Environmental change in Riemvasmaak 10 years after re-settlement

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SUMMARY

- In 1995, people who were forcibly removed from Riemvasmaak in 1974 returned to their land in one of the first land restitution cases after the democratically-elected government came into power in 1994. FARM-Africa, who assisted the Riemvasmaak families for several years after their return, commissioned the then National Botanical Institute to conduct a survey of the roughly 75,000 ha region immediately prior to this event.
- The objectives of this first survey were to assess the agricultural potential of Riemvasmaak and to develop a monitoring programme for the region. To do this the vegetation within four main landforms at 29 sites in Riemvasmaak was sampled over a two week period in January 1995 and panoramic photographs were taken at these sites. Wildlife abundance was also recorded in this initial survey.
- In 2004 FARM-Africa approached Timm Hoffman, Director of the Leslie Hill Institute for Plant Conservation in the Botany Department at the University of Cape Town, to repeat the survey. The objective of this work was primarily to assess the impact of 10 years of land use on the vegetation of the region. The repeat survey was carried out between 9-17 January 2005. The same sampling approach was adopted for the second survey. Repeat photographs were taken from the same locations as in 1995 using the same cameras and film as the earlier survey. The same landforms were sampled using the same approach as in 1995.
- Unlike in 1995, the repeat survey found evidence of human settlement throughout the region, especially in the flatter, low-lying areas. Distinct piospheres have developed around several homesteads and these are likely to increase in future. The plateau, however, has still not been settled.
- Wildlife has declined significantly since 1995, particularly the number of Klipspringer (89 individuals recorded in 1995 and only 2 in 2005) and Kudu (48 in 1995, none in 2005). Many of the smaller mammals such as ground squirrels, mongoose and dassies have also declined. However, more baboons were recorded in 2005 (60 individuals) than in 1995 (6 individuals).
- An analysis of the repeat photographs shows little difference in the tree component at Riemvasmaak between 1995 and 2005 except for an increase in size and number of some species (particularly *Acacia mellifera*) and the appearance of a distinct browse line in others including *A. mellifera*. There is evidence from the photographs that medium shrubs (0.25-1.5 m in height) (e.g. *Monechma spartioides*) have declined in abundance since 1995. The most significant change from the photographs, however, has been the decline in grass cover since 1995. This is very clear for areas on the sandy pediments and less so for the rocky foot slopes and pediments.
- The photographs also provide evidence of a general homogenization of the landscape particularly the sandy bottomlands. Where a braided stream network existed in 1995, with different plant species occurring in distinct patterns across the landscape, the impact of trampling has reduced these sandy pediments to a wide, open and homogenous plain with very low cover, particularly of grasses.
- The more detailed vegetation surveys provide quantitative evidence for the decline in different growth forms in Riemvasmaak since 1995. The data for all 29 photostations

are synthesised in a single table and show that the sandy pediments have changed the most in cover since 1995. Vegetation cover on this landform has been almost halved from nearly 30 % in 1995 to less than 15% in 2005. Most of this decline is as a result of a decline in grass cover from just over 15% in 1995 to about 3.5% in 2005. Medium shrubs have also declined on the sandy pediments. Trees, however, show no significant change in any of the land forms over the 10 years.

- The diversity of plant species appears not to have been affected by land use practices in the last 10 years although the long-term viability of palatable species is uncertain.
- Reasons for the changes, particularly in grass cover on the sandy pediments are discussed. Between 1995 and 2005 annual and seasonal rainfall totals have not declined and the slope of the trend line is close to zero. Rainfall, therefore seems not to be an important reason for the changes observed. Stock numbers on the other hand have increased more than six fold since 1995 from 183 Large Stock Units to 1,122 LSU in 2005. However, long-term carrying capacity estimates suggest that the region could support up to 1,028 LSU and this number was exceeded for the first time in 2005 only. More than a quarter of the LSU total is comprised of donkeys which now number 450 animals.
- The main conclusion from this study therefore is that it has been the concentration of domestic livestock on the sandy pediments that has been responsible for most of the changes evident in the landscape and particularly in the grassy component of the vegetation between 1995 and 2005.
- The suggestion is that much of the growth seen in livestock numbers between 1995 and 2005 is due to the high quality of grazing that was present when the displaced communities returned to the area. During the intervening decade, much of the 'natural capital' that was accumulated during the twenty-year period prior to 1995 has been reduced. It is doubtful that current high levels of utilisation are sustainable, particular for the sandy pediments.
- The prediction from this analysis is that livestock owners will become more vulnerable to drought in the next 10 years and beyond as the edible perennial component of the vegetation has been significantly reduced since 1995. There will probably also be an increased emphasis on goats as they are less reliant on grass for their survival than cattle and sheep and are also better able to exploit the vegetation of the more inaccessible rocky slopes.
- The Riemvasmaak donkey population needs to be managed actively. Difficult decisions will need to be made about the excess or unused animals otherwise their numbers will continue to rise. Their uncontrolled increase could compromise the livelihoods of those who rely on livestock for an income as they compete with commercially important animals for forage.
- Unless actively managed or controlled, stock numbers will probably continue to increase in the next 10 years to values close to 2,000 LSU. The challenge for livestock owners is to manage in a sustainable way, the productive, yet more vulnerable sandy pediments which have provided much of the natural capital for the industry in the last 10 years.

BACKGROUND TO THE 2005 SURVEY

In one of the first land restitution cases in the new democratic South Africa, the Commission on Land Allocation decided in 1993 that the people who were forcibly removed from Riemvasmaak in 1974 should be allowed to return to their land. From January 1995 onwards many people returned to Riemvasmaak from Namibia, the eastern Cape in South Africa and from the Orange River region where they had been relocated.

However, people returned to very little in terms of infrastructure and economy and had to rebuild their lives after a 20 year absence from the region. Between 1974 and 1994 the South African Defence Force had used the area as a training ground for its troops and artillery and left very little when it departed in 1994 except the ruins of homesteads and neglected grave sites. Several development organisations assisted the Riemvasmaak community in rebuilding their lives and their economy.

One such organisation was FARM-Africa, a UK-based agricultural development organisation, which was active in Riemvasmaak during the immediate post-1995 period. In planning their initial activities, FARM-Africa approached the National Botanical Institute to conduct a baseline survey of the natural resources of Riemvasmaak and develop a monitoring programme for the region. This was carried out by a small team of biologists led by Timm Hoffman between 16-30 January 1995. The findings of this initial survey are detailed in an unpublished 222 page report (see Hoffman *et al.* (1995)) which contains a synthesis of the historical and biological literature of Riemvasmaak and provides a detailed account of the natural resources of the region. Its lasting contribution is the set of 29 photostations established as part of the January 1995 survey. These sites provide a detailed photographic panorama of each location and a relatively comprehensive survey of the abundance of species in each main landform in one view from each site.

In order to assess the impact of 10 years of land use on the natural resources of Riemvasmaak, FARM-Africa commissioned a resurvey of the region. This report presents the main findings from the resurvey and provides a complete set of matched repeat photographs and survey data. Details of the impact of resettlement on wildlife

abundance are also outlined. Finally, the implications of these findings are briefly discussed.

APPROACH

For the purposes of the 2005 survey Riemvasmaak was visited during 9-17 January 2005. An itinerary of this field trip is provided in Appendix 1. Site selection for the 29 photostations and background to the sampling approach adopted in the 1995 baseline survey are described in Hoffman *et al.* (1995). We re-photographed the 29 photostations in 2005 using the same three cameras (Mamiya 645; Minolta X300S, Minolta X70) that were used in the 1995 survey. In addition to these three cameras we also used a Nikon Coolpix E995 digital camera. The photographs were all taken by Timm Hoffman, using the same lenses and the same film in each camera (Ilford FP4Plus for the black and white images (ASA 125) and Fujichrome Sensia 35 mm colour slide film (ASA 100)). The same tripod was also used at each photostation and was positioned above the rock cairn and metal dropper left to the mark the original 1995 photographic site. At 11 of the sites the dropper had disappeared but the rock cairn made it possible to relocate the image with ease in most instances. In addition, a print of the main view as well as the full panorama taken in 1995 enabled an accurate match of the earlier image. Where possible we tried to take each photograph at more or less the same time of day as the original 1995 image. Weather conditions on 11-13 January 2005, however, were overcast and an exact match therefore seemed less important.

At each photostation we also sampled the vegetation in each of the different landforms using photocopies of the original data sheets to guide our assessments of the observed changes in species cover. These were largely carried out by Simon Todd after an initial orientation of the method used. The main landform sampling units and the direction of the sampling transect were discussed at the photostation prior to sampling. Information from these transects was synthesised largely by John Duncan to assess the main trends in vegetation change at Riemvasmaak since 1995.

MAIN FINDINGS

Human settlement in Riemvasmaak

Apart from one livestock farmer near Bokseputs, we encountered few people during our 1995 survey since we had surveyed the area immediately prior to the return of the Riemvasmakers. This was not the case in 2005. Except for the plateau region, almost everywhere we travelled in 2005 there were signs of human settlement either in the form of working homesteads, abandoned kraals, boreholes or mines. It was only towards Xubuxnap beyond the Molopo turnoff (around photostations 8-11) that the intensity of human settlement declined somewhat. Even here, however, stockposts were located within a few km of all the photostations and signs of domestic livestock grazing were evident. We did not see any settlements on the plateau region although a few water points were observed. The very stony environment, poor water provision and poor grazing might have discouraged settlement of this area.

The road infrastructure has improved considerably in the 10 years since the initial survey and a reasonably well-maintained network of roads now occurs where a single, poorly maintained track existed in the past. The presence of two quartz mines in the Donkiemond region (near photostations 17 and 18) has also increased the presence of people in the north western portion of Riemvasmaak.

Impacts on wildlife

The number of wild ungulates recorded in Riemvasmaak in 2005 was spectacularly lower than the number recorded in 1995 (Table 1). While people we spoke to indicated that Gemsbok (*Oryx gazella*) and Kudu (*Tragelaphus strepsiceros*) are still present in Riemvasmaak, we did not see any individuals of these species. Kudu dung was, however, recorded near the Orange River close to Photostation 10. It seems likely that Riemvasmaak is no longer a source of wild ungulates but is instead a sink. Local testimony suggests that wild ungulates move freely between Namibia and Riemvasmaak

and are influenced by the level of hunting that occurs on either side. When the Namibians hunt, the Riemvasmaak ungulate populations increase as the animals escape the region and vice versa.

Table 1. Number of individuals of wild ungulates and domestic livestock in Riemvasmaak recorded by the survey teams in January 1995 and January 2005.

	No. individuals	
	1995	2005
Wild ungulates		
Springbok (*Antidorcas masupialis*)	4	0
Klipspringer (*Oreotragus oreotragus*)	89	2
Steenbok (*Raphicerus campestris*)	4	1
Kudu (*Tragelaphus strepsiceros*)	48	0
Domestic livestock (See also Table 3)		
Cattle	12	57
Goats and Sheep	494	1617
Donkeys	24	49
Horses	3	29

In addition to the ungulate species listed in Table 1, a few of the following small mammals were also seen in 1995: Ground squirrel (*Xerus inaurus*) (4 individuals seen in 1995), African wildcat (*Felis lybica*) (1), Black-backed jackal (*Canis mesomelas*) (2), Yellow mongoose (*Cynictis penicillata*) (1), Small grey mongoose (*Galerella pulverulenta*) (3). None of these species were recorded in 2005. While we did not specifically count the number of rock dassie (*Procavia capensis*) in 2005, they were very

rarely seen and less than 10 individuals were observed during the eight days in the field compared with the 75 individuals recorded in 1995. The only wild mammal species for which an increase in number was recorded was baboons (*Papio ursinus*). Six individuals were recorded in 1995 while this number had increased to 60 in 2005. These individuals were observed in two troops, both of which were recorded within sight of human settlements.

Domestic livestock have increased significantly since January 1995 (Table 1 & Table 3). Unpublished records for Riemvasmaak provided by Mr Steenkamp in June 2005 indicate that the entire region now supports 505 head of cattle, 1100 goats, 510 sheep and 450 donkeys (see later). The number of horses was not listed in this data set.

Vegetation change: 1995-2005

Matched photographs

The location of the 29 photostations established in 1995 is shown in Figure 1 and is taken from Hoffman *et al.* (1995). The original (1995) and repeat (2005) photographs with their extended captions and the cover of each growth form within different landforms are shown in Appendix 2. Together, these data provide a record of the major changes in the landscape since people returned to the region in 1995. A quantitative analysis of the photographs is beyond the scope of this report but qualitative impressions can be gained from studying the images. The main points shown by the matched photo pairs are as follows:

- Although there has been very little change in tree cover between 1995 and 2005 occasionally individual trees have disappeared (e.g. *Boscia albitrunca* at Photostation 12; *Acacia mellifera* at Photostation 24) and there is evidence of turnover in some species. This is particularly true for *Acacia mellifera* which has recruited significantly at some sites. Most individuals have also grown noticeably larger over the 10 years, which is enough time for an individual to recruit and grow to a

reproductive adult taller than 2 m (see foreground in Photostation 26, for example). In many species, including the spiny *Acacia mellifera*, a distinct browse line has appeared at the base of many individuals since 1995 (Figure 2, see also Photostation 11). This represents a significant removal of biomass from the landscape over the 10 years.

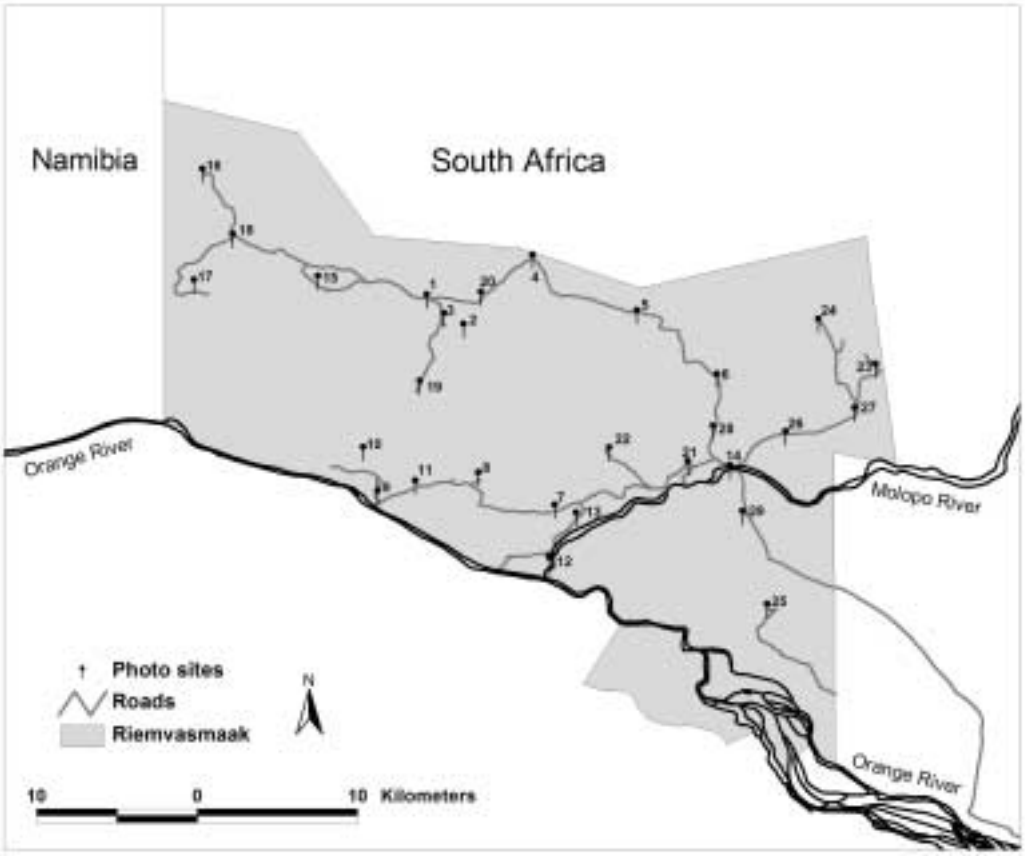

Figure 1. The location of the 29 photostations in Riemvasmaak.

