differences seen between the years 1956 and 2016.

Keywords: Repeat photography, drone imagery, bush encroachment

1. Introduction

The study of the changes in rangelands using matched repeat photography is a useful concept, as it has helped the decision makers to formulate informed decisions regarding the future of land use (Rohde, 1997). This concept becomes especially significant when considering that environmental issues have become an progressively larger determinant of Namibian policy formulation and enterprises promoting sustainable development (Barnard, Shikongo, & Zeidler, 2001; Rhode, 1997). Furthermore, matched photography acts as an early warning system, where the study draws attention to any possible degradation, which can subsequently lead to action by the interested stakeholders of the study area (Hoffman, Rohde, & Zeitsman, 2011). However, there is a very limited knowledge regarding the vegetation dynamics in semi-arid rangelands in Namibia, and therefore further research is needed to study these historical dynamics (Joubert, Rothauge, & Smit, 2008). Understanding the historical drivers of change in Namibia has always been an important research topic, as land degradation has often been attributed to the poorly managed land practices, which have led to many common environmental challenges such soil erosion, bush encroachment, and desertification (Rohde & Hoffman, 2010; Zeeman, Lunt, & Morgan, 2014). Since, therefore, there are so many implications regarding the economies of the savanna systems (Sankaran et al., 2005), it is important to study the changes seen over a prolonged period of time.

The usefulness of matched photography is in the notion of being able to compare areas with the earliest photographical records (Rohde & Hoffman, 2008; Rohde & Hoffman, 2010; Russell & Ward, 2014) and also being able to compare several areas that have experienced changes within a matter of decades, due to a variable environment (a technique incorporated in fixed-point photography) (de Beer, Kilian, Versfeld, & van Aarde, 2006; Henschel, Seely, & Zeidler, 2000; Hipondoka & Versfeld, 2006). Changing management practices within these variable environments (semi-arid rangelands) has an important influence on the species cover and composition especially where the plant cover tends to be sparse (Hoffman & Rohde, 2011).

To date, there have been well over 450 studies conducted worldwide using the principles of matched photography and a large portion of these projects were conducted in semi-arid environments (Rhode, 1997). One of the first notable studies that were conducted took place in the United States; with some of the more noteworthy sites studied located in the arid south-eastern Arizona (McAuliffe, 1994). Though some areas that have been studied are not necessarily semi-arid, they still make good case studies for showing degradation across a long period of time. Such studies even include the mountainous forests of Yunnan, China (Moseley, 2006) and Khumbu, Nepal (Byers, 1987), where the impacts on the forests and glaciers were studied.

There have also been a number of notable studies conducted across South Africa ranging from the mesic environment of Kwa-Zulu Natal (Russell & Ward, 2014) to the dry savannah of Kimberley (Ward, Hoffman, & Collocott, 2014) to the arid Karoo biome (Aarsen, 1997; Hoffman, Rohde, Schmiedel, & Jürgens, 2010; Hoffman, 1991; Rohde & Hoffman, 2008) and even to the rocky shores of the South Africa's Western Cape (Reimers, 2012). In other instances, studies conducted in South Africa (Kaleme, 2003; Webb, 2010) and Namibia (Gallaher, 2014) have used matched photography to study the long term population dynamics of *Aloe dichotoma* as a local indicator of climate change.

With regards to Namibia, matched photography is still somewhat in its infancy, as Namibia has only a few long-term sources of monitoring from which the conclusions on the change of the physical environment can be assessed (Rhode, 1997). However, there have been previous studies, which have attempted to remedy these gaps in understanding, and have included the studies conducted in the more semi-arid to arid Damaraland (Rhode, 1997) and the more recent study conducted in central and southern Namibia (Rohde & Hoffman, 2010). The latter study indicated that there had been a substantial increase in grass cover and a slight decrease in shrub cover in the Nama Karoo sites; the Tree and Shrub Savanna had experienced a substantial change (with a large variation between sites) in grass cover and had experienced an even larger change (less variation between the sites) in the tree density; and finally, the riverine habitats recorded in the south of Namibia had experienced an overall increase in cover.

Therefore, the main research aim to be answered during the course of the project was whether the vegetation structure had changed significantly on three commercial farms Gamsberg, Weener, and Erichsfelde, based on the matched photographs that were taken in 2016. Another research question was whether the tree density structure had increased in higher rainfall areas (O'Connor, Puttick, & Hoffman, 2014; Sankaran et al., 2005). Accordingly, the objectives aimed at answering the main research aims included:

- Finding the locality of the relevant photographs taken in 1956 and replicating the exact same landscape
- Conducting a vegetation survey to estimate species quantity and percentage cover at each photographical site using the Braun-Blanquet Method (Mueller-Dombois & Ellenberg, 2002)
- Using aerial photographs to estimate the number of individual trees per hectare at the appropriate sample sites
- Using the available analytical methods to compare the differences observed between the vegetation noted in the 1956 photograph and the vegetation observed in the 2016 survey

2. Methods and study site

The methodology used within the context of this project can be divided between the actual repeat photography and the remote sensing component. The repeat photography component was inclusive of the all the photographical points as seen in Figure 1. The remote sensing imagery were inclusive of the sites at Erichsfelde, as there was a fair amount of uncertainty that existed as to whether the photograph points were in fact accurate on this specific farm (due to a fairly featureless landscape). Therefore, the drone imagery taken this year were compared to aerial photographs taken from the year 1968, and these were taken to act as a second method in determining vegetation change on the farm Erichsfelde (as a safeguard for any inaccuracies found in the landscape repeat photographs); this method has been incorporated within South Africa for this specific purpose (Davis, 2013).

The methodology of repeat photography within Southern Africa has been described quite unambiguously (Hoffman, Rohde, Duncan, & Kaleme, 2010; Hoffman, Rohde, Schmiedel, et al., 2010; Hoffman & Rohde, 2011; Hoffman, 1991; Rohde & Hoffman, 2010), and as a result most of these methods were incorporated within the implementation of the project. The first step was the locating of the photograph points using the physical features within the photograph as a means of common sense triangulation (Rohde, 1997). The photographical points were then georeferenced (Appendix B) as waypoints using a GPS (Garmin eTrex 10). Once each point had been located, the matching photographs were taken using a camera (Canon EOS 700D) and a tripod, using various reference features within the 1956 photographs to get a close match. As the photographs were taken specific care was made to note the photographic information of each point, which included: camera height, film type (JPEG+RAW), frame number, lens zoom, exposure speed, f-stop and time. Cairns were raised to note the exact position of the 2016 photograph points for the purpose of future reference (some cairns could not be placed due to some points being on used roads). Finally, the analysis of the actual changes of the various habitats within the photographs was subjectively measured by means of an index of change (Table 1).

Table 1: Index of change in vegetation cover

-2	Decrease in vegetation cover is greater than 25%
-1	Decrease in vegetation cover is between 5-25%
0	Rate of change is between -5% and 5%
+1	Increase in vegetation cover is between 5-25%
+2	Increase in vegetation cover is greater than 25%

Moreover, the existence of the original Volk relevé data of Erichsfelde (Volk, 1956) and data from a similar study on Erichsfelde (Strohbach & Sheuyange, 2001), was a motivation to draw comparisons between the years 1956, 1999, and 2016. A survey was conducted within the general area indicated within each specific photograph set, using the Braun-Blanquet method (Mueller-Dombois & Ellenberg, 2002) as the standard means for determining vegetation cover at each site. The purpose for utilizing the Braun-Blanquet method was due to its simplicity and due to it being the method originally used in 1956 and 1999.

The final part of the project required the use of the Sensefly Ebee drone to aerially photograph sections of the farm Erichsfelde that were thought to be within the 1956 photographs. Additionally, aerial photographs were collected from the year 1968 and 1997 in order to show gradual changes from an aerial perspective. The comparisons of individual tree per hectare of the two time periods were derived using a grid overlay of the two exact same areas (using three grids of 1 hectare size in the locality of the photographs to achieve an accurate estimate) that included the areas of the assumed photographical points.

The study sites (Figure 1) were two farms, Erichsfelde and Weener, and a game farm, Gamsberg. Erichsfelde, which receives more rainfall than the other two farms is a part of the Thornbush Savanna (Giess, 1987). The farms Gamsberg and Weener are part of a more arid environment and are a part of the Highland Savanna.