- In most repeat photo pairs there has been a reduction, largely through grazing, in the number and size of medium and large shrubs such as *Monechma spartioides*, *Phaeoptilum spinosum* and *Zygophyllum suffriticosum* (Figure 3). *Monechma spartioides* in particular has declined significantly throughout Riemvasmaak. In 1995

it was the most dominant shrub but has been grazed to a stump at many locations (Figure 4).

- Populations of the ungrazed stem succulent *Euphorbia gregaria* are dynamic and a large turnover in individuals of this species is apparent in many of the recent photographs. In some locations (e.g. Photostation 7) clear evidence of the burning of living adult plants was noticed during the 2005 field survey and the reasons for and impact of this practice on populations of this species is not known.
- Grass cover has declined significantly since 1995. This is the most noticeable change seen in the matched photo pairs (Figures 3 & 4). While grass tufts are still commonly observed in the 2005 photographs, their basal and especially their canopy cover has declined significantly. This is clearly evident around homesteads and kraal sites and at sites close to the Orange River (e.g. Photostation 9). Annual and summer rainfall totals have not been particularly low in the last 10 years (see later) and although the role of termites also needs to be considered, the largest impact is without a doubt that of grazing by domestic livestock. In 1995 *Stipagrostis uniplumis* dominated Riemvasmaak but in 2005 we saw very few tussocks that hadn't been grazed, even at relatively remote locations.
- One exception to this general trend is found at Photostation 18 (Figure 5). It is unclear why this has occurred but the basal cover of *Stipagrostis hochstetteriana* on the foreground sandy pediment has increased significantly since 1995. This species generally appears more resilient to grazing than most other grasses in the region (with the exception perhaps of *S. namaquensis*). At nearly all sites where it occurred in 1995 it did not decline to the same extent as finer, more palatable grasses such as *S. uniplumis*, *S. anomela*, *S. ciliata*, *S. obtusa* and *Enneapogon scaber*. This is the only site, however, where *S. hochstetteriana* visibly increased in cover.
- Distinct piospheres have developed around homesteads and settlements. Besides the areas immediately adjacent to the Riemvasmaak (Photostations 14 & 28) and Vredevallei (Molopo River) (Photostation 12) settlements themselves, the region north of Berylkop (Photostation 6) has also been heavily impacted by a number of stockposts in this area. While still relatively localised, these piospheres will undoubtedly expand over the coming years.

- The flat, sandy lowlands are clearly more heavily impacted that the rocky slopes. This is because homesteads, kraals and water points all occur on the lowlands. The only place where this doesn't apply is on the plateau where water supply is more limited. This phenomenon is not unique to Riemvasmaak but occurs throughout the world: flat, low-lying areas have been more transformed than rocky, mountainous upland areas.
- There appears to have been a general homogenization of the landscape since the return of people to Riemvasmaak in 1995, which is evident from a comparison of the matched photo pairs. Minor drainage lines on the sandy pediments in particular have been targeted by grazers and the cover of grasses has been reduced over the last decade. Where the landscape was previously characterized by an extensive braided stream network (e.g. Photostations 9 and 11), this has been homogenized by the extensive trampling and grazing effects of domestic livestock in the region (Figure 6; see also Figure 3 & 4). In 1995 the grassy interfluves between the main stream beds were characterized by small stream channels which coalesced and then separated again. This braided network of rivulets and streams sorted sand particle sizes which controlled to some extent the abundance and pattern of the three or four dominant grasses occurring on the sandy pediments. For example, the coarse sand particles in larger river channels favoured the dominance of *Stipagrostis namaquensis* while *S. uniplumis* and *S. hochstetteriana* sorted themselves according to soil depth, particle size and slope at sites away from the larger river channels. *Schmidtia kalahariensis* generally dominated the small ridges between the stream channels at some sites. These patterns were very clear both on the ground but also to some extent in the 1995 photographs. This fine-scale pattern has now disappeared and the impact of trampling and grazing has left a more homogenous imprint on the landscape. This is particularly evident close to homesteads but the impact is also noticed several kilometres from kraal sites.

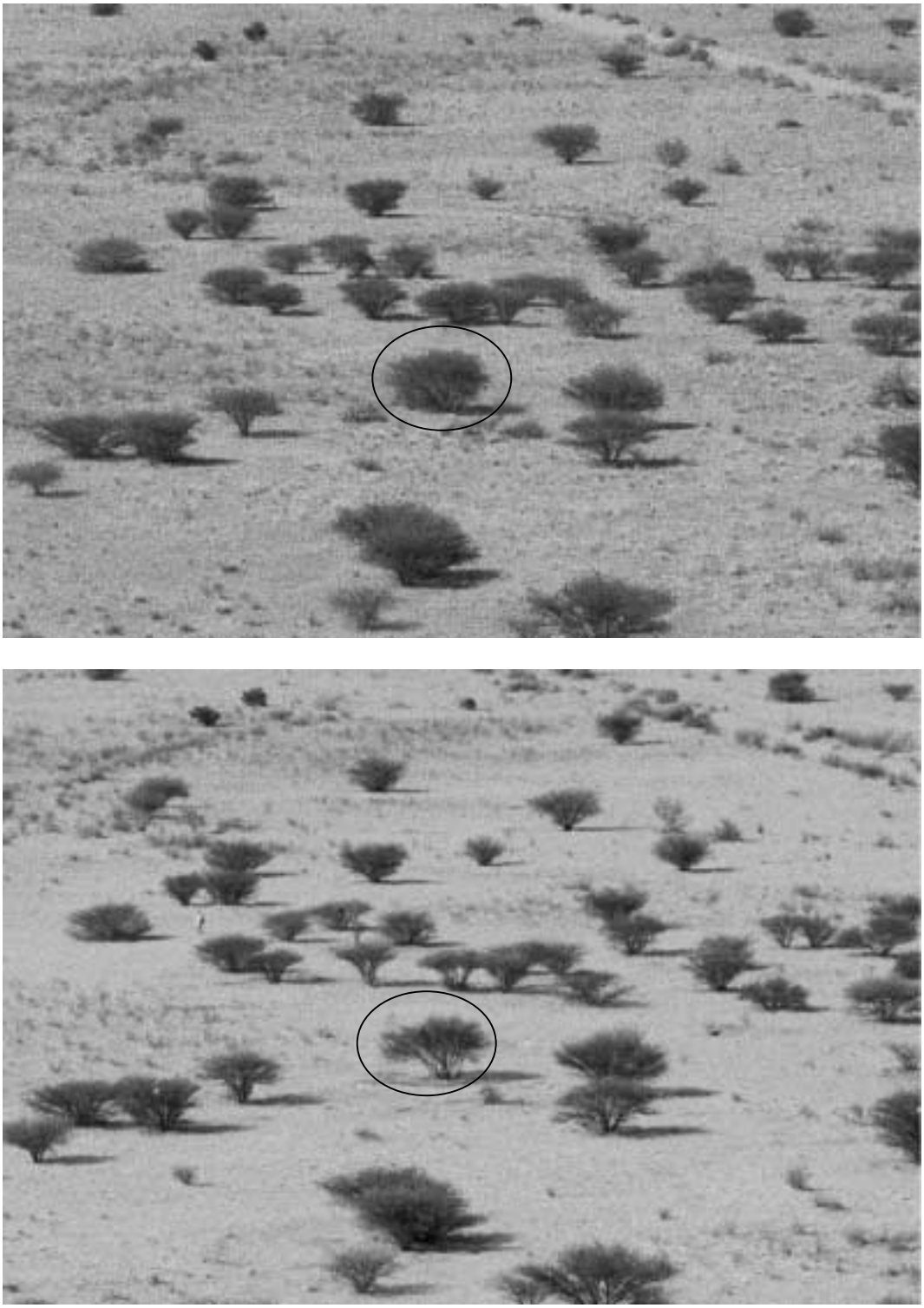

Figure 2. The creation of a distinct browse line at the base of most large shrubs and trees is clearly shown in these Acacia mellifera individuals *at Photostation 27 where the top photograph was taken in 1995 and the bottom photograph in 2005.*

Figure 3. Reduction in grass, shrub and tree biomass between 1995 (top) and 2005 (bottom) at Photostation 11 near the Orange River at Xubuxnap,Riemvasmaak.

Figure 4. Reduction in shrub and grass cover along a stream channel at Photostation 11. Dominant shrubs such as Monechma spartioides *and grasses such as* Stipagrostis uniplumis *have decreased in cover between 1995 (top) and 2005 (bottom) although the stumps of some individuals remain. This site is within a few hundred metres of a stockpost at Xubuxnap, Riemvasmaak.*

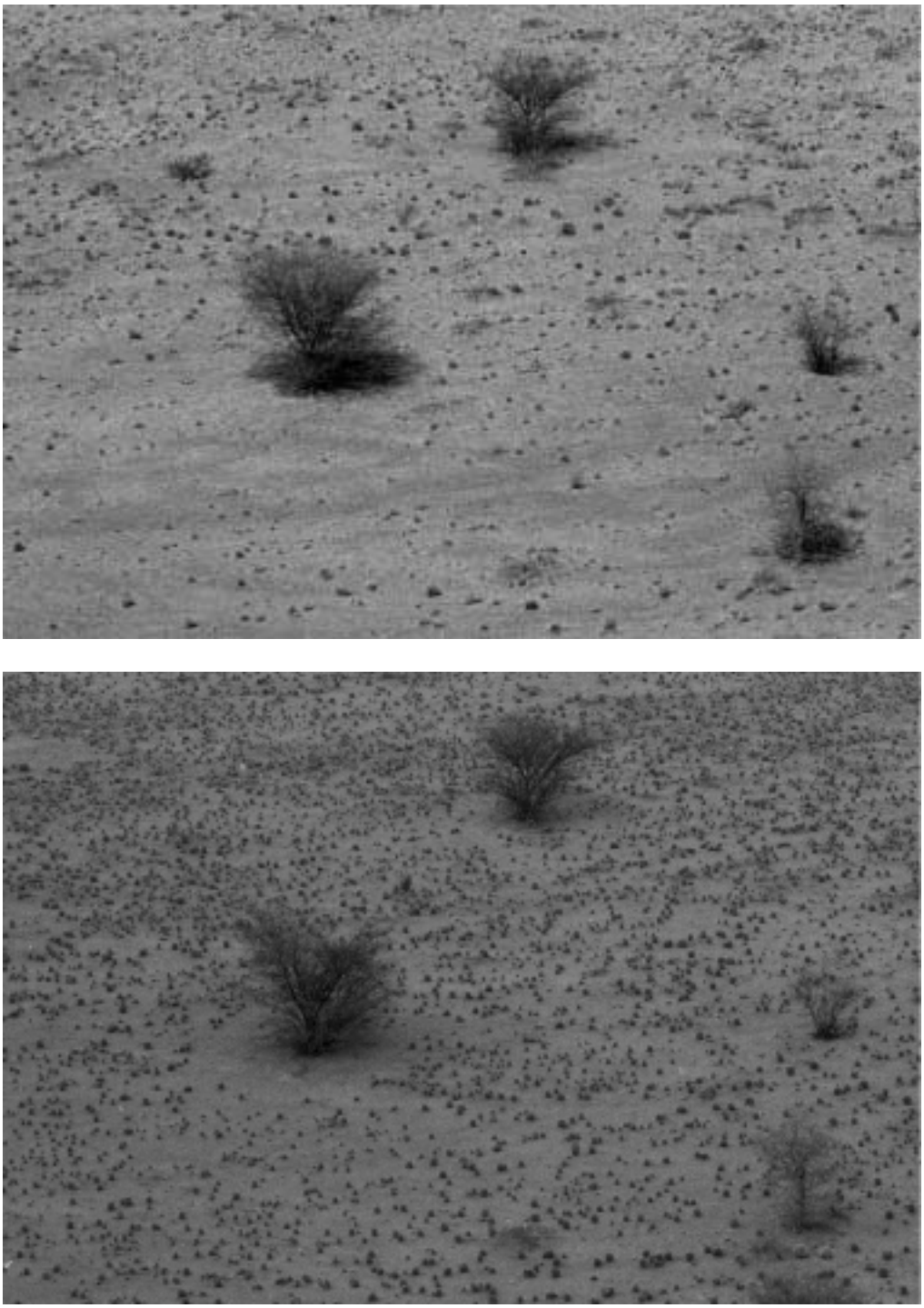

Figure 5. This is one of the few sites where grass cover at Riemvasmaak has increased since 1995 (top). This close-up view represents a portion of Photostation 18 which is located close to a stockpost and mine. For reasons that are difficult to explain, Stipagrostis hochstetteriana *shows a significant increase in basal cover at this site.*

Figure 6. Homogenisation of the braided stream network at Photostation 9 near Xubuxnap between 1995 (top) and 2005 (bottom) as a result of the trampling and grazing effects of livestock. The top photograph shows an extensive network of minor and major streams with different grass species (e.g. Stipagrostis uniplumis, S. hochstetteriana, S. namaquensis, Schmidtia kalahariensis*) distributed on this pediment largely according to soil depth and particle size characteristics. In the bottom photograph this fine-scale patterning is only weakly evident.*

Survey data

Details of the changes in each growth form within each landform at each photostation are shown in Appendix 2 while a synthesis of the key findings observed in the survey data are shown in Table 2. The main points are:

- The growth forms which comprise the greatest cover are grasses (e.g. *Stipagrostis uniplumis, S. hochstetteriana, Enneapogon scaber*), medium shrubs (0.25-1.5 m in height) (e.g. *Monechma spartioides, Rhigozum trichotomum, Zygophyllum microcarpum*), stem succulents (especially *Euphorbia gregaria*) and trees (e.g. *Acacia mellifera, A. erioloba, Boscia foetida*). Annuals/forbs, low shrubs (<0.25 m), tall shrubs (>1.5 m) and leaf succulents seldom make up a significant proportion of the total cover at a site and are not discussed further.
- There has been a reduction in total plant cover in all landforms since 1995. This reduction is greatest for sandy pediments and inselbergs where grass species dominated in the past and less so for rocky slopes and pediments, river channels and the plateau sites. Total cover has almost halved on the sandy pediments, largely because of the reduction in the cover of grasses and medium shrubs.
- At most sites and in most landforms, the cover of trees and stem succulents has not changed significantly. The most dynamic tree species are *Acacia mellifera* and *Tamrix usneiodes* which have both increased and decreased at different sites. Although tree cover has been relatively unaffected, most trees now display a distinctive browse line (Figure 2). In 1995 tree branches hung low towards the ground. In 2005, most branches within reach of livestock have been grazed bare, resulting in trees taking on a more ‘umbrella-like’ shape.
- There is a general decrease in the impact of grazing on individual plants with increasing plant height. Annuals/forbs and particularly grasses appear to be the most negatively affected by heavy grazing impact while large shrubs and trees are the least affected. This is not surprising since domestic livestock are simply not large enough to impact on tree species such as *Acacia erioloba* other than to create a distinctive

browse line at the base of each individual including individuals of the spiny *Acacia mellifera* (see Figure 2). However, future impacts on woody species cannot be excluded since livestock may limit recruitment of larger woody species by eating seeds and grazing seedlings. Since such woody species are long-lived, it will be some decades before any impacts of grazing on tree recruitment become evident.