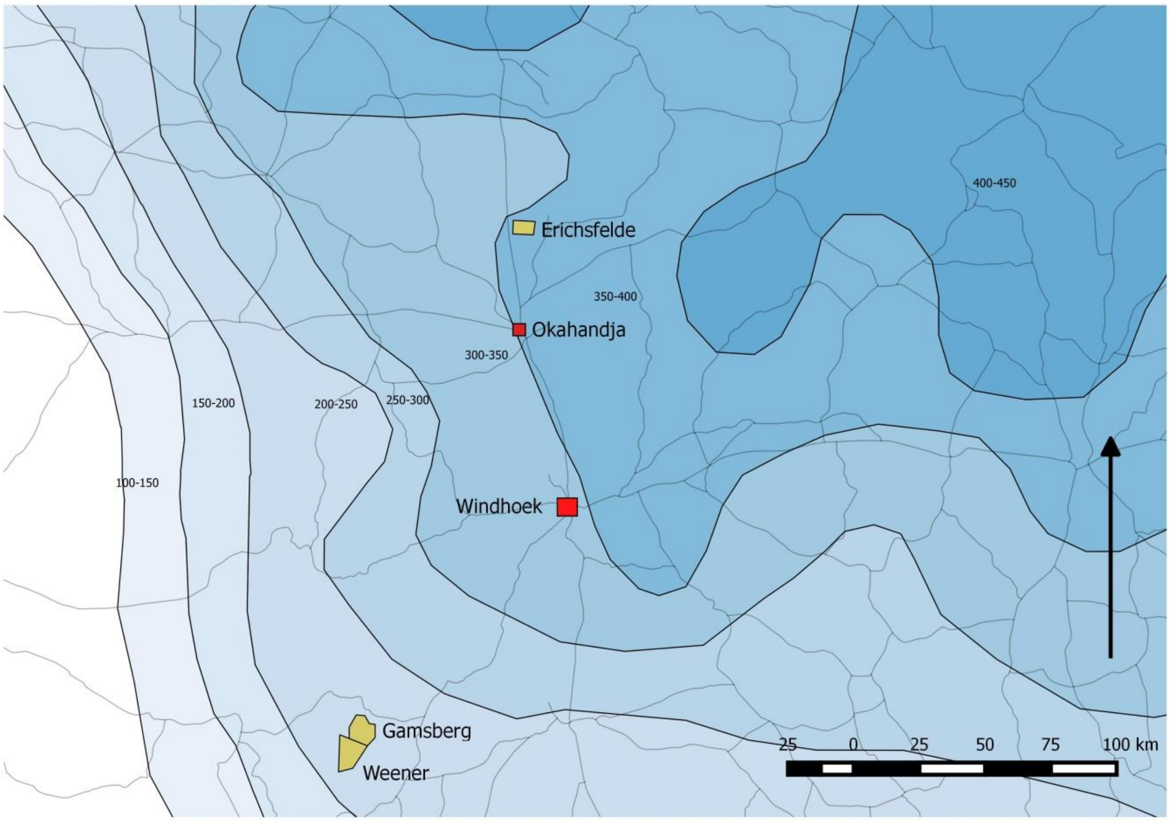
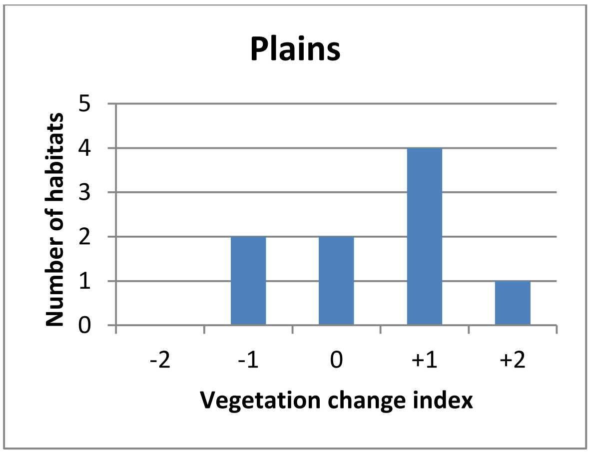


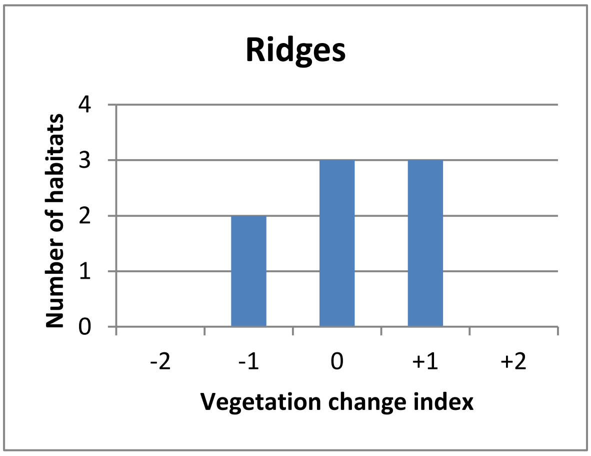
Figure 1: Project study areas with the relevant rainfall gradients

3. Results

The results displayed throughout the course of the project displayed a fair amount of variation with regards to the vegetation cover displayed between the three study sites. Using a transition index for vegetation change (Table 1), one could determine the relative change in vegetation cover based on a subjective comparative analysis of the 1956 and 2016 photographs. Overall, there wasn't a pronounced decrease in vegetation cover to the point that there was a -2 decrease. Most of the study sites suggested very little change in the total vegetation especially in areas where there were rocky slopes. It is however important to note that most areas did in fact show a decrease in grass cover, exclusively due to the fact that the year 2016 has been defined as a below average rainfall year and as such the grass coverage was already shown to be noticeably less at the height of 2016 rainy season. The biggest determinants of total percentage cover of these habitat zones were therefore determined by the percentage cover of shrubs and trees.

The pictures displayed various types of habitats which were broadly classified as plains, rocky slopes, ridges, or disturbed areas. Nine of the habitats within the fourteen photographs were defined as plains habitat, three zones were defined as disturbed, eight were defined as mountainous ridges and ten zones were defined as rocky slopes. Through use of the change index, one could conclusively see that the rocky slopes showed the least amount of change (total change in vegetation cover is predominantly 0). This is contrasted by the plains habitat which displayed a greater amount of change (specifically due to an increase in woody vegetation) and it was among the only habitats to have achieved a change index of +2 (a change attributed to increase in woody vegetation on Erichsfelde). Erichsfelde did in fact show the greatest amount of change, since it was the only farm that had a site which showed a +2 increase and would have contributed a second site with a +2 increase had it not been for the bush clearing currently taking place. The disturbed habitats were generally underrepresented within all three project areas, but nevertheless depending on the nature of the disturbance, the changes were either a minor loss in vegetation, no change at all, or a slight increase in vegetation. The mountainous ridges (which displayed larger surface areas in comparison to rocky slopes) predominantly experienced either no significant change or they experienced a slight increase in vegetation cover.





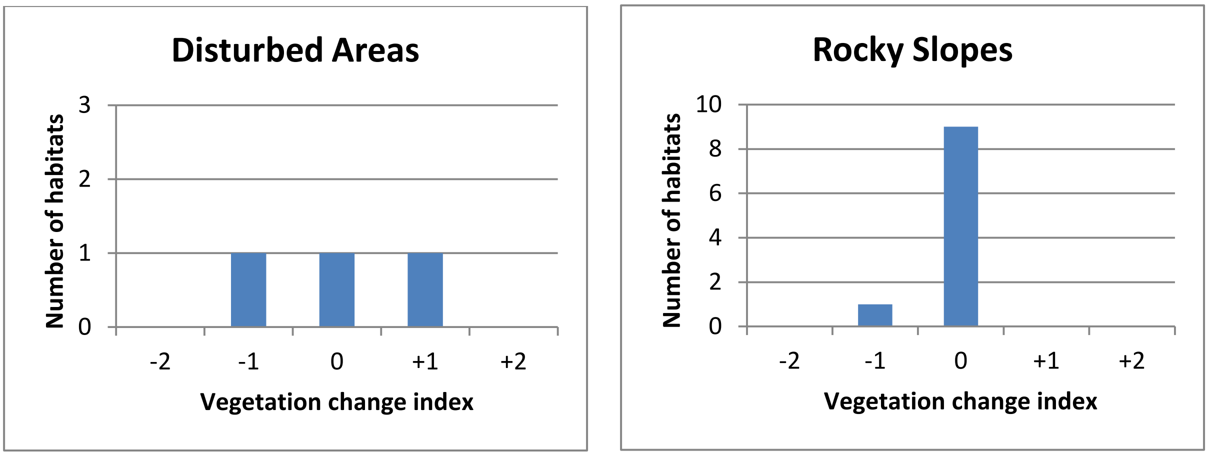


Figure 2: Vegetation change index for the total habitats across all three study sites

For the sake of space in this research paper, three sets of photographs (one from each farm) will be selected as examples to show readers the results of the methodology, which specifically involve the actual comparisons of the photographs.

3.1 Weener

A

B

Figure 3

A Listed as site 10, this photograph which had the description of "Farmhaus Weener, Dam" (Farmhouse Weener, Dam) displays a healthy population of *Acacia karroo* (Otto Volk, 19 February, 1956)

B The repeat of the photograph reveals a slight increase in the percentage of shrubs in the rocky foreground. Upon closer inspection the midground plain has experienced a slight decrease in the amount of *Acacia karroo* (Matthew Walters, 19 July, 2016).

In terms of the rocky slopes seen in this photograph, one can see that even in terms of the grass coverage the amount of change seems to be relatively stable, except for the slight increase in the amount of shrubs in the immediate foreground. However, as has been observed by the farmers themselves, the rocky slopes are hardly grazed by the cattle due to the inaccessibility and steepness of the grazing area on the rocky slopes (Roseli van Heerden, personal commounication, 2016). The particular area of interest in this photograph is the plain between the farmhouse and the rocky slope. One can noticeably see that the coverage of *Acacia karroo* has declined slightly, but there are no obvious causes of the decline (no removal or clearing of the area). One can attribute the decline of the *Acacia karroo* due to the shorter longevity (Ben Strohbach, personal communication, 2016) of this particular tree species, but there also seems to be a slight increase in the number of *Acacia karroo* on the far side of the plain, indicating some recruitment in the last sixty years.

The area close to and surrounding the farmhouse was classified as disturbed area. However, this disturbed area was ranked as having experienced no change in the vegetation cover. This particular area on the photograph has changed only slightly due to the construction of additional buildings, but the amount of woody species has stayed the same.

The ridge in the background of this photograph set, dominated by *Catophractes alexandrii, Searisa marlothii,* and *Lycium* species, did not show a vast amount of change (the grass layer would be difficult to determine especially due to the range and colour of the photograph). The tree cover does stay comparatively the same (with a slight increase on the lower gradient slopes) since this area does not typically have an abundant tree cover to begin with.