- There is a clear and heavy physical grazing impact on a number of palatable and targeted species such as *Ceraria namaquensis, Adenolobus gariepensis, Maerua galpinii, Salsola aphylla*, *Petalidium lucens* and most of the *Stipagrostis* grass species such as *S. uniplumis*, *S. hochstetteriana*, *S. obtusa* and *S. ciliata*. In many areas, particularly around stock posts, grass tussocks have been physically removed from the soil (e.g. Photostation 6) or now stand on wind and water eroded stilts above the soil surface. They are unlikely to survive another 10 years in this condition.
- At one site (Photostation 18) the basal cover of *Stipagrostis hochstetteriana* has increased substantially since 1995 (see Figure 5). This is the only site where grass cover has not declined and since it is within a few hundred metres of a stockpost, its persistence and increase over time is difficult to explain. Most grass tussocks have been grazed indicating that it is not unused by livestock.
- While firewood collection is ubiquitous, little evidence of the removal of living trees was observed. Some dead *Acacia erioloba* branches have been cut and removed and several dead *A. mellifera* individuals have also been removed. A few donkey carts full of wood were observed during the 2005 survey. One *Adenolobus gariepensis* tree near Deksel had had its branches broken to reach the ground so that livestock could graze this palatable species.
- It is difficult to comment on the impact of land use on plant diversity. Fewer species were recorded at most of the sites in 2005 even though sampling was undertaken at more or less the same level of intensity during both survey periods. Identification was more difficult in 2005 since grazing has reduced leaf and reproductive material necessary for plant identification. The reduction in species number, however, was not a universal finding and we suggest that grazing in the last 10 years has had little impact on species richness at Riemvasmaak. The greatest effect has been on altering the composition of the flora through the grazing of accessible, palatable species.

Table 2. Mean % cover values (± std dev) for different growth forms in each of the landforms sampled in Riemvasmaak in 1995 and again in 2005. A "-" sign indicates that the growth form was not recorded in the landform. Significant differences in % cover between 1995 and 2005 for each growth form within each landform (excluding Plateau sites because of insufficient replication) were tested using a non-parametric Wilcoxon matched pairs test. Underlined: p < 0.05; bold: p<0.01; bold underline: p<0.001.

Landform	Plateau		Inselbergs		Rocky slopes & pediments		Sandy pediments		River channels	
Sites (n)	2		5		36		23		30	
Year	1995	2005	1995	2005	1995	2005	1995	2005	1995	2005
Annuals/Forbs	0.1 (0.1)	0.1 (0)	0.9 (1.3)	0.1 (0.1)	**1.2 (2.2)**	**0.1 (0.4)**	**0.9 (1.0)**	**0.02 (0.1)**	**0.3 (0.4)**	**0.05 (0.1)**
Grasses	2.6 (3.6)	2.5 (3.6)	7.7 (3.3)	1.6 (3.1)	**5.1 (5.6)**	**1.9 (2.8)**	**15.1 (15.7)**	**3.4 (3.8)**	**9.1 (7.6)**	**6.2 (5.1)**
Low shrubs (<0.25 m)	3.2 (4.1)	3.2 (4.1)	-	0.03 (0)	0.2 (0.4)	0.1 (0.3)	**0.3 (0.6)**	**0.04 (0.1)**	**0.1 (0.2)**	**0.08 (0.4)**
Medium shrubs (0.25-1.5 m)	12.6 (7.8)	11.6 (10.5)	0.6 (0.9)	2.1 (4.5)	5.0 (4.6)	4.4 (4.2)	**5.3 (4.0)**	**4.0 (4.2)**	4.3 (9.4)	3.5 (7.8)
Tall shrubs (>1.5 m)	0.01 (0)	-	0.6 (0.6)	1.0 (1.2)	0.3 (0.6)	0.3 (0.7)	0.9 (1.7)	0.7 (2.2)	**1.7 (3.6)**	**2.2 (4.5)**
Leaf succulents	-	-	-	-	0.4 (1.2)	0.4 (1.2)	0.1 (0.6)	-	0.01 (0)	-
Stem succulents	13.5 (19.1)	13.5 (19.1)	0.4 (0.9)	0.4 (0.9)	6.0 (5.2)	6.0 (5.2)	0.1 (0.2)	0.1 (0.4)	0.1 (0.3)	0.04 (0.2)
Trees	0.5 (0.7)	0.5 (0.7)	0.9 (1.1)	0.9 (1.1)	4.1 (5.3)	4.0 (5.3)	6.5 (5.4)	6.6 (5.5)	18.3 (17.6)	18.0 (16.6)
Mean	32.5	31.4	11.0	6.1	22.1	17.2	29.2	14.9	33.8	30.0

Causes of change

The most important influences on plant cover and composition are rainfall, plant use and grazing by wild and domestic animals. Figure 7 shows the annual rainfall for Augrabies, situated immediately south of Riemvasmaak, for the period 1946-2004. Annual rainfall has not declined significantly over this period and the slope of the trend line, although negative, is close to zero. While 2003 was a dry year with only 72.4 mm recorded at Augrabies the period 1999-2005 has generally experienced annual totals close to or above the mean value of 125 mm.

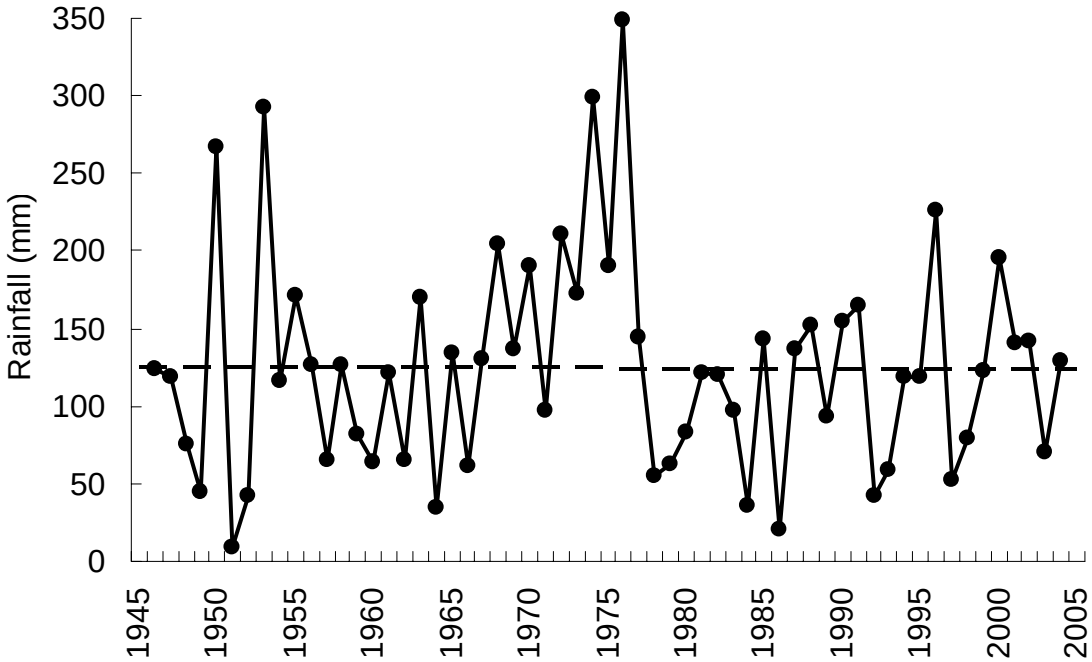

Figure 7. Annual rainfall for Augrabies for the period 1946-2004. The mean value for the 58 years is 125 mm while the dashed lined shows the trend over the 58 years (y = -0.0136x+125.34; R^2=0.00001).

However, seasonal rainfall is sometimes more important for forage production than annual totals since some growth forms, and especially grasses, grow mostly in the warmer summer months. The mean value for summer rainfall (October-March) for the period 1946-2004 for Augrabies is 85.7 mm. Since 1995, Augrabies has received slightly

more than this (90.8 mm) with above average summer rainfall amounts occurring in five of the 10 years recorded.

If rainfall has not changed significantly since 1995, it can be discounted as an important determinant of the observed changes at Riemvasmaak over the last 10 years, and alternative explanations must be sought. The relatively few cases where whole trees have been removed can be ascribed to people collecting firewood. No other direct use impacts were noticed (e.g. harvesting of medicinal plants, thatch, poles). Wild ungulates have had a decreasing impact on the vegetation since they appear to have all but been exterminated from the region. Most of the cover and compositional changes observed in the landscape, therefore, can be ascribed primarily to the grazing impacts of domestic animals.

The number of individuals within all breeds of domestic animals has increased significantly at Riemvasmaak since 1995, with the number of Large Stock Units increasing more than six fold over this period (Table 3). It is difficult to explain the minor fluctuations over the years in the number of individuals of different breeds. High sales in one year or an increase in deaths due to drought, disease or predators could all account for these differences. Drought, however, seems to have had a relatively minor effect on animal numbers in Riemvasmaak. For example, in the low rainfall years of 1997 and 1998 when 52 mm and 79 mm fell at Augrabies respectively, sheep were the only breed which declined in abundance. In addition, in the single-year drought of 2003, when 70 mm of rain fell in the region (i.e. 56% of the long term average of 125 mm for Augrabies) the number of LSU actually increased by 13% (from 707-798 LSU).

The relative impact of cattle, goats, sheep and donkeys is difficult to assess although they are likely to consume different components of the vegetation. Their combined impact, however, is perhaps more important. Together they have had a significant effect, particularly on the cover of palatable grasses and medium shrubs at Riemvasmaak, and especially on the sandy pediments and to a lesser extent on the rocky slopes and river channels.

In their 1995 report, Hoffman et al. suggested that with the Department of Agriculture's recommended stocking rate of about 60 ha/LSU (and after accounting for differences in the grazing potential of different landforms) Riemvasmaak could

accommodate about 1,028 LSU. Surprisingly, this number was surpassed for the first time only in 2005. Stock numbers currently exceed the recommended number of LSU by 9.1%. Interestingly, the 450 donkeys currently grazing Riemvasmaak's rangelands comprise more than 26% of the total LSU. Hoffman *et al.* (1995) assumed, however, that animals would graze the different land forms relatively evenly and that the sandy pediments would provide for only about 20% of the grazing potential. Clearly, this has not been the case and perhaps not surprisingly, the easily accessible sandy pediments which were dominated by palatable grasses in 1995, have borne the brunt of the grazing impact over the last 10 years.

Table 3. The number of cattle, goats, sheep and donkeys in Riemvasmaak from 1995-2005. The number of Large Stock Units (LSU) were calculated according to the guidelines set out in the Conservation of Agricultural Resources Act (Act 43 of 1983) where one LSU has the following value for each breed of animal: Cattle = 1.1, goats = 0.17, sheep = 0.17, donkeys = 0.65.

Year	Cattle	Goats	Sheep	Donkeys	LSU
1995	60	230	150	80	183
1996	105	300	200	120	279
1997	190	370	290	180	438
1998	210	440	200	200	470
1999	265	500	208	215	552
2000	311	570	250	290	670
2001	280	591	390	350	702
2002	320	540	400	300	707
2003	360	600	500	330	798
2004	440	810	450	400	958
2005	505	1,100	510	450	1,122

This impact is also evident, however, on the more rocky areas particularly at the few sites bordering private farms. For example, grass cover on the rocky slopes and pediments at site 4 has increased on the private farm but has decreased in the communal

area (Figure 8). These observations support the conclusion that it is grazing by domestic livestock over the last 10 years that is responsible for the differences in composition and cover at the Riemvasmaak photostations between the two sampling dates. Other factors, which might account for the differences in plant composition and cover between 1995 and 2005, are of lesser importance.

Figure 8. Fence-line contrast at Photostation 4 showing the removal of Stipagrostis uniplumis *on the communal side of the fence (left foreground) relative to the private farm across the fence-line.*

IMPLICATIONS

While a relatively wide variety of plants are usually eaten by domestic livestock, in Riemvasmaak the effects of this consumption is most noticeable on palatable grasses and medium shrubs which have declined in cover since 1995 on most landforms but particularly on the sandy pediments. Both photographic and survey data confirm these observations. However, what does this mean for the long-term sustainability of Riemvasmaak's environments and the livestock industry in the region?

The "new thinking" in rangeland ecology (Behnke *et al*. 1993, Scoones 1995) suggests that in arid savannas such as Riemvasmaak, with low and variable annual rainfall amounts, heavy grazing has no long-term impact on the diversity, composition and dynamics of these systems. Proponents suggest that in these rainfall-driven systems, animal numbers never reach levels which could permanently influence composition and cover since frequent droughts and consequent mortality maintain livestock numbers well below the ecological carrying capacity of these systems (Behnke and Scoones 1993, Shackleton 1993). This view maintains that animal numbers and vegetation are uncoupled from each other and do not, therefore, exist in equilibrium. It further suggests that controlling stock numbers is wasteful since it prevents farmers from capitalising on the excess biomass that is produced in above-average rainfall years. Proponents of the "new thinking" argue that a tracking strategy with a flexible response to drought and seasonal forage deficits is the best approach for livestock production systems in these arid conditions (Andrew *et al.* 2003).

Results from our survey show that contrary to this view, domestic animals have had an important impact on the vegetation and landscapes of Riemvasmaak. When compared with data from 1995, the cover of particularly grasses and medium shrubs has been significantly reduced across much of Riemvasmaak but particularly on the sandy pediments and to a lesser extent on the rocky slopes and river channels. Trees, tall shrubs and stem succulents, however, appear not to have been affected either because they are out of reach of animals (trees, tall shrubs) or unpalatable or even toxic (e.g. *Euphorbia gregaria*). Trees are also relatively long-lived and so any impacts are likely to manifest themselves only in the future as adults die and are not replaced. These observations

suggest that livestock impact is not uniform across the landscape but that different species, growth forms and landforms are more susceptible to animal damage than others. The differential impact of grazing should be more carefully considered by proponents of the disequilibrium view of rangeland ecology as high stock numbers could be devastating for individual species in selected and preferred habitats (see also van Rooyen 1998 who discusses the "improper" application of the "non-equilibrium view" in relatively small, fenced arid savannas of southern Africa).

What we have not demonstrated, however, is the long-term impact of domestic livestock on grasses and shrubs and the permanency or otherwise of this impact on these components. The ability of the vegetation (especially palatable *Stipagrostis* spp. grasses and heavily-grazed medium shrubs) to grow, flower and set seed in response to high rainfall events needs to be investigated. A limited response to good rains with no new recruitment of individuals into existing populations would challenge the view that high stock numbers have no impact on the rangeland resources of arid ecosystems. However, a good response in the populations of vulnerable species would confirm the views proposed by the "new thinking" that livestock grazing has little impact on these systems. In Botswana, for example, local villagers believe that the visible loss of grass cover due to heavy grazing is temporary and good rains will restore this component with no long-term effects (Dahlberg 2000). Clearly, if all domestic animals are withdrawn from Riemvasmaak it will respond in the way it did between 1974 and 1995. However, the complete removal of domestic animals for 20 years together with exceptionally high rainfall at the start of this period (Hoffman *et al.* 1995) is unlikely to occur again. Therefore, the real measure of livestock impact should include the response of vegetation under current stocking rates.

An equally permanent effect of the land use practices in Riemvasmaak since 1995 is the homogenisation of the sandy pediments as a result of trampling by high numbers of domestic livestock. Twenty years of rest from domestic livestock between 1974 and 1994 resulted in a heterogeneous micro topography of the sandy pediments driven largely by water movement across the landscape. Water movement within rills and channels sorted sand particles according to their different sizes. Grass species, in particular, responded to these differences and in 1995 the separation of *Stipagrostis* spp., *Schmidtia*

kalahariensis and a few shrubs (e.g. *Monechma spartioides*) along these micro topographic gradients was particularly apparent. No doubt, 20 years of rest will re-establish these patterns, but under current stocking rates and grazing practices, the homogenisation of the landscape and the removal of this fine-scale heterogeneity should be considered permanent.

We have not been able to measure the effect of heavy grazing and the reduction in plant cover at Riemvasmaak on less tangible aspects of ecosystem function such as wind and water erosion, nutrient cycling, carbon storage, albedo effects and so on. It is difficult to imagine, however, that the removal of so much biomass from Riemvasmaak since 1995 has had no effect on these aspects of ecosystem function but without good baseline data it is difficult to know precisely what has happened.

Changes in Riemvasmaak over the last 10 years have important implications for the livestock industry itself. The region has supported a considerable number of people over this time and the contribution of livestock production to their livelihoods should be determined. Our evidence suggests, however, that much of this production could have been drawn from the "natural capital" that had accumulated between 1974 and 1994 when few domestic animals grazed the area.

The role of donkeys in the region needs to be carefully considered. They compete with other animals for forage. The uncontrolled increase of excess donkeys (i.e. those not used for transport or draught) could compromise the livelihoods of those who farm with commercial breeds. Solutions to this problem lie in the establishment of strong management institutions which are able to make decisions and act on such issues.

Finally, one of the predictions from our study is that with available biomass now significantly lower than when Riemvasmakers returned in 1995, farmers will become more vulnerable to the impact of drought. It will become increasingly difficult to maintain the growth in the number of animals that was possible in the first ten years of their return since the cover and composition of plants in the most heavily utilised landforms has declined significantly over the last 10 years. While there is still considerable room for stock numbers to increase their maintenance will be increasingly affected by drought. We predict that a rainfall-driven oscillation in stock numbers will

emerge in the next ten years as the remaining elements of nature's capital become drawn down by the domestic animals in Riemvasmaak.

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APPENDIX 1.

Itinerary of the 9-17 January 2005 survey. The team comprised of Timm Hoffman who took all the photographs and Simon Todd who sampled most of the sites. Key findings were discussed between Timm and Simon after sampling and photographing each site.

DAY 1: (Sunday, 9th). Left Cape Town in the early afternoon and stayed overnight in Calvinia.

DAY 2: (Monday, 10th). Arrived in Riemvasmaak in the late morning. Photographed and sampled Photostation 28. Met with Mr Richard Roman and Mr Romeo Adams from the Riemvasmaak Trust. Discussed our study objectives, reporting procedures and logistic arrangements for our stay. Stayed overnight at the Warmbaths.

DAY 3: (Tuesday, 11th). Drove to Deksel via the plateau site (Photostation 5) which we photographed and sampled. Photographed Photostations 2 and 3 at Deksel but only sampled Photostation 2 as we were under some time pressure to get to Photostation 15. We got a bit lost along the way finding this latter site as there are considerably more roads now in use in the region and we took a wrong turn at one point. Eventually made our way back to the correct location and photographed and sampled this site. Drove to Photostation 16 which we photographed and sampled and then drove back to Bokseputs to Photostation 18. The light was not suitable to photograph photostation 18 and it was also too late in the day to make for a good matched photograph so we sampled this site only. Slept at the quartz mine at Donkiemond and shared a very pleasant evening with Mr Makabane who works at the mine.

DAY 4: (Wednesday, 12th). Photographed and sampled Photostation 17 at Donkiemond and photographed Photostation 18 which we had sampled the day before. Drove to Photostation 1 which we sampled. Simon and I split up and I sampled at Photostation 20 while Simon finished the sampling at Photostation 3 which we had photographed the morning before. We then joined up again and drove down the Kourop Valley to Photostation 19 which we photographed and sampled in the early afternoon. We finished the day by photographing Photostations 1 and 20 and sampling and photographing Photostation 4. Returned to the Warmbaths in the evening.

DAY 5: (Thursday, 13th). Photographed Acocks' site (Photostation 21) just above the Warmbaths but didn't sample at this site. Drove to Photostation 29 which we photographed and sampled before driving to Photostation 23 and photographing at this site. We were in a bit of a rush to get to Photostation 6 past Berylkop after this and similarly we couldn't sample at Photostation 6 either as we needed to be at Photostation 26 around midday. We photographed and sampled at this site before driving to Photostations 24 and 27 which we photographed and sampled. We ended the day by sampling at Photostation 23 which we had photographed earlier in the day. A localised thunderstorm caught us on the way home with torrents of water running off the rocky hillslopes and moving down the road near Photostation 26. Slept at the Warmbaths.

DAY 6: (Friday, 14th). Arranged to visit Photostation 25 on the Melkbosrand side of Riemvasmaak and had to go to Augrabies National Park to fetch the key to the Renosterhek. Photographed and sampled this site and returned to Riemvasmaak in time to photograph and sample Photostation 14 just above the village in the afternoon. Stayed at the Warmbaths for the last time.

DAY 7: (Saturday, 15th). Photographed and sampled Photostation 7 returning to Photostation 22 which we sampled and photographed as well. We had to rush to Photostation 13 a bit down the Molopo River road which we photographed only before heading on to the Mostertshoek site at Photostation 8 which we photographed and sampled. Drove to Xubuxnap and photographed and sampled Photostation 11 on the lower Kourop River Valley. Spent the evening on the banks of the Orange River at Xubuxnap.

DAY 8: (Sunday, 16th). Since we had located Photostation 9 at Xubuxnap the evening before we photographed and sampled this site before searching unsuccessfully for an hour and a half for the road to Petrushoek at Photostation 10. We eventually had to park our vehicle and walk the 1.1 km from this position to the photostation which we photographed and sampled in the late morning. We decided to return to Photostation 21 near Riemvasmaak and sample this site in the afternoon since we had taken the photograph on the Thursday before. After this we made our way down the Molopo River to VredesVallei sampling at Photostation 13 along the way. We located our final Photostation (No. 12) and sampled a portion of this site before spending a hot and windy night on the banks of the Orange River.

DAY 9: (Monday, 17th). Photographed Photostation 12 and surveyed the upper and lower reaches of the Molopo River. Drove to Riemvasmaak to report back to Mr Richard Roman and Mr Romeo Adams from the Riemvasmaak Trust and left for Cape Town soon thereafter.

APPENDIX 2.

Matched photographs for the 29 photostations at Riemvasmaak

PHOTOSTATION 1: Deksel West (28.36025; 20.14656). Looking 90º E, the t op photograph was taken at 18h20 on 17 January 1995 while the bottom photograph was taken at 15h53 on 12 January 2005. Cover in the foreground (1a) has been halved over the ten year period largely as a result of the decline of *Stipagrostis uniplumis* from an estimated 15% cover in 1995 to 1% cover in 2005 and *S. obtusa* from 1% to 0.1%. Cover of *S. uniplumis* has also fallen from 5-1% in the river channel (1b) in the midground while other grasses such as *S. hochstetteriana* (2-1%) and *Cenchrus ciliaris* (1-0.1%) have declined as well. *Cyperus marginatus* has remained unchanged at an estimated 5% cover in the river channel. The dominant shrubs and trees such as *Calicorema capitata* (4%), *Zygophyllum suffruticosum* (1%) and *Acacia mellifera* (10%) have remained unchanged in both landforms over the ten years. However, several shrubs such as *Limeum* sp. (0.1-0%), *Galenia secunda* (1-0%), *Sisyndite spartea* (0.01-0%) and *Kleinia longiflorus* (0.01-0%) and annual or short-lived grasses such as *Setaria verticillata (0.1-0%)* and *Eragrostis aspera* (0.1-0%) which were uncommon in 1995, were not seen in 2005. The local disappearance of these species accounts for the general decline in species number at this site.

Table 1. Changes in the estimated % cover of different growth forms in Riemvasmaak between 1995 and 2005 for the rocky pediment in the foreground and the river channel in the midground at Photostation 1.

Growth form	Rocky slope & pediment		River channel	
	1a	1a	1b	1b
	1995	2005	1995	2005
Annuals/Forbs	-	-	0.02	0.02
Grasses	16.1	1.2	13.2	6.2
Low shrubs (<0.25 m)	1.0	0	0.01	0
Medium shrubs (0.25-1.5 m)	5.2	5.1	0.1	0.1
Tall shrubs (>1.5 m)	0.02	0.01	-	-
Leaf succulents	-	-	-	-
Stem succulents	0.01	0	-	-
Trees	10.0	10.0	30.1	30.1
Total cover %	**32.3**	**16.3**	**43.4**	**36.4**
No. species	**14**	**8**	**19**	**15**

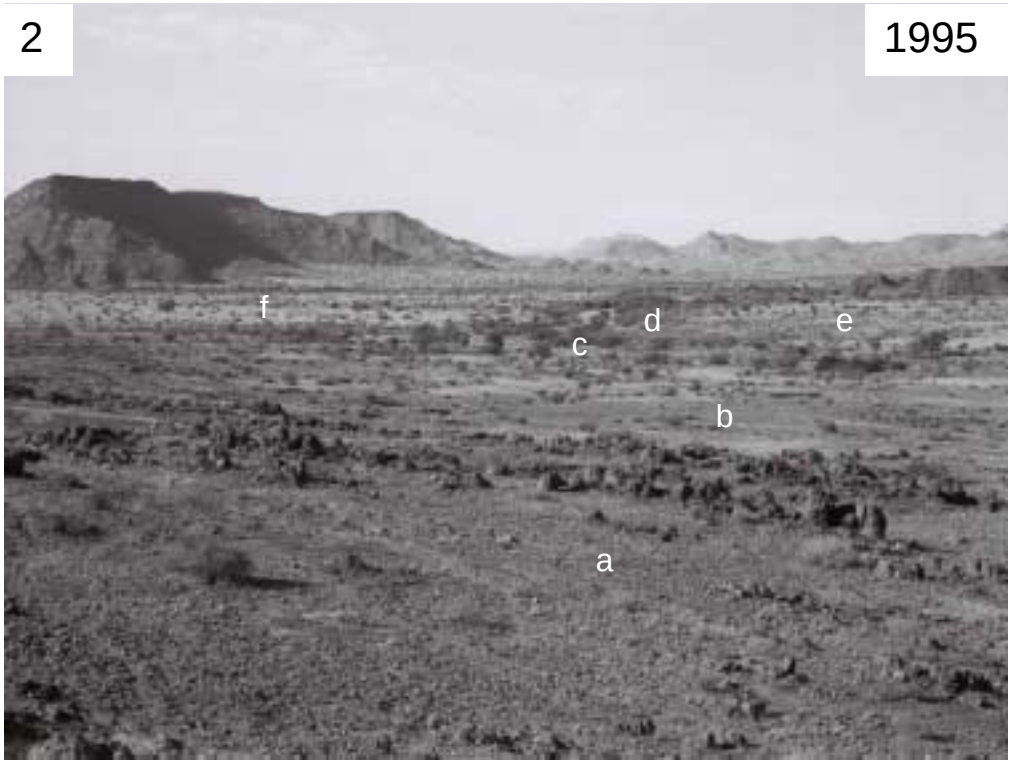
1

PHOTOSTATION 2: Upper Kourop Valley (28.36991; 20.15680). Looking 212º SSW, the top photograph was taken at 08h18 on 17 January 1995 while the bottom photograph was taken at 09h55 on 11 January 2005. The two photographs of this wide, extensive valley look remarkably similar although detailed ground surveys indicate that overall cover has declined in all landforms except possibly the river channel (2c) where the only decline is that of grass cover, primarily *Stipagrostis uniplumis* (2-0.1%), *Cenchrus ciliaris* (2-0.1%) and *Setaria verticillata* (2-0%) Grass cover has generally plummeted within all landforms and in region 2e, which is within a few hundred metres from a small cluster of houses and stockposts, *S. uniplumis* has gone from 25% to zero, On the sandy pediment in the left distance (2f), *S. hochstetteriana* has similarly declined from 40% cover in 1995 to about 10% in 2005 while the invasive tree, *Acacia mellifera*, has increased from 5-10% in this landform. Shrubs such as *Calicorema capitata* and *Monechma spartioides* are relatively unchanged on the rocky pediments although the latter species, together with *Zygophyllum microcarpum*, has declined substantially on the sandy pediment in the left distance.

Table 2. Changes in the estimated % cover of different growth forms in Riemvasmaak between 1995 and 2005 for the rocky toeslope in the foreground (2a), the rocky pediment in the midground (2b), the river channel directly beyond this in the middle distance (2c), the rocky pediment fringing the river in the right distance (2d), the rocky pediment in the right distance (2e) and the sandy pediment in the left distance (2f) at Photostation 2.

Growth form	Rocky slopes & pediments								Sandy pediment		River channel	
	2a	2a	2b	2b	2d	2d	2e	2e	2f	2f	2c	2c
	1995	2005	1995	2005	1995	2005	1995	2005	1995	2005	1995	2005
Annuals/ Forbs	4.1	0.01	3.0	1.0	4.0	0	10.0	0.1	1.0	0	0.02	0.03
Grasses	7.0	3.0	10.2	2.1	0.1	0.1	27.1	5.1	45.2	10.1	12.2	6.2
Low shrubs (<0.25 m)	0.1	0.02	0.03	0.02	0	0.01	-	-	-	-	0.02	0.01
Medium shrubs (0.25-1.5 m)	8.1	5.0	1.2	1.1	20.0	21.0	7.0	3.1	4.0	0.2	2.0	2.0
Tall shrubs (>1.5 m)	0.01	0.01	0.1	0.1	0.01	0.01	0.01	0.02	3.1	3.1	0.1	0.1
Leaf succulents	-	-	-	-	-	-	-	-	-	-	-	-
Stem succulents	1.1	1.0	2.0	2.0	10.0	10.0	0.01	0.01	-	-	-	-
Trees	0.0	0.0	0.2	0.1	0.2	0.2	6.1	6.1	6.0	11.0	31.3	31.2
Total cover %	**20.4**	**9.0**	**16.7**	**6.4**	**34.3**	**31.3**	**50.2**	**14.4**	**59.3**	**24.4**	**45.6**	**39.5**
No. species	**19**	**14**	**22**	**20**	**8**	**11**	**15**	**14**	**15**	**11**	**24**	**19**

2



PHOTOSTATION 3: Deksel South (28.36956; 20.15686). Looking 8º N, the top photograph was taken at 08h42 on 18 January 1995 while the bottom photograph was taken at 10h26 on 11 January 2005. The most significant change at this site, beside the difference in annual cover (especially *Zygophyllum simplex*) is the loss of grass cover (mainly *Stipagrostis uniplumis*), particularly on the rocky toeslopes and pediments. The slight decline in the cover of medium shrubs in some landforms is as a result of the drop from 2-0.1% cover of *Monechma spartioides* at site 3c and the drop from 7-5% cover of *Calicorema capitata* at site 3d. *Euphorbia gregaria*, the dominant and ungrazed stem succulent, has remained unchanged at between 1 and 10% since 1995 in all landforms where it occurs. Tree cover has remained the same except in the river channel where *Tamarisk usneoides* has declined from 35-25%. The increase in species number in some landforms is as a result of the inclusion of several medium shrubs such as *Curoria decidua, Microloma incanum* and *Tetrogonia arbuscula* but it is difficult to tell if these are new recruits or species that were simply missed in the 1995 survey.

Table 3. Changes in the estimated % cover of different growth forms in Riemvasmaak between 1995 and 2005 for the rocky toeslope in the foreground (3a), the river channel in the middle distance (3b), and the rocky pediments in the left midground (3c) and right midground (3d) at Photostation 3.