3.2 Gamsberg

A B

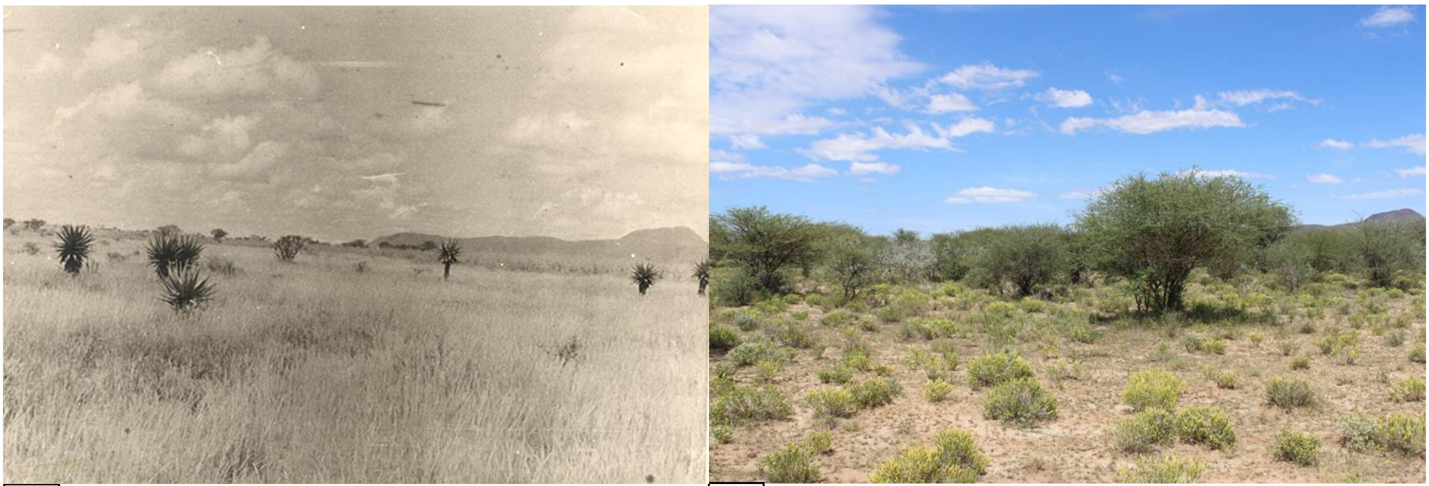
Figure 4

A Listed as site 3, the photograph G02/56 has the attached label of "Granietberge oste de Gamsberg" (Granite mountains east of the Gamsberg) (Otto Volk, 19 February, 1956).

B The repeat of the photograph reveals a decrease in the number of shrubs and grass in the rocky foreground. However, the midground plains do not really reveal any significant changes, besides what seems to be a slight decrease in the amount of trees in riverine section (Matthew Walters, 19 July, 2016).

The overall impression with regards to Gamsberg was that there were no overall significant changes, especially in terms of woody vegetation. The dominant trees and shrubs shown in the immediate foreground are the *Acacia hereroensis* (11%), *Tarchonanthus camphoratus* (11%) and *Euclea undulata* (3%). In terms of the above matching photographs, the lack of grass (characterised by the dominant *Anthephora pubescens* and *Pennisetum foermaranum*) could be attributed to the time of the year as well as the below average rainfall of 2016. The tufts of grass that are growing in-between the granite boulders on the rocky foreground indicate the limiting nature of rocky areas in grazing patterns. The decrease in the woody vegetation along the riverine areas of mid-ground plain would likely be the same phenomenon experienced in Figure 3 where the *Acacia karroo* seemed to have decreased in cover. Nevertheless, the overall impression is that there are no extreme changes which can be observed on the Gamsberg sites.

3.3 Erichsfelde



A

B

Figure 5

A Listed as site 1, the photograph R11-35 was one of the photographs with the attached relevé notes, which noted the presence of seven *Aloe littoralis* (Otto Volk, February, 1956)

B Though the locality of this specific photograph is questionable; the overall coverage shown in the photograph is fairly representative of the area that it was taken in. The *Aloe littoralis* are absent and the increase in the coverage of shrubs, especially *Acacia mellifera*, is very pronounced. (Matthew Walters, 31 March, 2016).

This site, by far, showed the greatest vegetation change in comparison to all the other 13 sites across central Namibia. It was fairly evident that the open grassy plain of 1956 had gradually been transformed into a dense shrubland which consisted of mainly *Acacia mellifera* (12%) and *Acacia reficiens* (6%). As indicated in the early relevé data, the presence of the woody species were recorded as being a low as 6.2 % of the total surface area, whereas the percentage cover of woody species in the 2016 study were as high 25.6%

(see Table 2). Additionally, as witnessed in the Khomas Hochland, the dominant smaller shrubs that tend to form dense clusters are the *Catophractes alexandrii* (not entirely captured in the Braun-Blanquet result, but seen in the drone images).

Table 2: Braun-Blanquet results of Site 1

<table>
<tr><td></td><td>1956</td><td>1999</td><td>2016</td></tr>
<tr><td>Shrubs</td><td rowspan="2">6,2</td><td>12,5</td><td>19</td></tr>
<tr><td>Small shrubs</td><td>16,5</td><td>6,5</td></tr>
<tr><td>Herbs and grasses</td><td>159,9</td><td>19,5</td><td>51,5</td></tr>
</table>

However, since there was a fair amount of uncertainty regarding the exact locality of the photograph point at both sites, the drone images along with aerial images from 1968 and 1997 were compared to ascertain whether the changes seen in the aerial photographs were reflected in the terrestrial photographs. Close examination of the aerial photographs did indeed show a drastic change in the amount of individual trees, due to the average of the three grids (for site 1 only) shifting from 64 individuals to 305 individuals per hectare. The aerial photographs for site 2 reflect a similar trend since the average amount of trees increased from 75 individuals to 203 individuals per hectare (prior to the current bush clearing).

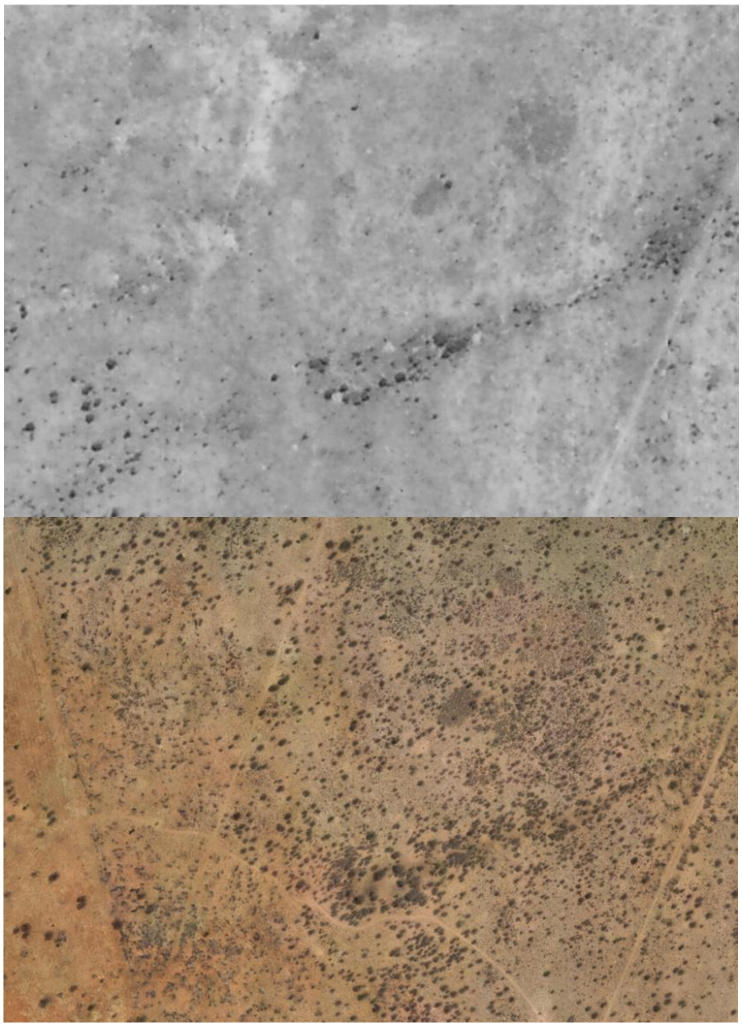


Figure 6: The progressive change in vegetation cover at Site 1 from the year 1968 to 2016.

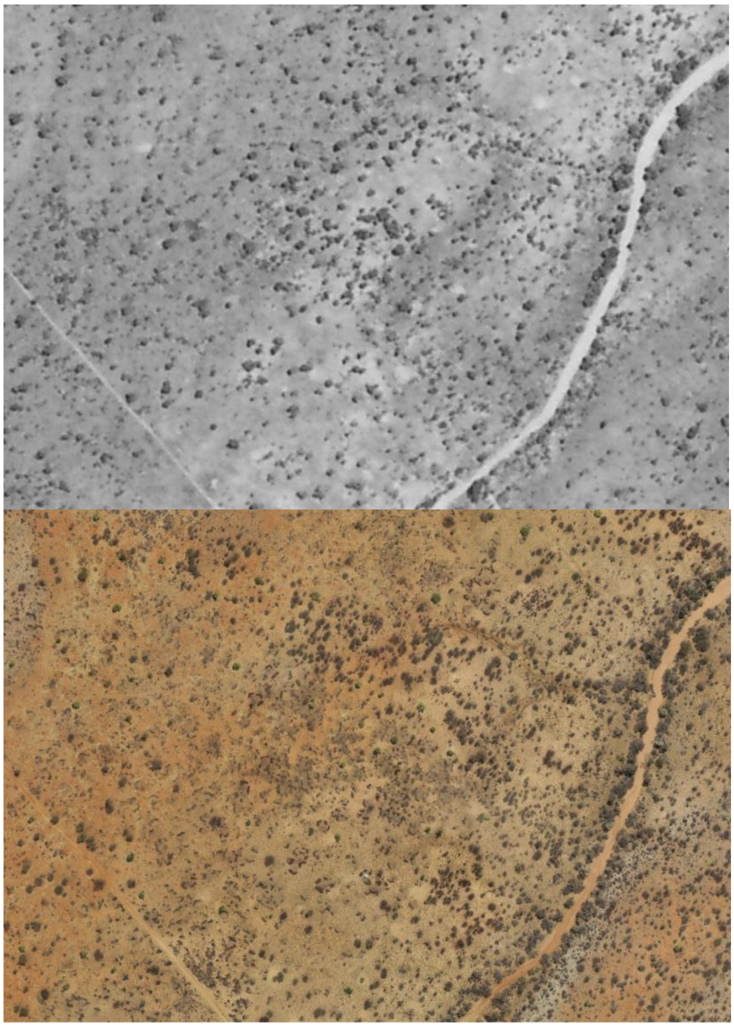


Figure 7: The progressive change in vegetation cover at Site 2 from the year 1968 to 2016.