Growth form	Rocky slopes & pediments						River channel	
	3a	3a	3c	3c	3d	3d	3b	3b
	1995	2005	1995	2005	1995	2005	1995	2005
Annuals/Forbs	5.0	0.01	2.0	0	5.0	0.01	0.1	0.03
Grasses	5.2	0.2	7.2	0.2	5.1	0.2	3.1	1.2
Low shrubs (<0.25 m)	0.1	0.01	0	0.01	0.01	0.03	-	-
Medium shrubs (0.25-1.5 m)	2.2	2.2	6.0	5.2	8.0	6.1	0	0.02
Tall shrubs (>1.5 m)	0.2	0.1	-	-	0	0.01	0.02	0.02
Leaf succulents	-	-	0.01	0	-	-	0.01	0
Stem succulents	1.0	1.0	10.0	10.0	7.0	7.0	-	-
Trees	1.1	1.1	7.0	7.0	7.1	7.1	37.1	27.1
Total cover %	**14.8**	**4.6**	**32.2**	**22.4**	**32.2**	**20.4**	**40.3**	**28.4**
No. species	**19**	**18**	**13**	**16**	**18**	**20**	**16**	**18**


3
1995
c
d
b
a

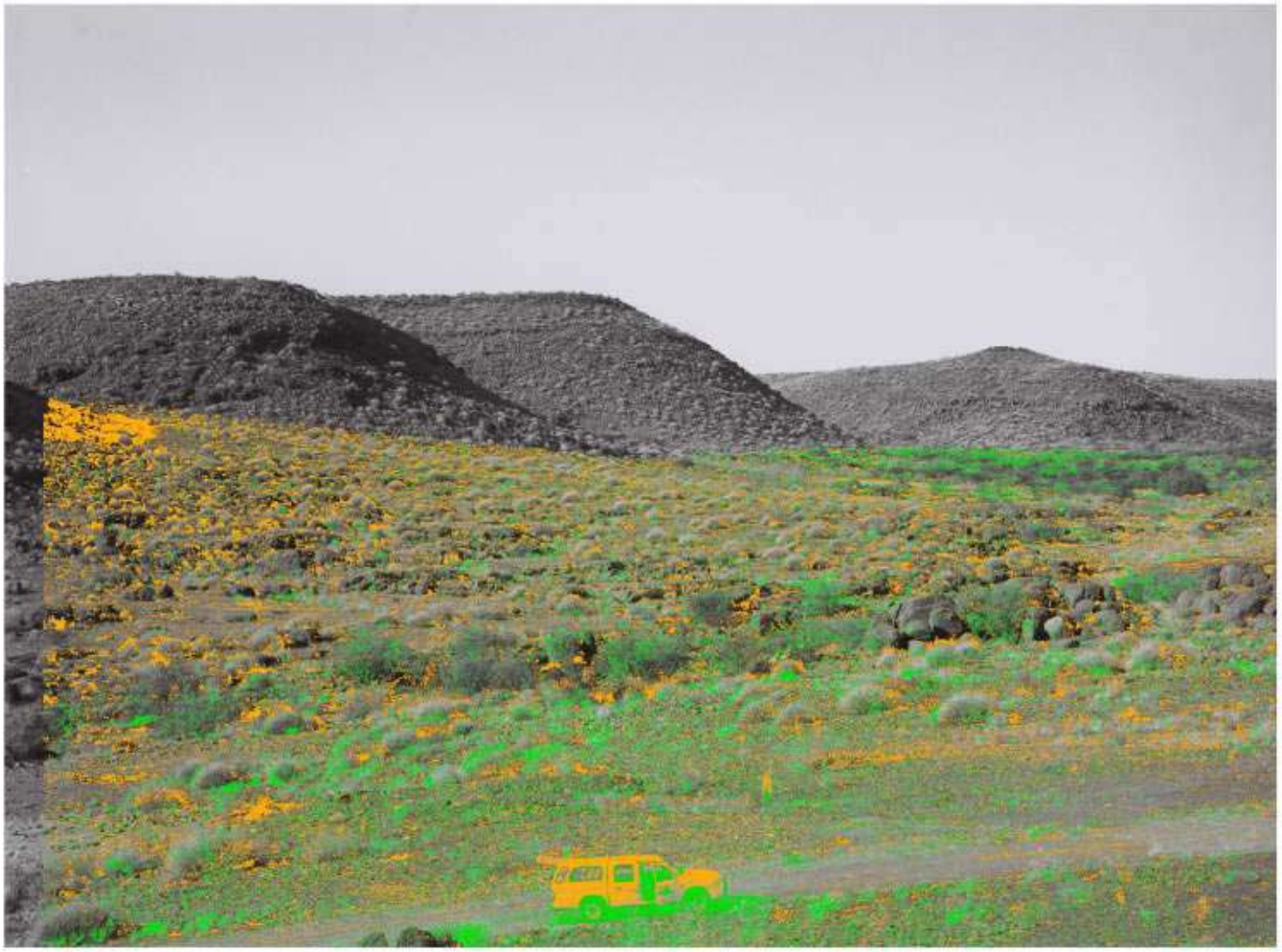

2005

PHOTOSTATION 4: Naruxas (28.33805; 20.20587). Looking 40º NE, the top photograph was taken at 17h39 on 18 January 1995 while the bottom photograph was taken at 17h34 on 12 January 2005. This site is on the north-central border of Riemvasmaak and looks across to private farmland. The foreground (landforms 4a, 4b and 4d2) shows the communal area of Riemvasmaak while the remaining landforms in the distance are on private farmland. In general, rocky pediments in the communal area show a decline in cover, particularly of grasses such as *Stipagrostis uniplumis* while grass cover has increased on the rocky pediments of the private farm (especially *S. uniplumis* and *Enneapogon scoparius*). The relatively palatable medium shrub, *Monechma spartioides* has declined on the rocky pediments of the communal area but not on the private farm while the ungrazed stem succulent, *Euphorbia gregaria* has remained unchanged on both sides of the fence. Cover in the river channels has increased on both the communal area (4b) and on the private farm (4c) largely as a result of an increase in grass and sedge cover (*S. uniplumis* and *Cyperus marginatus*). *Tamarisk usneiodes* – an unpalatable tree – has increased in landform 4b on the communal side of the fence. The cover of trees such as *Acacia mellifera* and *Schotia afra* has remained unchanged in both 4b and 4c although young *S. afra* individuals, documented in 1995 have been heavily browsed in the river channel on the communal side of the fence (landform 4b).

Table 4. Changes in the estimated % cover of different growth forms in Riemvasmaak between 1995 and 2005 for the rocky river terrace in the foreground (4a), the river channel in the middle distance (4b) and right background (4c), and the rocky pediments (4d1 & 4d) and rocky southeast-facing slopes (4e1 & 4e2) at Photostation 4.

Growth form	Rocky slopes & pediments										River Channels			
	4a	4a	4d1	4d1	4d2	4d2	4e1	4e1	4e2	4e2	4b	4b	4c	4c
	1995	2005	1995	2005	1995	2005	1995	2005	1995	2005	1995	2005	1995	2005
Annuals/Forbs	2.0	0.1	-	-	-	-	0.1	0.1	-	-	1.1	0.1	2.0	0.2
Grasses	3.1	0.2	0.1	10.0	2.0	1.1	0	10.0	0.1	5.2	11.3	17.2	8.2	14.1
Low shrubs (<0.25 m)	-	-	-	-	-	-	-	-	-	-	0.1	0	0.1	0
Medium shrubs (0.25-1.5 m)	5.0	2.0	5.0	5.0	8.0	5.1	4.2	4.2	10.2	9.2	0.1	0.1	1.2	1.3
Tall shrubs (>1.5 m)	-	-	-	-	0.1	1.0	0.1	0.1	0.1	0.1	-	-	-	-
Leaf succulents	-	-	-	-	-	-	0.01	0	-	-	-	-	-	-
Stem succulents	5.0	5.0	3.0	3.0	15.0	15.0	16.1	16.1	10.0	10.0	-	-	0.1	0
Trees	1.1	2.1	7.0	7.0	0.02	0.03	0.1	0.1	0.1	0.02	4.1	9.0	21.0	21.0
Total cover %	**16.2**	**9.4**	**15.1**	**25.0**	**25.1**	**22.2**	**20.6**	**30.6**	**20.5**	**24.5**	**16.7**	**26.4**	**32.6**	**36.6**
No. species	**15**	**13**	**14**	**16**	**13**	**23**	**13**	**20**	**13**	**16**	**19**	**17**	**16**	**20**

4



PHOTOSTATION 5: Plateau (28.36796; 20.26364). Looking 250º WSW, the top photograph was taken at 08h15 on 19 January 1995 while the bottom photograph was taken at 07h35 on 11 January 2005. The plateau region is one of the most inhospitable environments in Riemvasmaak. Water is scarce and the terrain difficult to negotiate away from the road as it is so stony. *Euphorbia gregaria* continues to dominate the plateau vegetation and has not changed in cover (25%) since 1995. The medium shrub *Monechma spartioides*, however, has declined in cover from 5 to 2% over the 10 years. Although there are signs that grasses, such as *Enneapogon scaber* and *Panicum arbusculum*, have been eaten they have not declined appreciably in cover on the rocky plateau. *Stipagrostis uniplumis*(4-1%) and *S. obtusa* (2-0.1%), which dominated the sandy pediment (5b) surrounding the pan in 1995, however, have both declined in cover. Medium shrubs such as *Rhigozum trichotomum* (2%),and *Salsola aphylla* (0.1-0.1%) have not changed in cover on the sandy pediment (5b) nor has the leguminous tree *Parkinsonia africana* (7%) while *Zygophyllum retrofractum* (2-1%) has declined. The vegetation on the pan itself (5c) has changed very little since 1995 and remains dominated by *Z. retrofractum* (15%), *Aptosimum spinescens* (4%), *Salsola aphylla* (2%) and *Geigaria ornativa* (2%). *Galenia africana*, an indicator of disturbance, has increased in cover on the pan from 1 to 2% since 1995.

Table 5. Changes in the estimated % cover of different growth forms in Riemvasmaak between 1995 and 2005 for the rocky plateau site (5a), the sandy pediment (5b) surrounding an exposed pan (5c) to the right of the landform 5b at Photostation 5.

Growth form	Plateau		Sandy pediment		Pan	
	5a	5a	5b	5b	5c	5c
	1995	2005	1995	2005	1995	2005
Annuals/Forbs	0.1	0.1	0.1	0	0	0.1
Grasses	5.1	5.0	6.1	1.2	-	-
Low shrubs (<0.25 m)	0.3	0.2	0.4	0.3	6.1	6.1
Medium shrubs (0.25-1.5 m)	7.1	4.2	8.3	8.5	18.1	19.0
Tall shrubs (>1.5 m)	-	-	-	-	-	-
Leaf succulents	-	-	-	-	-	-
Stem succulents	27.0	27.0	-	-	0.02	0
Trees	1.0	1.0	8.0	8.0	-	-
Total cover %	**40.6**	**37.5**	**22.9**	**18.0**	**24.2**	**25.2**
No. species	**20**	**24**	**18**	**20**	**11**	**9**

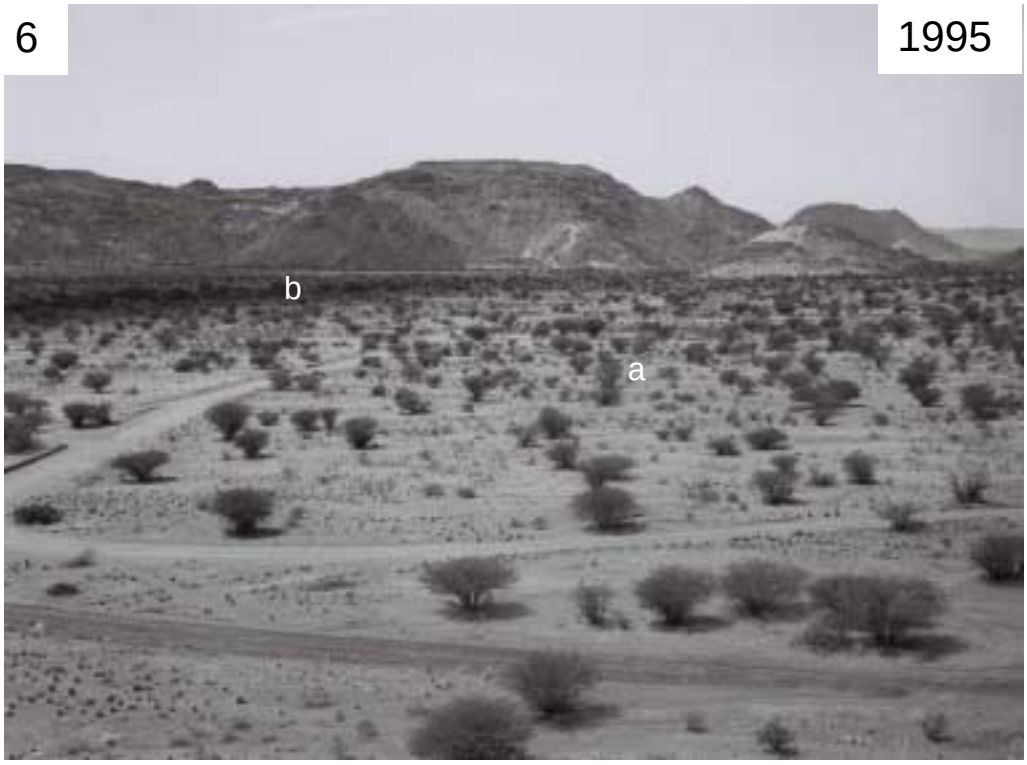
5

PHOTOSTATION 6: Berylkop (28.40493; 20.30905). Looking 180º S, the top photograph was taken at 11h08 on 13 January 1995 while the bottom photograph was taken at 11h44 on 13 January 2005. This wide open valley is close to the Riemvasmaak mission station and has been settled by five or six relatively extensive stockposts with large herds of cattle, sheep and goats. The impact of settlement and grazing on the vegetation has been extreme, particularly on the sandy pediments (6a) around the homesteads and this valley has become something of a dustbowl, particularly in the centre. Most of the grass tufts of species such as *Stipagrostis hochstetteriana* (3-0.1%), *S. ciliata* (1-0.1%) and *S. uniplumis* (1-0%) have been eaten to the ground and many tufts have also become dislodged. Medium shrubs have declined significantly on the sandy pediments since 1995 and species such as *Monechma spartioides* (2-1%), *Salsola aphylla* (3-1%) and even the hardy *Rhigozum trichotomum* (2-1%) have declined in cover. The density of *Acacia mellifera* (20%) individuals appears not to have changed although most individuals have grown taller and have filled out over the 10 years. In the wide, sandy river channel in the left background (6b), grass cover has increased a little as a result of an increase of the robust grass, *Stipagrostis namaquensi*s (10-12%). The finer and more palatable species, *S. uniplumis*, however, had a cover of 1% in 1995 but was not recorded in 2005. The cover of medium shrubs such as *R. trichotomum* (1%) has not changed in the river channel since 1995 while tree cover has increased a little as a result of an increase in *Acacia mellifera* from 5-10%. Several large *A. erioloba* (10-7%) individuals occur in the river channel and one or two have died resulting in a slight decrease in cover.

Table 6. Changes in the estimated % cover of different growth forms in Riemvasmaak between 1995 and 2005 for the sandy pediment (6a) in the foreground and the river channel (6b) to the left background at Photostation 6.