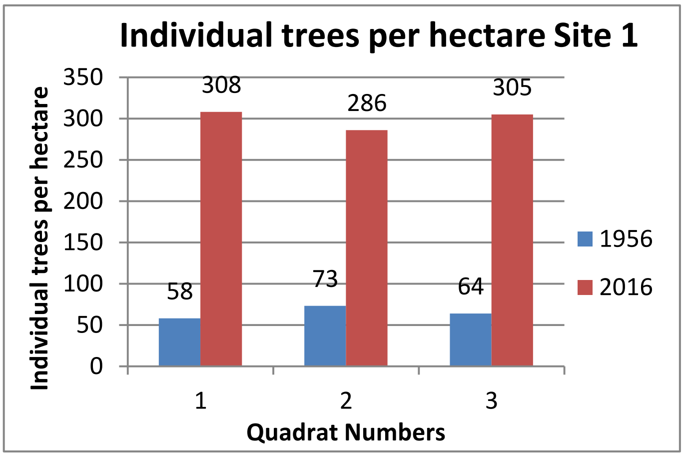


Figure 8: The number of individual trees in the three grids at Site 1 according to drone and aerial photographs. Important to note are the grids 1 and 2 which had a high number of *Catophractes alexandrii*.

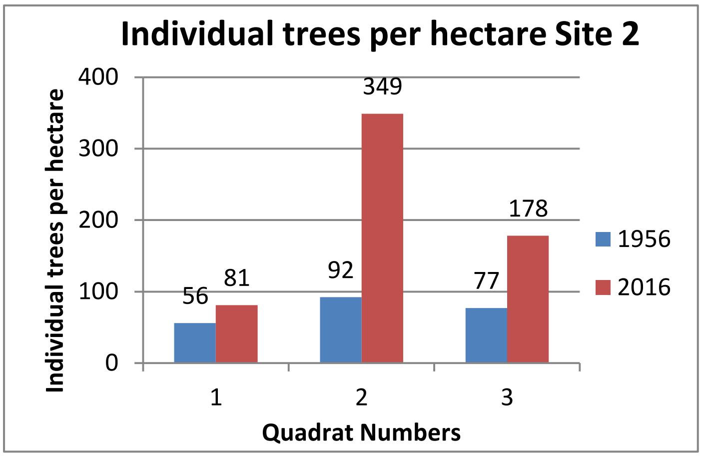


Figure 9: The number of individual trees in the three grids at site 2 according to drone and aerial photographs. Important to note are high number of individuals in grid 2 due to the number of trees that been felled and dragged into heaps.

4. Discussion

Not all of the changes observed were directly linked to natural processes; some were due to the changes in existing infrastructure. For instance, on Weener at Site 12, besides the observable increase in the shrub cover on the mid-ground plain, there has been an increase in the amount of medium and tall trees in the riverine section below the background ridge (see Figure 10), and this can attributed to the construction of an earthen dam between 1960 and 1970. Furthermore, the increase in the *Ziziphus mucronata* at Site 12 reflects the establishment of a drainage-way on the abandoned and eroded roadway.

Figure 10: Site 12 showing the dominance of *Ziziphus mucronata* in the foreground and the thickening of medium trees at the earthen dam and *Catophractes alexandrii* in the mid-ground plains.

However, most of the changes observed are directly a result of bush encroachment, a phenomenon debated due to the presence of local and global drivers (Sankaran et al., 2005). Nevertheless, based on the climatological and the various external factors, some of the observed trends on the various sites can be closely linked into the more commonly accepted views regarding bush encroachment (local changes). With regards to the bush thickening observed on the farm Weener, the only shrubs responsible for this occurrence are the *Catophractes alexandrii*, (noted in previous studies for being responsible for encroachment in the Highland Savanna) (Rohde & Hoffman, 2010) but the amount of bush thickening observed on Farm Weener (in comparison to Erichsfelde) does indeed reflect a model where shrub encroachment is greatly influenced by rainfall gradients.

However, a contrast can also be observed where in certain areas of the farm have shown an absence of grazing due to the inaccessibility, which further reflects why the rocky slopes displayed the least amount of change; a trend displayed in other research studies (Russell & Ward, 2014). Furthermore, the grazing patterns on Weener have changed since the original 1956 photographs were taken. Originally, Weener was a sheep farm, firstly for Karakul (more than 47 years ago) and then for Damara sheep. Afterwards, Weener transitioned to a cattle farm, first breeding in Afrikaner cattle and then to the current Bonsmara. Stocking rates have also changed to improve the grazing management on Weener (changing from 1 LSU/12 ha to 1 LSU/ 25 ha) (Roseli van Heerden, personal communication, 2016).

Erichsfelde, by far, displays the typical trends of bush encroachment being experienced in central Namibia. Not only, does the hypothesis of higher rainfall gradient having a greater influence on the rate of change hold true, but it displays the more common concept of local drivers that are responsible for the shrub encroachment as a whole. Based on the stocking rates of Erichsfelde, which is 1/20 LSU per hectare (slightly higher than Weener) (Rudi Scheidt, personal communication, 2016), there is a seemingly good causal pretext to assume that local drivers, such as overgrazing or rainfall variability may be partly responsible for the changes in vegetation structure observed on Erichsfelde particularly (the presence of *Monechma genistifolium* does indicate a fairly recent history of overgrazing or of disturbance). However, since Erichsfelde is above the 250 mm rainfall gradient, the effects of global drivers by means of increased atmospheric CO_2 may have increased synergistic effect on the rate of bush encroachment (O'Connor et al., 2014).

Fire and rainfall history are often linked to the spread of bush encroachment. This is especially pronounced when droughts denude the affected areas of the competing grass layers (De Klerk, 2004). When these areas are subsequently followed by two or more years of above average rainfall, seedlings of invader bushes can subsequently become established. Figure 11 and 12 represent the known droughts (Botha, 1998) and possible recruiting periods for both Weener and Gamsberg.

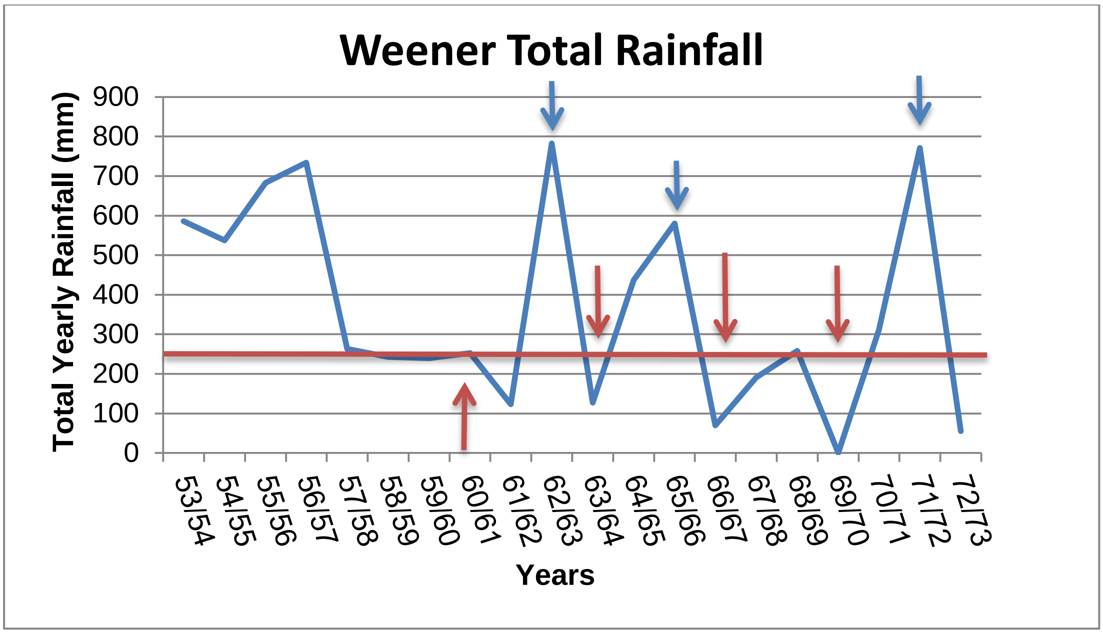


Figure 11: Recorded rainfall from 1953 to 1973 on Farm Weener with the mean rainfall indicated in red (Red arrows indicate notable drought periods; blue arrows indicate prime recruitment periods)

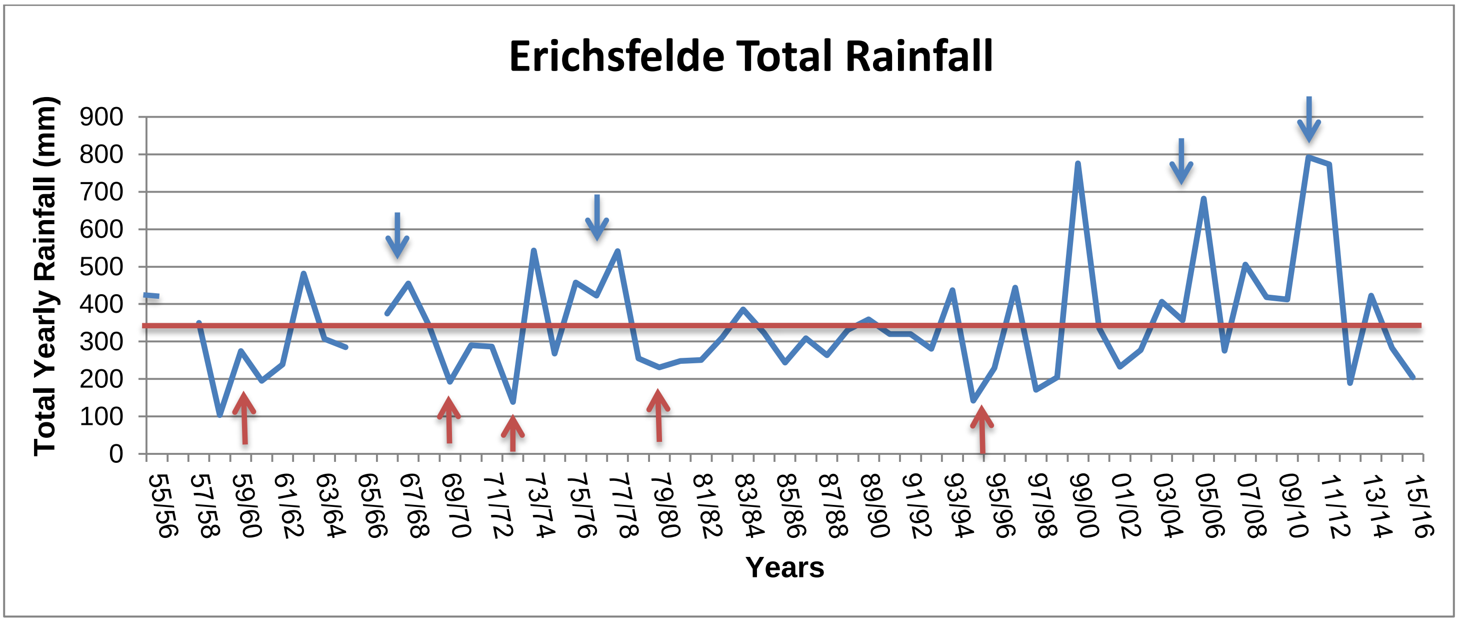


Figure 12: Recorded Erichsfelde rainfall from 1955 to 2016 with the mean rainfall indicated in red (Red arrows indicate notable drought periods; blue arrows indicate prime recruitment periods).

5. Conclusion

Therefore, based on the index of change per habitat per farm, the overall conclusion is that Erichsfelde (part of the higher rainfall isohyet) has experienced the most change due to bush encroachment (O’Connor et al., 2014). Also, the fair amounts of bush encroachment which can be seen between Erichsfelde and Weener are a result of the *Acacia mellifera* and

Catophractes alexandrii respectively. Most of photograph points which experienced the least amount of change were in the more arid zones on the rocky slopes of Weener and Gamsberg, but edaphic soil conditions in the low-gradient areas allow for small-scale encroachment to take place within the local area.

Acknowledgements

A special thanks to Dr Ben Strohbach for his support and guidance throughout the course of this project, and I also thank him for lending his expertise in the drone survey imagery and the various other methods that were necessary for this project. I thank Professor Timm Hoffmann and Samuel Jack for giving the necessary guidance in the actual methodology of repeat photography. I thank Roseli van Heerden of Farm Weener and Rudi Scheidt of Farm Erichsfelde for their cooperation and invaluable assistance in helping me find the various photograph points and for also providing the necessary data that helped in understanding the reasons for the changes observed within the various photographs.

References

Aarsen, L. W. (1997). High productivity in grassland ecosystems: effected by species diversity or productive species? Oikos, 80(1), 183–184.

Barnard, P., Shikongo, S., & Zeidler, J. (2001). *Biodiversity and development in Namibia: Namibia's ten-year strategic plan of action for sustainable development through biodiversity conservation*. Windhoek, Namibia: Ministry of Environment and Tourism.

Botha, L. (1998). History of drought in Namibia. *Agricola*, *10*, 5–12.

Byers, A. (1987). An assessment of landscape change in the Khumbu region of Nepal using repeat photography. *Mountain Research and Development*, 77–81.

Davis, C. L. (2013). *Trends in vegetation productivity and seasonality for Namaqualand, South Africa between 1986 and 2011: an approach combining remote sensing and repeat photography*. University of Cape Town.

de Beer, Y., Kilian, W., Versfeld, W., & van Aarde, R. J. (2006). Elephants and low rainfall alter woody vegetation in Etosha National Park, Namibia. *Journal of Arid Environments*, *64*, 412–421.

De Klerk, J. N. (2004). *Bush encroachment in Namibia: Report on phase 1 of the bush encroachment research, monitoring, and management project*. Ministry of Environment and Tourism, Directorate of Environmental Affairs.

Gallaher, K. S. L. (2014). *The influence of rainfall seasonality and climate change on the demography of* Aloe dichotoma*, a long-lived succulent tree from semi-arid southern Africa* (Master's thesis). University of Cape Town, Cape Town, South Africa.

Giess, W. (1987). *A preliminary vegetation map of South West Africa. Dinteria 4: 8-9*. Bothalia.

Henschel, J. R., Seely, M. K., & Zeidler, J. (2000). Long-term ecological research at Gobabeb: Gaining and applying knowledge about a highly variable environment. *Journal of the Namibia Scientific Society*, *48*, 89–115.

Hipondoka, M. H. T., & Versfeld, W. D. (2006). Root system of *Terminalia sericea* shrubs across rainfall gradient in a semi-arid environment of Etosha National Park, Namibia. *Ecological Indicators*, *6*(3), 516–524.

Hoffman, M. T., & Rohde, R. F. (2011). Rivers through time: Historical changes in the riparian vegetation of the semi-arid, winter rainfall region of South Africa in response to climate and land use. *Journal of the History of Biology*, *44*(1), 59–80.

Hoffman, M. T., Rohde, R. F., Duncan, J., & Kaleme, P. (2010). Repeat photography, climate change and long-termed population dynamics of Tree Aloes in southern Africa. In *Application in Population Ecology* (pp. 133–142).

Hoffman, M. T., Rohde, R. F., Schmiedel, U., & Jürgens, N. (2010). An analysis of 20th century vegetation change in Namaqualand using repeat photography. *Biodiversity in Southern Africa*, *2*, 15–21.

Hoffman, M. T., Rohde, R. F., & Zeitsman, L. (2011). Long-term changes in the vegetation of southern Africa as revealed by repeat photography. *Observations of Large-Scale and Long-Term Trends in Southern Africa*, 79–83.

Hoffman, T. (1991). Is the Karoo spreading? *Veld & Flora*, *March 1991*, 5–7.

Joubert, D. F., Rothauge, A., & Smit, G. N. (2008). A conceptual model of vegetation dynamics in the semiarid Highland savanna of Namibia, with particular reference to bush thickening by *Acacia mellifera*. *Journal of Arid Environments*, *72*(12), 2201–2210. https://doi.org/doi: DOI: 10.1016/j.jaridenv.2008.07.004

Kaleme, P. K. (2003). Regional differences in the long-term population dynamics of a succulent tree, *Aloe dichotoma* in the semi-arid Karoo, South Africa as revealed by repeat photography. *Unpublished M. SC., Thesis, Percy Fitzpatrick Institute of African Ornithology, University of Cape Town*.

McAuliffe, J. R. (1994). Landscape Evolution, Soil Formation, and Ecological Patterns and Processes in Sonoran Desert Bajadas. *Ecological Monographs*, *64*(2), 111–148. https://doi.org/10.2307/2937038

Moseley, R. K. (2006). Historical landscape change in northwestern Yunnan, China: Using repeat photography to assess the perceptions and realities of biodiversity loss. *Mountain Research and Development*, *26*(3), 214–219.

Mueller-Dombois, D., & Ellenberg, H. (2002). *Aims and Methods of Vegetation Ecology* (Reprint of First Edition). Cladwell, New Jersey: The Blackburn Press.

O’Connor, T. G., Puttick, J. R., & Hoffman, M. T. (2014). Bush encroachment in southern Africa: changes and causes. *African Journal of Range & Forage Science*, *31*(2), 67–88. https://doi.org/10.2989/10220119.2014.939996

Reimers, B. (2012). *Historical changes on rocky shores in the Western Cape, as revealed by repeat photography* (Master’s thesis). University of Cape Town, Cape Town, South Africa.

Rhode, R. F. (1997). Looking into the past: interpretations of vegetation change in Western Namibia based on matched photography. *Dinteria*, 121–149.

Rohde, R. F., & Hoffman, M. T. (2008). One Hundred Years of Separation: The Historical Ecology of a South African ‘Coloured Reserve’. *Africa: Journal of the International African Institute*, *78*(2), 189–222.

Rohde, R. F., & Hoffman, M. T. (2010). Landscape and vegetation change in Namibia since 1876 based on the photographs of the Palgrave Commission. In U. Schmiedel & N. Jürgens (Eds.), *Patterns and Processes at Regional Scale* (Vol. 2, pp. 6–14). Göttingen & Windhoek: Klaus Hess Publishers.

Russell, J., & Ward, D. (2014). Vegetation change in northern KwaZulu-Natal since the Anglo-Zulu War of 1879: local or global drivers? *African Journal of Range & Forage Science*, *31*(2), 89–105. https://doi.org/10.2989/10220119.2013.827740

Sankaran, M., Hanan, N. P., Scholes, R. J., Ratnam, J., Augustine, D. J., Cade, B. S., … Zambatis, N. (2005). Determinants of woody cover in African savannas. *Nature*, *438*(7069), 846–849. https://doi.org/10.1038/nature04070

Strohbach, B. J., & Sheuyange, T. P. (2001). Vegetation survey of Namibia. *Journal of the Namibia Scientific Society*, *49*, 93–124.

Volk, O. H. (1956). *Erichsfelde* (Unpublished relevé data from the farm Erichsfelde.).

Ward, D., Hoffman, M. T., & Collocott, S. J. (2014). A century of woody plant encroachment in the dry Kimberley savanna of South Africa. *African Journal of Range & Forage Science*, *31*(2), 107–121. https://doi.org/10.2989/10220119.2014.914974

Webb, R. H. (2010). *Repeat photography: methods and applications in the natural sciences*. Washington, D.C.: Island Press.

Zeeman, B. J., Lunt, I. D., & Morgan, J. W. (2014). Can severe drought reverse woody plant encroachment in a temperate Australian woodland? *Journal of Vegetation Science*, *25*(4), 928–936. https://doi.org/10.1111/jvs.12153

Appendix A: Guideline to Authors/Journal of Arid Environments[1]

Aims and Scope

The Journal of Arid Environments is an international journal publishing original scientific and technical research articles on physical, biological and cultural aspects of arid, semi-arid, and desert environments. As a forum of multi-disciplinary and interdisciplinary dialogue it addresses research on all aspects of arid environments and their past, present and future use.