Growth form	Sandy pediment		River channel	
	6a	6a	6b	6b
	1995	2005	1995	2005
Annuals/Forbs	0.1	0	0.2	0.2
Grasses	5.1	0.2	11.4	12.2
Low shrubs (<0.25 m)	-	-	-	-
Medium shrubs (0.25-1.5 m)	7.1	3.0	1.3	1.3
Tall shrubs (>1.5 m)	-	-	1.0	1.0
Leaf succulents	-	-	-	-
Stem succulents	0.1	0.1	-	-
Trees	20.1	20.1	16.1	18.1
Total cover %	**32.5**	**23.4**	**30.0**	**32.8**
No. species	**14**	**12**	**22**	**21**

6

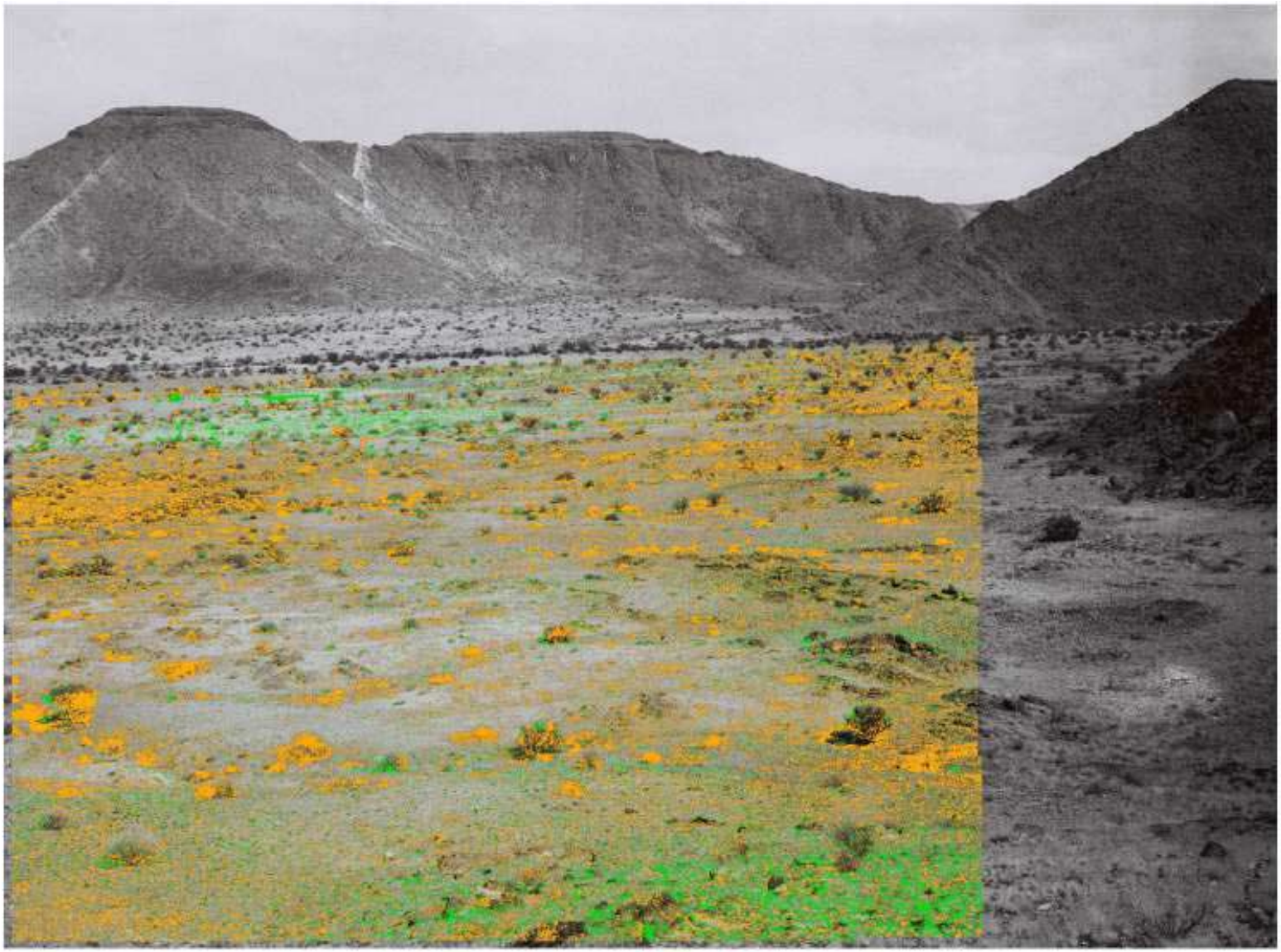


PHOTOSTATION 7: ||Ana||as (28.47836; 20.21818). Looking 324º NW, the top photograph was taken at 09h33 on 20 January 1995 while the bottom photograph was taken at 09h17 on 15 January 2005. A stockpost has been established in the left midground of this photograph. The complex geology and topography in the foreground (7a) is comprised of quartz, granite, calcrete and sandy patches dissected by narrow stream channels in places. In 1995 strong soil/vegetation patterns were evident with, for example, *Stipagrostis anomela* (10-0%) more abundant on quartz, *S. obtusa* (3-0%) associated with surface calcrete, *S. uniplumis* (7-1%) and *S. hochstetteriana* (15-2%) dominating on sandy soils and *Euphorbia gregaria* (1-2%) abundant where rock cover was highest. As a result of grazing and trampling impacts, this pattern was no longer evident in 2005. The cover of all *Stipagrostis* species has plummeted at this photostation and plant cover in 7a has dropped from over 50% in 1995 to less than 10% in 2005. This decline has been similar for landform 7c. This latter landform is one of the few sites where tree cover has declined significantly. This has occurred largely as a result of the unexplained death of many *Acacia mellifera* (5-2%) individuals. Total cover in the river channel (7b) has halved since 1995, driven largely by a drop in the grasses *Stipagrostis namaquensis* (4-0.1%) and *S. hochstetteriana* (15-5%). The palatable medium shrubs *Monechma spartioides* (2-0.1%) and *Phaeoptilum spinosum* (2-0.1%) have also decreased in cover in the river channel.

Table 7. Changes in the estimated % cover of different growth forms in Riemvasmaak between 1995 and 2005 for the sandy pediment in the foreground (7a) and slope of an alluvial fan in the distance (7c) and the river channel located in the middle distance (7b) at Photostation 7.

Growth form	Sandy pediments				River channel	
	7a	7a	7c	7c	7b	7b
	1995	2005	1995	2005	1995	2005
Annuals/Forbs	1.2	0	0.2	0	1.0	0
Grasses	42.0	3.1	36.0	10.1	6.1	0.2
Low shrubs (<0.25 m)	-	-	0.1	0	-	-
Medium shrubs (0.25-1.5 m)	4.0	2.2	1.2	0.2	4.0	0.2
Tall shrubs (>1.5 m)	-	-	3.0	0.1	0.1	2.0
Leaf succulents	-	-	-	-	-	-
Stem succulents	1.1	2.1	0.1	0.01	-	-
Trees	3.1	2.1	8.0	5.0	8.0	7.0
Total cover %	**51.4**	**9.5**	**48.6**	**15.4**	**19.2**	**9.4**
No. species	**28**	**24**	**15**	**16**	**15**	**15**

7



PHOTOSTATION 8: Mostertshoek (28.46015; 20.17552). Looking 99º E, the top photograph was taken at 15h32 on 20 January 1995 while the bottom photograph was taken at 15h12 on 15 January 2005. This is one of the more remote locations at Riemvasmaak and is several kilometres from the nearest stockpost. Despite this, most of the grass tufts here have been grazed and grass cover has declined on all landforms. The decrease has been greatest on the sandy pediments in the foreground (8a) where grasses such as *Stipagrostis uniplumis* (7-2%), *S. obtusa* ((1-0.01%) and *S. anomela* (1-0%) have been most affected. Medium shrubs such as *Monechma spartioides* and *Rhigozum trichotomum* have decreased a little on this landform while the disturbance indicator species, *Galenia africana*, has increased from 0.01-2%. In the river channel (8b) *S. namaquensis* has lost half of its cover (10-5%) while the medium shrubs *Monechma spartioides* (2-1%) and *Dyerophytum africanum* (2-0%) have also decreased significantly in cover since 1995. The tall shrub, *Sisyndite spartea*, however has increased slightly (7-10%). *Acacia mellifera* dominates the river channel and its cover has remained unchanged at 10%. Several palatable, and relatively ungrazed trees are still present in low numbers in the river channel (e.g. *Maerua gilgii*, *Ehretia rigida*, *Adenolobus gariepensis*, *Ziziphus mucronata*). A few large *Acacia erioloba* individuals also remain. Although *Monechma spartioides* has decreased in cover on the rocky slopes on the left (8c) and right background (8d), *Zygophyllum suffruticosum* has increased significantly at both locations accounting for most of the increase in medium shrub cover on these rocky pediments.

Table 8. Changes in the estimated % cover of different growth forms in Riemvasmaak between 1995 and 2005 for the sandy pediments in the foreground (8a), the river channel in the midground (8b) and the rocky slopes and pediment in the left (8c) and right (8d) background at Photostation 8.

Growth form	Sandy pediment		River channel		Rocky slopes & pediments			
	8a	8a	8b	8b	8c	8c	8d	8d
	1995	2005	1995	2005	1995	2005	1995	2005
Annuals/Forbs	3.0	0	-	-	-	-	0.1	0
Grasses	9.3	2.1	10.2	5.0	3.1	1.1	3.0	2.0
Low shrubs (<0.25 m)	0.4	0.3	0.2	0.1	-	-	0	0.1
Medium shrubs (0.25-1.5 m)	6.0	4.0	4.1	1.0	2.2	5.2	0	2.2
Tall shrubs (>1.5 m)	-	-	7.1	10.1	-	-	0.1	1.1
Leaf succulents	-	-	-	-	1.0	1.0	5.0	5.0
Stem succulents	0.1	0.01	0.01	0	15.0	15.0	15.0	15.0
Trees	12.0	12.0	10.6	10.4	2.0	0.1	1.1	2.1
Total cover %	**30.8**	**18.4**	**32.2**	**26.6**	**23.3**	**22.4**	**24.3**	**27.5**
No. species	**23**	**16**	**23**	**20**	**8**	**10**	**9**	**19**

8

1995

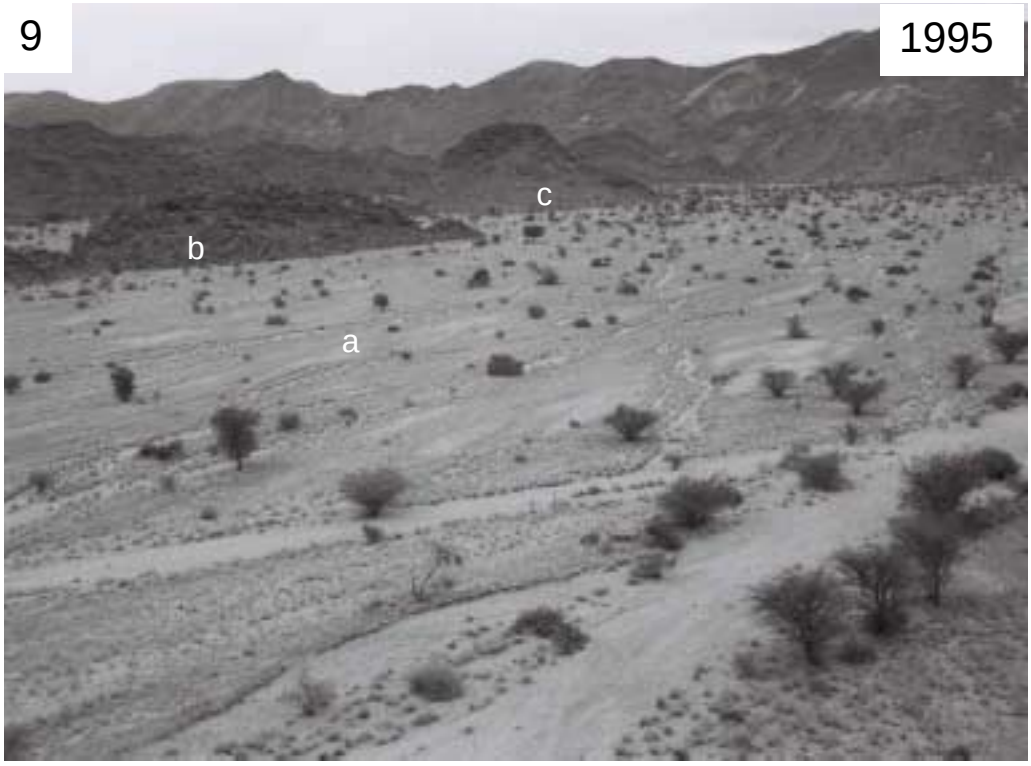
2005

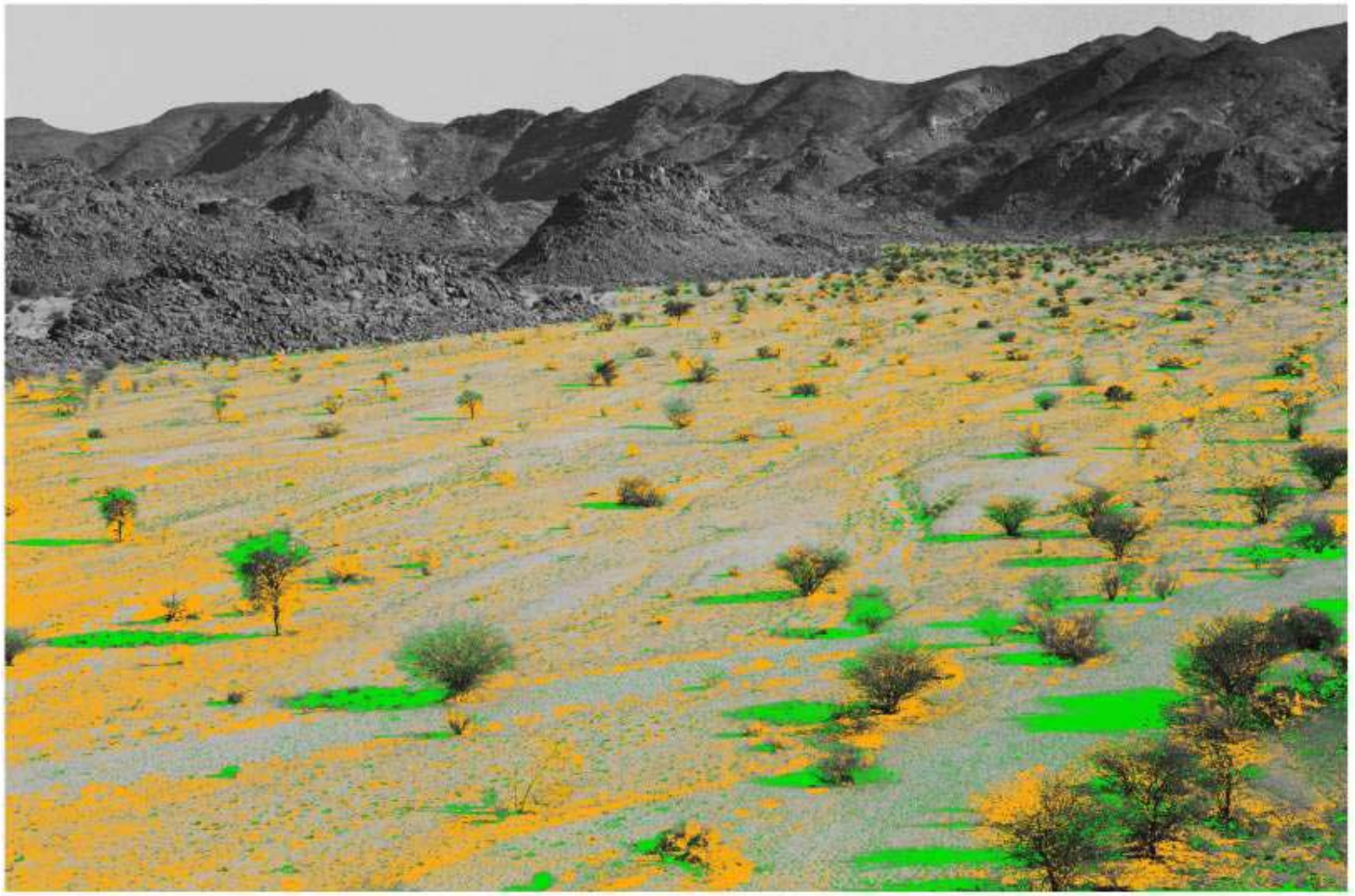
PHOTOSTATION 9: Xubuxnap (28.47034; 20.11906). Looking 18º NNE, the top photograph was taken at 08h10 on 21 January 1995 while the bottom photograph was taken at 08h05 on 16 January 2005. There has been a 30% reduction in the cover of grasses in the sandy foreground pediments (9a) driven largely by the decrease in cover of *Stipagrostis uniplumis* from 30-5% since 1995. The drop in grass cover on the two inselberg sites (9b, 9c) is primarily as a result of the decline in *Enneapogon scaber*. *Sisyndite spartea* is an interesting tall shrub which has decreased from 3-1% on the sandy pediment (9a), increased from 1-3% on the first inselberg (9b) and has remained unchanged at 1% on the second inselberg (9c). Tree cover has not changed since 1995. What is more difficult to measure at this site, however, is the change in the braided stream network that is so characteristic of the sandy pediment (9a) in the 1995 photograph. Minor and major stream channels criss-crossed the sandy pediment and water movement sorted the sand particle according to size and weight. Coarse sand associated with the middle of larger stream channels supported *Stipagrostis namaquensis* while *S. uniplumis, S. hochstetteriana, Schmidtia kalahariensis* and the medium shrub *Monechma spartioides* were distributed in a predictable pattern across the pediment. Constant trampling and grazing between 1995 and 2005 has resulted in a homogenization of this landscape and the pattern in species distribution is now only weakly evident both in the photograph and on the ground.