Research Areas include:

- Paleoclimate and Paleoenvironments
- Climate and Climate Change
- Hydrological processes and systems
- Geomorphological processes and systems
- Soils (physical and biological aspects)
- Ecology (Plant and Animal Sciences)
- Anthropology and human ecology (archaeology, sociology, ethnobotany, human adaptations,etc. Agriculture Land use grazing, mining, tourism, etc)
- Land use (agronomy, grazing, mining, tourism, etc)
- Conservation (theory, policy, sustainability, economics, heritage)
- Land degradation (desertification) and rehabilitation
- Environmental monitoring and management

Types of paper

Research Articles: reporting original and previously unpublished work. Research papers have a reference limit of 50 cites

Short Communications: These are concise, but complete descriptions of a limited investigation, which will not be included in a later paper. Examples include descriptive research on seed-germination conditions, plant responses to salinity, animal feeding habits, etc. Short communications have a reference limit of 20 cites

Short communications should not exceed 2400 words (six printed pages), excluding references and legends. Submissions should include a short abstract not exceeding 10% of the length of the communication and which summarizes briefly the main findings of the work to be reported. The bulk of the text should be in a continuous form that does not require numbered sections such as Introduction, Materials and methods, Results and Discussion. However, a Cover page, Abstract and a list of Keywords are required at the beginning of the

[1] https://www.elsevier.com/journals/journal-of-arid-environments/0140-1963/guide-for-authors#25000

communication and Acknowledgements and References at the end. These components are to be prepared in the same format as used for full-length research papers. Occasionally authors may use sub-titles of their own choice to highlight sections of the text. The overall number of tables and figures should be limited to a maximum of three (i.e. two figures and one table).

Review Articles: Critical evaluation of existing data, defined topics or emerging fields of investigation, critical issues of public concern, sometimes including the historical development of topics. Those wishing to prepare a review should first consult the Editors or Associate Editors concerning acceptability of topic and length.

Think Notes: Short, one page notes describing new developments, new ideas, comments on a controversial subject, or comments on recent conferences will also be considered for publication.

Letter to the Editor: A written discussion of papers published in the journal. Letters are accepted on the basis of new insights on the particular topic, relevance to the published paper and timeliness.

Contact details for submission
Authors may send queries concerning the submission process, manuscript status, or journal procedures to the Editorial Office at jae@elsevier.com.

Submission checklist

You can use this list to carry out a final check of your submission before you send it to the journal for review. Please check the relevant section in this Guide for Authors for more details.

Ensure that the following items are present:

One author has been designated as the corresponding author with contact details:
• E-mail address
• Full postal address

All necessary files have been uploaded:
Manuscript:
• Include keywords
• All figures (include relevant captions)
• All tables (including titles, description, footnotes)
• Ensure all figure and table citations in the text match the files provided
• Indicate clearly if color should be used for any figures in print
Graphical Abstracts / Highlights files (where applicable)
Supplemental files (where applicable)

Further considerations
• Manuscript has been 'spell checked' and 'grammar checked'
• All references mentioned in the Reference List are cited in the text, and vice versa
• Permission has been obtained for use of copyrighted material from other sources (including the Internet)

• Relevant declarations of interest have been made
• Journal policies detailed in this guide have been reviewed
• Referee suggestions and contact details provided, based on journal requirements

For further information, visit our Support Center.

Before You Begin

Ethics in publishing

Please see our information pages on Ethics in publishing and Ethical guidelines for journal publication.

Human and animal rights

If the work involves the use of human subjects, the author should ensure that the work described has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for experiments involving humans; Uniform Requirements for manuscripts submitted to Biomedical journals. Authors should include a statement in the manuscript that informed consent was obtained for experimentation with human subjects. The privacy rights of human subjects must always be observed.

All animal experiments should comply with the ARRIVE guidelines and should be carried out in accordance with the U.K. Animals (Scientific Procedures) Act, 1986 and associated guidelines, EU Directive 2010/63/EU for animal experiments, or the National Institutes of Health guide for the care and use of Laboratory animals (NIH Publications No. 8023, revised 1978) and the authors should clearly indicate in the manuscript that such guidelines have been followed.

Declaration of interest

All authors are requested to disclose any actual or potential conflict of interest including any financial, personal or other relationships with other people or organizations within three years of beginning the submitted work that could inappropriately influence, or be perceived to influence, their work. More information.

Submission declaration and verification

Submission of an article implies that the work described has not been published previously (except in the form of an abstract or as part of a published lecture or academic thesis or as an electronic preprint, see 'Multiple, redundant or concurrent publication' section of our ethics policy for more information), that it is not under consideration for publication elsewhere, that its publication is approved by all authors and tacitly or explicitly by the responsible authorities where the work was carried out, and that, if accepted, it will not be published elsewhere in the same form, in English or in any other language, including electronically without the written consent of the copyright-holder. To verify originality, your article may be checked by the originality detection service CrossCheck.

Contributors

Each author is required to declare his or her individual contribution to the article: all authors must have materially participated in the research and/or article preparation, so roles for all authors should be described. The statement that all authors have approved the final article should be true and included in the disclosure.

Changes to authorship

Authors are expected to consider carefully the list and order of authors **before** submitting their manuscript and provide the definitive list of authors at the time of the original submission. Any addition, deletion or rearrangement of author names in the authorship list should be made only **before** the manuscript has been accepted and only if approved by the journal Editor. To request such a change, the Editor must receive the following from the **corresponding author**: (a) the reason for the change in author list and (b) written confirmation (e-mail, letter) from all authors that they agree with the addition, removal or rearrangement. In the case of addition or removal of authors, this includes confirmation from the author being added or removed.
Only in exceptional circumstances will the Editor consider the addition, deletion or rearrangement of authors **after** the manuscript has been accepted. While the Editor considers the request, publication of the manuscript will be suspended. If the manuscript has already been published in an online issue, any requests approved by the Editor will result in a corrigendum.

Copyright

Upon acceptance of an article, authors will be asked to complete a 'Journal Publishing Agreement' (see more information on this). An e-mail will be sent to the corresponding author confirming receipt of the manuscript together with a 'Journal Publishing Agreement' form or a link to the online version of this agreement.

Subscribers may reproduce tables of contents or prepare lists of articles including abstracts for internal circulation within their institutions. Permission of the Publisher is required for resale or distribution outside the institution and for all other derivative works, including compilations and translations. If excerpts from other copyrighted works are included, the author(s) must obtain written permission from the copyright owners and credit the source(s) in the article. Elsevier has preprinted forms for use by authors in these cases.

For open access articles: Upon acceptance of an article, authors will be asked to complete an 'Exclusive License Agreement' (more information). Permitted third party reuse of open access articles is determined by the author's choice of user license.

Author rights
As an author you (or your employer or institution) have certain rights to reuse your work. More information.

Elsevier supports responsible sharing
Find out how you can share your research published in Elsevier journals.

Role of the funding source

You are requested to identify who provided financial support for the conduct of the research and/or preparation of the article and to briefly describe the role of the sponsor(s), if any, in study design; in the collection, analysis and interpretation of data; in the writing of the report; and in the decision to submit the article for publication. If the funding source(s) had no such involvement then this should be stated.

Funding body agreements and policies
Elsevier has established a number of agreements with funding bodies which allow authors to comply with their funder's open access policies. Some funding bodies will reimburse the author for the Open Access Publication Fee. Details of existing agreements are available online.

Open access

This journal offers authors a choice in publishing their research:

Open access
• Articles are freely available to both subscribers and the wider public with permitted reuse.
• An open access publication fee is payable by authors or on their behalf, e.g. by their research funder or institution.
Subscription
• Articles are made available to subscribers as well as developing countries and patient groups through our universal access programs.
• No open access publication fee payable by authors.

Regardless of how you choose to publish your article, the journal will apply the same peer review criteria and acceptance standards.

For open access articles, permitted third party (re)use is defined by the following Creative Commons user licenses:

Creative Commons Attribution (CC BY)
Lets others distribute and copy the article, create extracts, abstracts, and other revised versions, adaptations or derivative works of or from an article (such as a translation), include in a collective work (such as an anthology), text or data mine the article, even for commercial purposes, as long as they credit the author(s), do not represent the author as endorsing their adaptation of the article, and do not modify the article in such a way as to damage the author's honor or reputation.

Creative Commons Attribution-NonCommercial-NoDerivs (CC BY-NC-ND)
For non-commercial purposes, lets others distribute and copy the article, and to include in a collective work (such as an anthology), as long as they credit the author(s) and provided they do not alter or modify the article.

The open access publication fee for this journal is **USD 2500**, excluding taxes. Learn more about Elsevier's pricing policy: http://www.elsevier.com/openaccesspricing.

Green open access
Authors can share their research in a variety of different ways and Elsevier has a number of green open access options available. We recommend authors see our green open access page for further information. Authors can also self-archive their manuscripts immediately and enable public access from their institution's repository after an embargo period. This is the version that has been accepted for publication and which typically includes author-incorporated changes suggested during submission, peer review and in editor-author communications. Embargo period: For subscription articles, an appropriate amount of time is needed for journals to deliver value to subscribing customers before an article becomes freely available to the public. This is the embargo period and it begins from the date the article is formally published online in its final and fully citable form. Find out more.

This journal has an embargo period of 24 months.

Elsevier Publishing Campus
The Elsevier Publishing Campus (www.publishingcampus.com) is an online platform offering free lectures, interactive training and professional advice to support you in publishing your research. The College of Skills training offers modules on how to prepare, write and structure your article and explains how editors will look at your paper when it is submitted for publication. Use these resources, and more, to ensure that your submission will be the best that you can make it.

Language (usage and editing services)
Please write your text in good English (American or British usage is accepted, but not a mixture of these). Authors who feel their English language manuscript may require editing to eliminate possible grammatical or spelling errors and to conform to correct scientific English may wish to use the English Language Editing service available from Elsevier's WebShop.

Submission

Our online submission system guides you stepwise through the process of entering your article details and uploading your files. The system converts your article files to a single PDF file used in the peer-review process. Editable files (e.g., Word, LaTeX) are required to typeset your article for final publication. All correspondence, including notification of the Editor's decision and requests for revision, is sent by e-mail.