Table 9. Changes in the estimated % cover of different growth forms in Riemvasmaak between 1995 and 2005 for the sandy pediments in the foreground (9a) and the two inselbergs in the distance (9b, 9c) at Photostation 9.

Growth form	Sandy pediment		Inselbergs			
	9a	9a	9b	9b	9c	9c
	1995	2005	1995	2005	1995	2005
Annuals/Forbs	2.1	0	0.1	0.1	0.1	0
Grasses	37.1	7.1	7.1	0.2	10.1	0.2
Low shrubs (<0.25 m)	-	-	-	-	0	0.1
Medium shrubs (0.25-1.5 m)	1.0	0.1	0.1	0.1	2.2	0.1
Tall shrubs (>1.5 m)	3.1	1.0	1.1	3.0	1.0	1.0
Leaf succulents	-	-	-	-	-	-
Stem succulents	-	-	-	-	-	-
Trees	5.0	5.0	-	-	2.0	2.0
Total cover %	**48.3**	**13.2**	**8.4**	**3.4**	**15.4**	**3.4**
No. species	**18**	**15**	**7**	**6**	**12**	**11**

9





PHOTOSTATION 10: Petrushoek (28.44605; 20.11114). Looking 296º WNW, the top photograph was taken at 11h16 on 21 January 1995 while the bottom photograph was taken at 11h02 on 16 January 2005. The presence of clouds in 1995 complicates the interpretation of changes at this Photostation. Although this is one of the most remote sites in Riemvasmaak and is only accessible by vehicle with difficulty, evidence of grazing was everywhere to be seen in the form of animal dung and grazed grass tufts. Grasses (primarily *Stipagrostis uniplumis* and to a lesser extent *Enneapogon scaber*) never formed a large component of the foreground rocky pediments in 1995 although both species decreased significantly in 2005. The medium shrub, *Monechma spartioides* was common on the rocky pediments and its decrease in 10b accounts for the change in medium shrubs in this landform. Grasses such as *Schmidtia kalahariensis* (20-0%), *Stipagrostis uniplumis* (7-0.1%) and *S. hochstetteriana* (1-0.1%) dominated the alluvial fan in the distance (10c) in 1995 and have all but disappeared from this landform. Tree cover (e.g. *Acacia mellifera, Boscia foetida, B. albitrunca, Pappea capensis and Parkinsonia africana* (10c only)) has remained relatively constant in all landforms at this Photostation.

Table 10. Changes in the estimated % cover of different growth forms in Riemvasmaak between 1995 and 2005 for the very dissected rocky pediments in the foreground (10a, 10b) and the sandy pediment (alluvial fan) in the distance (10c) at Photostation 10.

Growth form	Rocky slopes & pediments				Sandy pediment	
	10a	10a	10b	10b	10c	10c
	1995	2005	1995	2005	1995	2005
Annuals/Forbs	0.1	0	3.0	0	1.0	0
Grasses	2.4	0.4	8.3	0.3	29.0	0.2
Low shrubs (<0.25 m)	-	-	0.1	0.1	0	0.1
Medium shrubs (0.25-1.5 m)	3.1	3.2	6.2	3.1	5.1	5.1
Tall shrubs (>1.5 m)	1.2	1.2	-	-	0.1	0.1
Leaf succulents	2.0	1.0	-	-	-	-
Stem succulents	0	0.01	7.0	7.0	-	-
Trees	5.2	5.2	3.2	3.2	5.0	5.0
Total cover %	**14.0**	**11.0**	**27.8**	**13.7**	**40.2**	**10.5**
No. species	**24**	**27**	**21**	**22**	**16**	**12**

10

PHOTOSTATION 11: Lower Kourop Valley (28.46465; 20.14012). Looking 134º SE, the top photograph was taken at 16h03 on 21 January 1995 while the bottom photograph was taken at 16h11 on 15 January 2005. A stockpost is located within 300 m of the Photostation and the impacts of grazing at this site are particularly noticeable on the sandy pediment in the foreground (11a). The effects of grazing and trampling on the braided stream network outlined for Photostation 9 are repeated here, where the cover of grasses such as *Schmidtia kalahariensis* (30-0%), *Stipagrostis uniplumis* (15-0%), *S. hochstetteriana* (2-0.1%) and the medium shrub, *Monechma spartioides* (2-0.1%) has plummeted since 1995. The tall shrub, *Sisyndite spartea* (5-1%) has also declined on the sandy pediment. A slight increase in the cover of *Stipagrostis namaquensis* accounts for most of the increase in grass cover in the river channel (11b) and a similarly slight increase in the tall shrub, *Sisyndite spartea* has also occurred here. The medium shrubs, *Monechma spartioides* and *Dyerophytum africanum*, however, have all but disappeared from this landform (11b). The cover of trees in the river channel (e.g. *Acacia mellifera*, *Acacia erioloba*, *Boscia foetida*, *B. albitrunca*) has not changed although many individuals now exhibit a distinct browse line. The change in plant cover on the inselberg (11c) is largely as a result of the decrease in the grasses *Stipagrostis uniplumis* (3-0.1%) and *Enneapogon scaber* (1-0.1%).

Table 11. Changes in the estimated % cover of different growth forms in Riemvasmaak between 1995 and 2005 for the sandy pediments in the foreground (11a), the river channel in the middle distance (11b) and the inselberg on the right in the distance (11c) at Photostation 11.

Growth form	Sandy pediment		River channel		Inselberg	
	11a	11a	11b	11b	11c	11c
	1995	2005	1995	2005	1995	2005
Annuals/Forbs	2.2	0.1	0.1	0.1	1.1	0.1
Grasses	47.0	0.1	3.4	5.1	4.1	0.2
Low shrubs (<0.25 m)	-	-	-	-	-	-
Medium shrubs (0.25-1.5 m)	2.0	0.1	4.0	0	-	-
Tall shrubs (>1.5 m)	5.0	1.0	7.0	10.0	1.0	1.0
Leaf succulents	-	-	-	-	-	-
Stem succulents	-	-	-	-	0.01	0.1
Trees	2.3	2.3	7.1	7.1	2.1	2.1
Total cover %	**58.5**	**3.6**	**21.6**	**22.3**	**8.3**	**3.5**
No. species	**16**	**10**	**17**	**14**	**9**	**12**

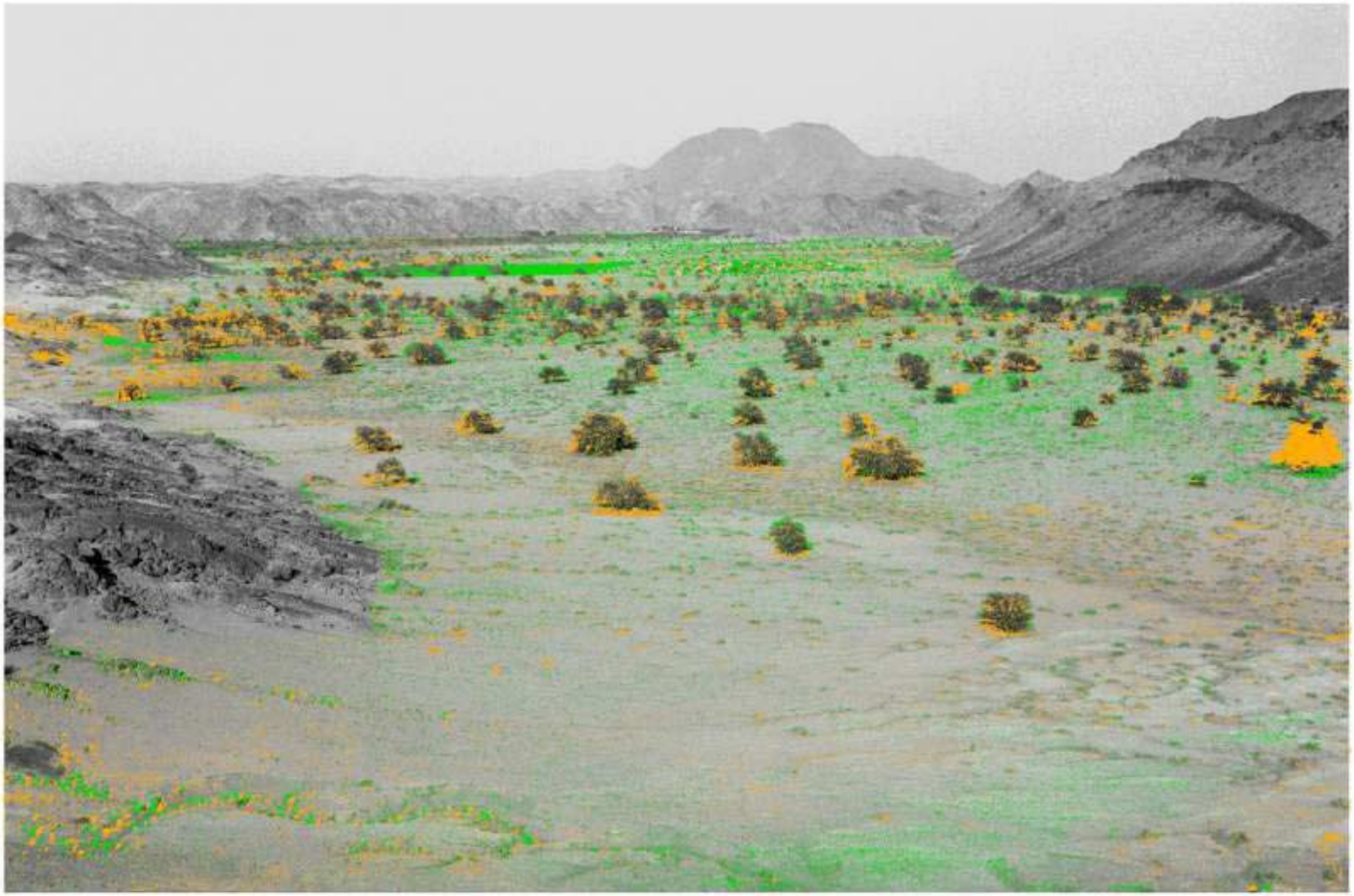
11

PHOTOSTATION 12: Molopo Fan (28.50752; 20.21514). Looking 290º WNW, the top photograph was taken at 07h42 on 22 January 1995 while the bottom photograph was taken at 07h36 on 17 January 2005. The wide sandy valley of the lower reaches of the Molopo River has been settled since 1995 and agricultural activities in the distance of the 2005 photograph form the basis for an emerging viticulture industry. The Vredevallei settlement has had a surprisingly low impact on the vegetation in the photograph and few signs of firewood collection, for example, were evident in 2005. Landforms 12e1 and 12e2, located behind the Photostation, have changed very little since 1995 and are not discussed further. Grass cover has declined by more than two-thirds in landform 12a1 largely as a result of the decrease in *Stipagrostis hochstetteriana* (25-10%), *S. uniplumis* (5-0.1%) and *Schmidtia kalahariensis* (5-0.1%). The tall shrub, *Sisyndite spartea* has also declined from 5-2% in this landform. Tree cover has not changed here although a single *Boscia albitrunca* individual (centre, extreme right) has died. *Zygophyllum microcarpum* dominates the saline and wind-eroded region of 12a2 and has declined by about 10% since 1995. *Stipagrostis hochstetteriana* (3-1%) and S. obtusa (1-0.1%) have also declined here. The dissected river channel in the distance (12b) shows a decline in grasses such as *S. namaquensis* (15-10%) and *S. uniplumis* (3-0.1%) while *Sisyndite spartea* (15-20%) has increased in cover over this time. The cover of trees such as *Acacia erioloba, A. mellifera, Schotia afra, Boscia foetida* and *Tamarix usneioides* has not changed since 1995.

Table 12. Changes in the estimated % cover of different growth forms in Riemvasmaak between 1995 and 2005 for the wide, sandy river valley of the lower Molopo River near the settlement of Vredevallei at Photostation 12. Landforms 12e1 and 12e2 are located behind the Photostation.

Growth form	River channels									
	12a1	12a1	12a2	12a2	12b	12b	12e1	12e1	12e2	12e2
	1995	2005	1995	2005	1995	2005	1995	2005	1995	2005
Annuals/Forbs	-	-	0.1	0	0.1	0	-	-	0.2	0.1
Grasses	37.2	10.5	4.4	1.3	18.3	10.2	3.2	1.1	2.3	2.2
Low shrubs (<0.25 m)	-	-	-	-	-	-	-	-	-	-
Medium shrubs (0.25-1.5 m)	0.2	0.2	50.0	40.0	0.1	0.1	-	-	0.2	0.1
Tall shrubs (>1.5 m)	5.0	2.0	-	-	15.0	20.0	-	-	2.0	2.0
Leaf succulents	-	-	-	-	-	-	-	-	-	-
Stem succulents	-	-	-	-	-	-	-	-	-	-
Trees	8.0	8.0	6.1	6.1	17.1	17.1	72.0	67.1	69.1	69.2
Total cover %	**50.4**	**20.7**	**60.6**	**47.4**	**50.6**	**47.3**	**75.2**	**68.2**	**73.8**	**73.6**
No. species	**17**	**15**	**11**	**9**	**20**	**13**	**12**	**14**	**17**	**21**

12



PHOTOSTATION 13: Descent to Molopo River (28.48275; 20.23018). Looking 254º WSW, the top photograph was taken at 121h26 on 22 January 1995 while the bottom photograph was taken at 12h42 on 15 January 2005. This photograph is taken just above a hairpin bend in the road descending to the Molopo River and Vredevallei. The biggest change in the rocky pediment in the foreground is the reduction in grass cover. *Stipagrostis uniplumis* (5-0.1%), *S. anomela* (1-0%) and *Enneapogon scaber* (1-0.1%) have shown the greatest decrease since 1995. The stem succulent, *Euphorbia gregaria* has not changed in cover over the last 10 years while the cover of the medium shrub, *Monechma spartioides* has also stayed the same on the rocky pediments and in the river channel (13b). Grass cover (*S. uniplumis* (101%) in this channel, which cuts into the pediment on the right of the photograph, has not changed much and the major difference in this growth form is as a result of the disappearance of the sedge, *Cyperus marginatus* (2-0%). Trees such as *Schotia afra* and *Boscia albitrunca* have not changed in cover since 1995 although *Euclea pseudebenus*, *Tamarix unsneiodies* and the tall shrub, *Cadaba aphylla*, which were rare in 1995 were not recorded in 2005.

Table 13. Changes in the estimated % cover of different growth forms in Riemvasmaak between 1995 and 2005 for the rocky slopes and pediments (13a) and river channel (13b) at Photostation 13.