Referees

Please submit, with the manuscript, the names, addresses and e-mail addresses of 5 potential referees. It is required that potential referees not be from the same institution as the authors. Please only supply the names of referees who can commit to the review, if invited. Note that the editor retains the sole right to decide whether or not the suggested reviewers are used.

Preparation

NEW SUBMISSIONS

Submission to this journal proceeds totally online and you will be guided stepwise through the creation and uploading of your files. The system automatically converts your files to a single PDF file, which is used in the peer-review process.
As part of the Your Paper Your Way service, you may choose to submit your manuscript as a single file to be used in the refereeing process. This can be a PDF file or a Word document, in any format or lay-out that can be used by referees to evaluate your manuscript. It should contain high enough quality figures for refereeing. If you prefer to do so, you may still provide all or some of the source files at the initial submission. Please note that individual figure files larger than 10 MB must be uploaded separately.

References
There are no strict requirements on reference formatting at submission. References can be in any style or format as long as the style is consistent. Where applicable, author(s) name(s), journal title/book title, chapter title/article title, year of publication, volume number/book chapter and the pagination must be present. Use of DOI is highly encouraged. The reference style used by the journal will be applied to the accepted article by Elsevier at the proof stage. Note that missing data will be highlighted at proof stage for the author to correct.

Formatting requirements
There are no strict formatting requirements but all manuscripts must contain the essential elements needed to convey your manuscript, for example Abstract, Keywords, Introduction, Materials and Methods, Results, Conclusions, Artwork and Tables with Captions.
If your article includes any Videos and/or other Supplementary material, this should be included in your initial submission for peer review purposes.
Divide the article into clearly defined sections.

Figures and tables embedded in text
Please ensure the figures and the tables included in the single file are placed next to the relevant text in the manuscript, rather than at the bottom or the top of the file.

REVISED SUBMISSIONS

Use of word processing software
Regardless of the file format of the original submission, at revision you must provide us with an editable file of the entire article. Keep the layout of the text as simple as possible. Most formatting codes will be removed and replaced on processing the article. The electronic text should be prepared in a way very similar to that of conventional manuscripts (see also the Guide to Publishing with Elsevier). See also the section on Electronic artwork.
To avoid unnecessary errors you are strongly advised to use the 'spell-check' and 'grammar-check' functions of your word processor.

Article structure

Subdivision - numbered sections
Divide your article into clearly defined and numbered sections. Subsections should be numbered 1.1 (then 1.1.1, 1.1.2, ...), 1.2, etc. (the abstract is not included in section numbering). Use this numbering also for internal cross-referencing: do not just refer to 'the

text'. Any subsection may be given a brief heading. Each heading should appear on its own separate line.

Introduction
State the objectives of the work and provide an adequate background, avoiding a detailed literature survey or a summary of the results.

Material and methods
Provide sufficient detail to allow the work to be reproduced. Methods already published should be indicated by a reference: only relevant modifications should be described.

Appendices
If there is more than one appendix, they should be identified as A, B, etc. Formulae and equations in appendices should be given separate numbering: Eq. (A.1), Eq. (A.2), etc.; in a subsequent appendix, Eq. (B.1) and so on. Similarly for tables and figures: Table A.1; Fig. A.1, etc.

Essential title page information

• ***Title.*** Concise and informative. Titles are often used in information-retrieval systems. Avoid abbreviations and formulae where possible.
• ***Author names and affiliations.*** Please clearly indicate the given name(s) and family name(s) of each author and check that all names are accurately spelled. Present the authors' affiliation addresses (where the actual work was done) below the names. Indicate all affiliations with a lower-case superscript letter immediately after the author's name and in front of the appropriate address. Provide the full postal address of each affiliation, including the country name and, if available, the e-mail address of each author.
• ***Corresponding author.*** Clearly indicate who will handle correspondence at all stages of refereeing and publication, also post-publication. **Ensure that the e-mail address is given and that contact details are kept up to date by the corresponding author.**
• ***Present/permanent address.*** If an author has moved since the work described in the article was done, or was visiting at the time, a 'Present address' (or 'Permanent address') may be indicated as a footnote to that author's name. The address at which the author actually did the work must be retained as the main, affiliation address. Superscript Arabic numerals are used for such footnotes.

Abstract

A concise and factual abstract is required. The abstract should state briefly the purpose of the research, the principal results and major conclusions. An abstract is often presented separately from the article, so it must be able to stand alone. For this reason, References should be avoided, but if essential, then cite the author(s) and year(s). Also, non-standard or uncommon abbreviations should be avoided, but if essential they must be defined at their first mention in the abstract itself.

Graphical abstract
Although a graphical abstract is optional, its use is encouraged as it draws more attention to the online article. The graphical abstract should summarize the contents of the article in a concise, pictorial form designed to capture the attention of a wide readership. Graphical

abstracts should be submitted as a separate file in the online submission system. Image size: Please provide an image with a minimum of 531 × 1328 pixels (h × w) or proportionally more. The image should be readable at a size of 5 × 13 cm using a regular screen resolution of 96 dpi. Preferred file types: TIFF, EPS, PDF or MS Office files. You can view Example Graphical Abstracts on our information site.
Authors can make use of Elsevier's Illustration and Enhancement service to ensure the best presentation of their images and in accordance with all technical requirements: Illustration Service.

Highlights
Highlights are mandatory for this journal. They consist of a short collection of bullet points that convey the core findings of the article and should be submitted in a separate editable file in the online submission system. Please use 'Highlights' in the file name and include 3 to 5 bullet points (maximum 85 characters, including spaces, per bullet point). You can view example Highlights on our information site.

Keywords

Immediately after the abstract, provide a maximum of 6 keywords, using American spelling and avoiding general and plural terms and multiple concepts (avoid, for example, 'and', 'of'). Be sparing with abbreviations: only abbreviations firmly established in the field may be eligible. These keywords will be used for indexing purposes.

Acknowledgements
Collate acknowledgements in a separate section at the end of the article before the references and do not, therefore, include them on the title page, as a footnote to the title or otherwise. List here those individuals who provided help during the research (e.g., providing language help, writing assistance or proof reading the article, etc.).

Formatting of funding sources
List funding sources in this standard way to facilitate compliance to funder's requirements:

Funding: This work was supported by the National Institutes of Health [grant numbers xxxx, yyyy]; the Bill & Melinda Gates Foundation, Seattle, WA [grant number zzzz]; and the United States Institutes of Peace [grant number aaaa].

It is not necessary to include detailed descriptions on the program or type of grants and awards. When funding is from a block grant or other resources available to a university, college, or other research institution, submit the name of the institute or organization that provided the funding.

If no funding has been provided for the research, please include the following sentence:

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Plant names
Authors and editors are, by general agreement, obliged to accept the rules governing biological nomenclature, as laid down in the *International Code of Botanical Nomenclature.*

Math formulae
Please submit math equations as editable text and not as images. Present simple formulae in line with normal text where possible and use the solidus (/) instead of a horizontal line for small fractional terms, e.g., X/Y. In principle, variables are to be presented in italics. Powers of e are often more conveniently denoted by exp. Number consecutively any equations that have to be displayed separately from the text (if referred to explicitly in the text).

Footnotes
Footnotes should be used sparingly. Number them consecutively throughout the article. Many word processors build footnotes into the text, and this feature may be used. Should this not be the case, indicate the position of footnotes in the text and present the footnotes themselves separately at the end of the article.

Artwork

Electronic artwork
General points
• Make sure you use uniform lettering and sizing of your original artwork.
• Preferred fonts: Arial (or Helvetica), Times New Roman (or Times), Symbol, Courier.
• Number the illustrations according to their sequence in the text.
• Use a logical naming convention for your artwork files.
• Indicate per figure if it is a single, 1.5 or 2-column fitting image.
• For Word submissions only, you may still provide figures and their captions, and tables within a single file at the revision stage.
• Please note that individual figure files larger than 10 MB must be provided in separate source files.
A detailed guide on electronic artwork is available.
You are urged to visit this site; some excerpts from the detailed information are given here.
Formats
Regardless of the application used, when your electronic artwork is finalized, please 'save as' or convert the images to one of the following formats (note the resolution requirements for line drawings, halftones, and line/halftone combinations given below):
EPS (or PDF): Vector drawings. Embed the font or save the text as 'graphics'.
TIFF (or JPG): Color or grayscale photographs (halftones): always use a minimum of 300 dpi.
TIFF (or JPG): Bitmapped line drawings: use a minimum of 1000 dpi.
TIFF (or JPG): Combinations bitmapped line/half-tone (color or grayscale): a minimum of 500 dpi is required.
Please do not:
• Supply files that are optimized for screen use (e.g., GIF, BMP, PICT, WPG); the resolution is too low.
• Supply files that are too low in resolution.
• Submit graphics that are disproportionately large for the content.

Color artwork
Please make sure that artwork files are in an acceptable format (TIFF (or JPEG), EPS (or PDF), or MS Office files) and with the correct resolution. If, together with your accepted article, you submit usable color figures then Elsevier will ensure, at no additional charge, that

these figures will appear in color online (e.g., ScienceDirect and other sites) regardless of whether or not these illustrations are reproduced in color in the printed version. **For color reproduction in print, you will receive information regarding the costs from Elsevier after receipt of your accepted article**. Please indicate your preference for color: in print or online only. Further information on the preparation of electronic artwork.

Figure captions

Ensure that each illustration has a caption. A caption should comprise a brief title (**not** on the figure itself) and a description of the illustration. Keep text in the illustrations themselves to a minimum but explain all symbols and abbreviations used.

Tables

Please submit tables as editable text and not as images. Tables can be placed either next to the relevant text in the article, or on separate page(s) at the end. Number tables consecutively in accordance with their appearance in the text and place any table notes below the table body. Be sparing in the use of tables and ensure that the data presented in them do not duplicate results described elsewhere in the article. Please avoid using vertical rules.

References

Citation in text

Please ensure that every reference cited in the text is also present in the reference list (and vice versa). Any references cited in the abstract must be given in full. Unpublished results and personal communications are not recommended in the reference list, but may be mentioned in the text. If these references are included in the reference list they should follow the standard reference style of the journal and should include a substitution of the publication date with either 'Unpublished results' or 'Personal communication'. Citation of a reference as 'in press' implies that the item has been accepted for publication.

Regular research papers have a reference limit of 50 cites and short communications should not exceed 20 cites.

Reference links

Increased discoverability of research and high quality peer review are ensured by online links to the sources cited. In order to allow us to create links to abstracting and indexing services, such as Scopus, CrossRef and PubMed, please ensure that data provided in the references are correct. Please note that incorrect surnames, journal/book titles, publication year and pagination may prevent link creation. When copying references, please be careful as they may already contain errors. Use of the DOI is encouraged.

A DOI can be used to cite and link to electronic articles where an article is in-press and full citation details are not yet known, but the article is available online. A DOI is guaranteed never to change, so you can use it as a permanent link to any electronic article. An example of a citation using DOI for an article not yet in an issue is: VanDecar J.C., Russo R.M., James D.E., Ambeh W.B., Franke M. (2003). Aseismic continuation of the Lesser Antilles slab beneath northeastern Venezuela. Journal of Geophysical Research, http://dx.doi.org/10.1029/2001JB000884i. Please note the format of such citations should be in the same style as all other references in the paper.

Web references
As a minimum, the full URL should be given and the date when the reference was last accessed. Any further information, if known (DOI, author names, dates, reference to a source publication, etc.), should also be given. Web references can be listed separately (e.g., after the reference list) under a different heading if desired, or can be included in the reference list.

References in a special issue
Please ensure that the words 'this issue' are added to any references in the list (and any citations in the text) to other articles in the same Special Issue.

Reference management software
Most Elsevier journals have their reference template available in many of the most popular reference management software products. These include all products that support Citation Style Language styles, such as Mendeley and Zotero, as well as EndNote. Using the word processor plug-ins from these products, authors only need to select the appropriate journal template when preparing their article, after which citations and bibliographies will be automatically formatted in the journal's style. If no template is yet available for this journal, please follow the format of the sample references and citations as shown in this Guide.

Users of Mendeley Desktop can easily install the reference style for this journal by clicking the following link:
http://open.mendeley.com/use-citation-style/journal-of-arid-environments
When preparing your manuscript, you will then be able to select this style using the Mendeley plug-ins for Microsoft Word or LibreOffice.

Reference formatting
There are no strict requirements on reference formatting at submission. References can be in any style or format as long as the style is consistent. Where applicable, author(s) name(s), journal title/book title, chapter title/article title, year of publication, volume number/book chapter and the pagination must be present. Use of DOI is highly encouraged. The reference style used by the journal will be applied to the accepted article by Elsevier at the proof stage. Note that missing data will be highlighted at proof stage for the author to correct. If you do wish to format the references yourself they should be arranged according to the following examples:

Reference style
Text: All citations in the text should refer to:
1. *Single author:* the author's name (without initials, unless there is ambiguity) and the year of publication;
2. *Two authors:* both authors' names and the year of publication;
3. *Three or more authors:* first author's name followed by 'et al.' and the year of publication.
Citations may be made directly (or parenthetically). Groups of references should be listed first alphabetically, then chronologically.
Examples: 'as demonstrated (Allan, 2000a, 2000b, 1999; Allan and Jones, 1999). Kramer et al. (2010) have recently shown ....'

List: References should be arranged first alphabetically and then further sorted chronologically if necessary. More than one reference from the same author(s) in the same year must be identified by the letters 'a', 'b', 'c', etc., placed after the year of publication.
Examples:
Reference to a journal publication:
Van der Geer, J., Hanraads, J.A.J., Lupton, R.A., 2010. The art of writing a scientific article. J. Sci. Commun. 163, 51–59.
Reference to a book:
Strunk Jr., W., White, E.B., 2000. The Elements of Style, fourth ed. Longman, New York.
Reference to a chapter in an edited book:
Mettam, G.R., Adams, L.B., 2009. How to prepare an electronic version of your article, in: Jones, B.S., Smith , R.Z. (Eds.), Introduction to the Electronic Age. E-Publishing Inc., New York, pp. 281–304.
Reference to a website:
Cancer Research UK, 1975. Cancer statistics reports for the UK. http://www.cancerresearchuk.org/aboutcancer/statistics/cancerstatsreport/ (accessed 13.03.03).

Please note that Journal names and references should be provided in full.

Video

Elsevier accepts video material and animation sequences to support and enhance your scientific research. Authors who have video or animation files that they wish to submit with their article are strongly encouraged to include links to these within the body of the article. This can be done in the same way as a figure or table by referring to the video or animation content and noting in the body text where it should be placed. All submitted files should be properly labeled so that they directly relate to the video file's content. In order to ensure that your video or animation material is directly usable, please provide the files in one of our recommended file formats with a preferred maximum size of 150 MB. Video and animation files supplied will be published online in the electronic version of your article in Elsevier Web products, including ScienceDirect. Please supply 'stills' with your files: you can choose any frame from the video or animation or make a separate image. These will be used instead of standard icons and will personalize the link to your video data. For more detailed instructions please visit our video instruction pages. Note: since video and animation cannot be embedded in the print version of the journal, please provide text for both the electronic and the print version for the portions of the article that refer to this content.

Supplementary material

Supplementary material can support and enhance your scientific research. Supplementary files offer the author additional possibilities to publish supporting applications, high-resolution images, background datasets, sound clips and more. Please note that such items are published online exactly as they are submitted; there is no typesetting involved (supplementary data supplied as an Excel file or as a PowerPoint slide will appear as such online). Please submit the material together with the article and supply a concise and descriptive caption for each file. If you wish to make any changes to supplementary data during any stage of the process, then please make sure to provide an updated file, and do not annotate any corrections on a previous version. Please also make sure to switch off the 'Track Changes' option in any Microsoft Office files as these will appear in the published supplementary file(s). For more detailed instructions please visit our artwork instruction pages.

Database linking

Elsevier encourages authors to connect articles with external databases, giving readers access to relevant databases that help to build a better understanding of the described research. Please refer to relevant database identifiers using the following format in your article: Database: xxxx (e.g., TAIR: AT1G01020; CCDC: 734053; PDB: 1XFN). More information and a full list of supported databases.

ARTICLE ENRICHMENTS

AudioSlides

The journal encourages authors to create an AudioSlides presentation with their published article. AudioSlides are brief, webinar-style presentations that are shown next to the online article on ScienceDirect. This gives authors the opportunity to summarize their research in their own words and to help readers understand what the paper is about. More information and examples are available. Authors of this journal will automatically receive an invitation e-mail to create an AudioSlides presentation after acceptance of their paper.

Google Maps and KML files

KML (Keyhole Markup Language) files (optional): You can enrich your online articles by providing KML or KMZ files which will be visualized using Google maps. The KML or KMZ files can be uploaded in our online submission system. KML is an XML schema for expressing geographic annotation and visualization within Internet-based Earth browsers. Elsevier will generate Google Maps from the submitted KML files and include these in the article when published online. Submitted KML files will also be available for downloading from your online article on ScienceDirect. More information.

Interactive plots

This journal enables you to show an Interactive Plot with your article by simply submitting a data file. Full instructions.

After Acceptance

Online proof correction

Corresponding authors will receive an e-mail with a link to our online proofing system, allowing annotation and correction of proofs online. The environment is similar to MS Word: in addition to editing text, you can also comment on figures/tables and answer questions from the Copy Editor. Web-based proofing provides a faster and less error-prone process by allowing you to directly type your corrections, eliminating the potential introduction of errors. If preferred, you can still choose to annotate and upload your edits on the PDF version. All

instructions for proofing will be given in the e-mail we send to authors, including alternative methods to the online version and PDF.
We will do everything possible to get your article published quickly and accurately. Please use this proof only for checking the typesetting, editing, completeness and correctness of the text, tables and figures. Significant changes to the article as accepted for publication will only be considered at this stage with permission from the Editor. It is important to ensure that all corrections are sent back to us in one communication. Please check carefully before replying, as inclusion of any subsequent corrections cannot be guaranteed. Proofreading is solely your responsibility.

Offprints

The corresponding author will, at no cost, receive a customized Share Link providing 50 days free access to the final published version of the article on ScienceDirect. The Share Link can be used for sharing the article via any communication channel, including email and social media. For an extra charge, paper offprints can be ordered via the offprint order form which is sent once the article is accepted for publication. Both corresponding and co-authors may order offprints at any time via Elsevier's Webshop. Corresponding authors who have published their article open access do not receive a Share Link as their final published version of the article is available open access on ScienceDirect and can be shared through the article DOI link.

Author Inquiries

Visit the Elsevier Support Center to find the answers you need. Here you will find everything from Frequently Asked Questions to ways to get in touch.
You can also check the status of your submitted article or find out when your accepted article will be published.

Appendix B: Photography Points

Site Number	Farm Name	Latitude	Longitude	Direction Faced	Date Taken
1	**Erichsfelde**	-21.59435	016.90000	SW	29/03/2016
2	**Erichsfelde**	-21.61887	016.91187	W	30/03/2016
3	**Gamsberg**	-23.36324	016.30281	E	18/07/2016
4	**Gamsberg**	-23.36312	016.30263	W	18/07/2016
5	**Gamsberg**	-23.37173	016.29834	SSW	18/07/2016
6	**Weener**	-23.38212	016.29016	N	18/07/2016
7	**Weener**	-23.38272	016.28964	E	18/07/2016
8	**Weener**	-23.38298	016.28935	SSE	18/07/2016
9	**Weener**	-23.38298	016.28933	S	18/07/2016
10	**Weener**	-23.38577	016.28758	S	18/07/2016
11	**Weener**	-23.41130	016.25142	SW	19/07/2016
12	**Weener**	-23.41133	016.25139	S	19/07/2016
13	**Weener**	-23.40935	016.25493	SW	19/07/2016
14	**Weener**	-23.40996	016.24995	SW	19/07/2016