Growth form	Rocky slope & pediment		River channel	
	13a	13a	13b	13b
	1995	2005	1995	2005
Annuals/Forbs	0.1	0	0.1	0.1
Grasses	7.0	0.2	3.3	1.2
Low shrubs (<0.25 m)	0.2	0.2	0.2	0.1
Medium shrubs (0.25-1.5 m)	1.6	1.5	0.3	0.3
Tall shrubs (>1.5 m)	0.1	0.1	-	-
Leaf succulents	-	-	-	-
Stem succulents	5.0	5.0	0.2	0.2
Trees	1.0	1.0	11.1	11.1
Total cover %	**15.0**	**8.0**	**15.2**	**13.0**
No. species	**20**	**18**	**25**	**23**

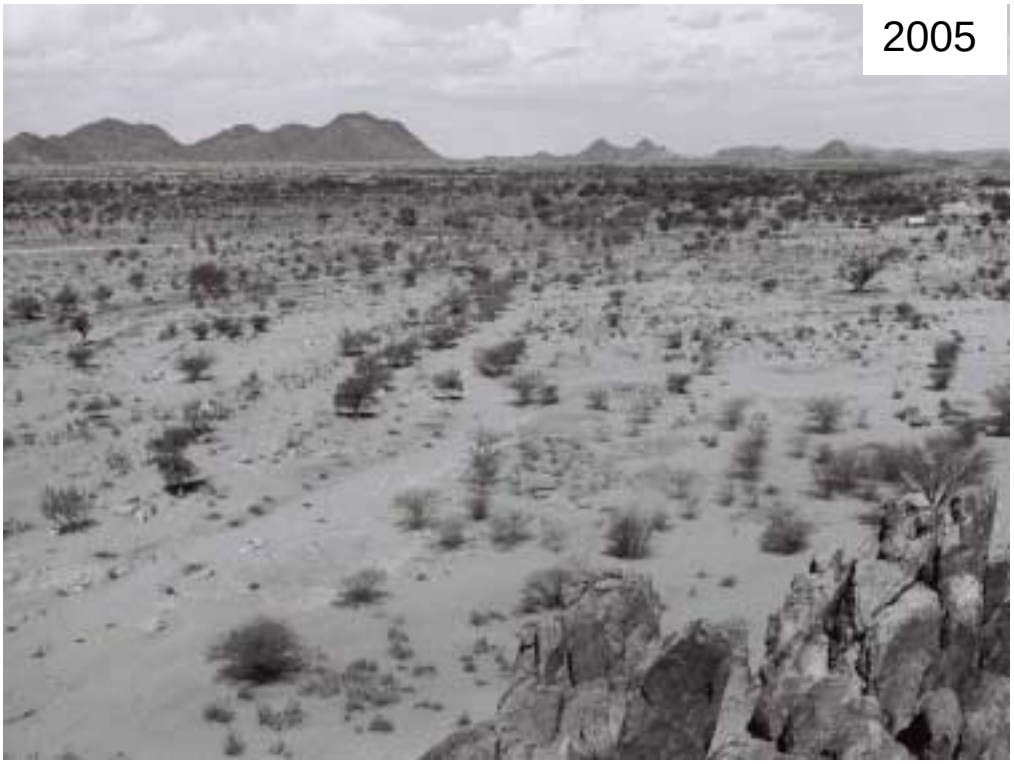
13

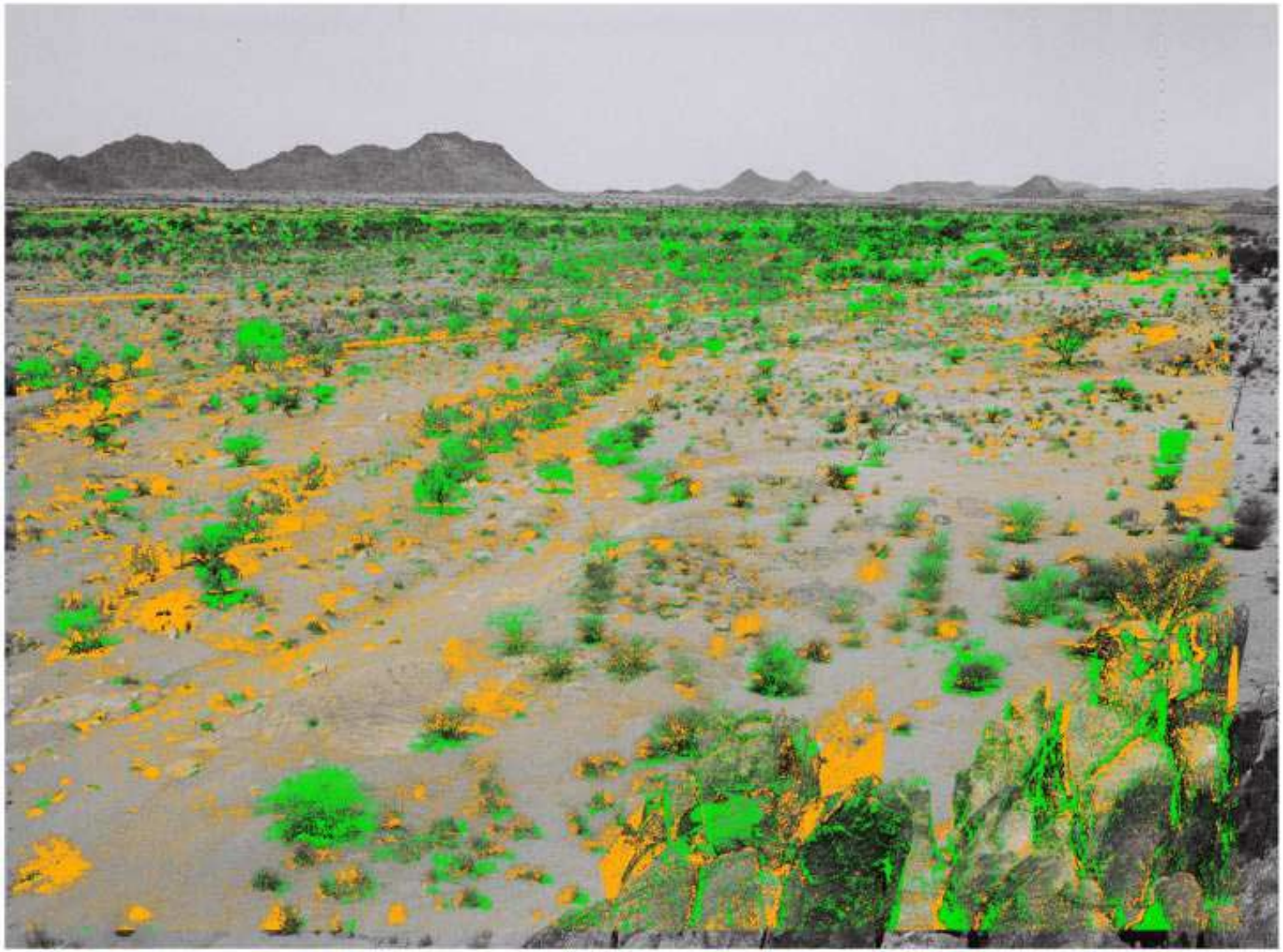
PHOTOSTATION 14: Riemvasmaak Mission East (28.45628; 20.31658). Looking 104º ESE, the top photograph was taken at 16h11 on 22 January 1995 while the bottom photograph was taken at 16h11 on 14 January 2005. This photostation overlooks the mission station which is situated just below and to the left of the low koppie from which this photograph was taken. The area has been heavily utilised by livestock in the last 10 years. The most important changes in the river channel in the foreground (14a) are the reduction in grass, medium shrub and tree cover. Key grasses include *Odyssea paucinervis* (3-1%) and *Stipagrostis namaquensis* (1-0.1%). The medium shrub *Galenia africana* has declined (1-0.1%) while the tree *Acacia erioloba* has stayed the same at 1% cover. *Tamarix usneoides* (20-10%) has decreased in cover but the two alien trees *Nicotiana glauca* (0-3%) and *Prosopis glandulosus* (0.1-1%) have both increased in cover since 1995 in the river channel. Plant cover in landform 14b has decreased by more than half while the more dense habitats within landform 14c remain largely unchanged both in terms of cover and species composition. In landform 14b, *Stipagrostis ciliata* (1-0.01%) has declined while the medium shrubs *Lycium cinereum* (5-1%), *Phaeoptilum spinosum* (1-0.1%) and *Giseckia pharnaceiodes* (1-0%) have also declined since 1995. *Acacia mellifera* (1-2%) has increased in cover in landform 14b, while the increase in tree cover since 1995 in landform 14c is accounted for by the increase in *Prosopis glandulosus* (0.1-1%) with *Acacia erioloba* and *A. mellifera* staying the same at 7% and 5% respectively.

Table 14. Changes in the estimated % cover of different growth forms in Riemvasmaak between 1995 and 2005 for the river channel (14a) and sandy pediments (14b & 14c) at Photostation 14.

Growth form	River channel		Sandy pediments			
	14a	14a	14b	14b	14c	14c
	1995	2005	1995	2005	1995	2005
Annuals/Forbs	0.4	0	0.3	0	0.1	0
Grasses	4.1	1.1	1.3	0.2	2.1	0.2
Low shrubs (<0.25 m)	0.2	0	1.2	0	-	-
Medium shrubs (0.25-1.5 m)	1.3	0.2	6.3	1.3	5.2	6.1
Tall shrubs (>1.5 m)	0.1	0.1	0.1	0.2	-	-
Leaf succulents	0.1	0	-	-	-	-
Stem succulents	-	-	0.01	0.01	-	-
Trees	21.1	15.0	1.1	2.1	12.1	13.0
Total cover %	**27.3**	**16.4**	**10.3**	**3.8**	**19.5**	**19.3**
No. species	**22**	**15**	**23**	**16**	**25**	**14**

14



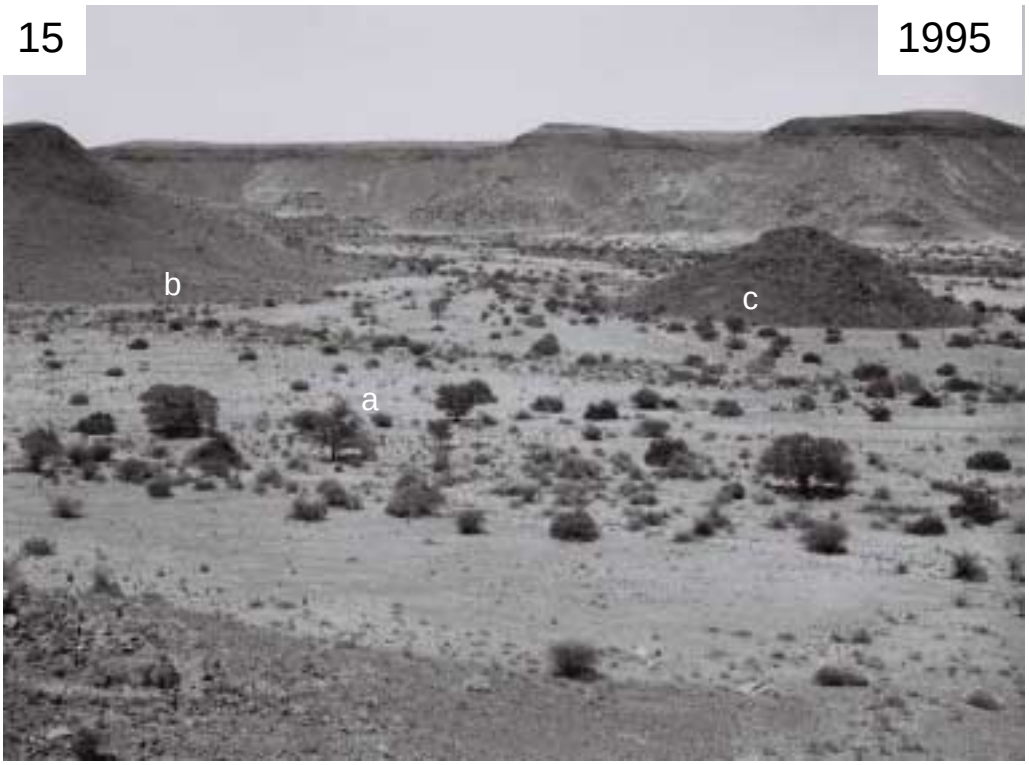


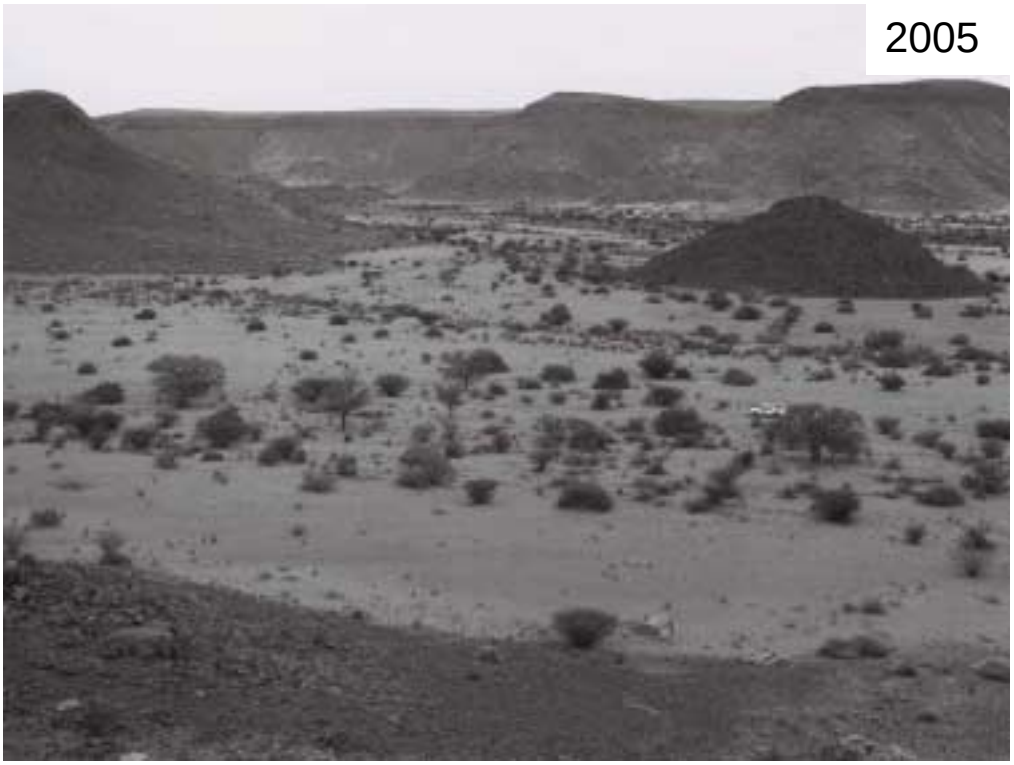
PHOTOSTATION 15: Loriesfontein River (28.34992; 20.08570). Looking 224º SW, the top photograph was taken at 11h44 on 23 January 1995 while the bottom photograph was taken at 12h47 on 11 January 2005 under slightly overcast conditions. The sandy pediment of the wide valley (15a) has lost most of its grass cover since 1995 as a result of a decrease in the abundance of *Stipagrostis uniplumis* (10-0.1%), *S. hochstetteriana* (10-5%) and *Schmidtia kalahariensis* (1-0%). Annuals/forbs were also more abundant in 1995 but medium shrub (Monechma spartioides (1%) and tree cover (Acacia mellifera (5%), A. erioloba (2%)) has not changed even though the photographs do suggest a slight thinning of the medium and tall shrubs and trees over the 10 years. Cover has nearly halved since 1995 on the rocky slope in the left background (15b), largely as a result of the decline in *S. uniplumis* (2-0.1%), the medium shrub, *Monechma genistifolium* (1-0%) and the stem succulent, *Euphorbia gregaria* (6-4%). The inselberg (15c) in the right midground has also recorded a loss in grass cover (*S. uniplumis* (5-0.1%)) and in annuals/forbs although little else has changed in the 10 years on this rocky, north-facing slope. The change in species richness is determined largely by the relative absence of annuals/forbs at this site in 2005.

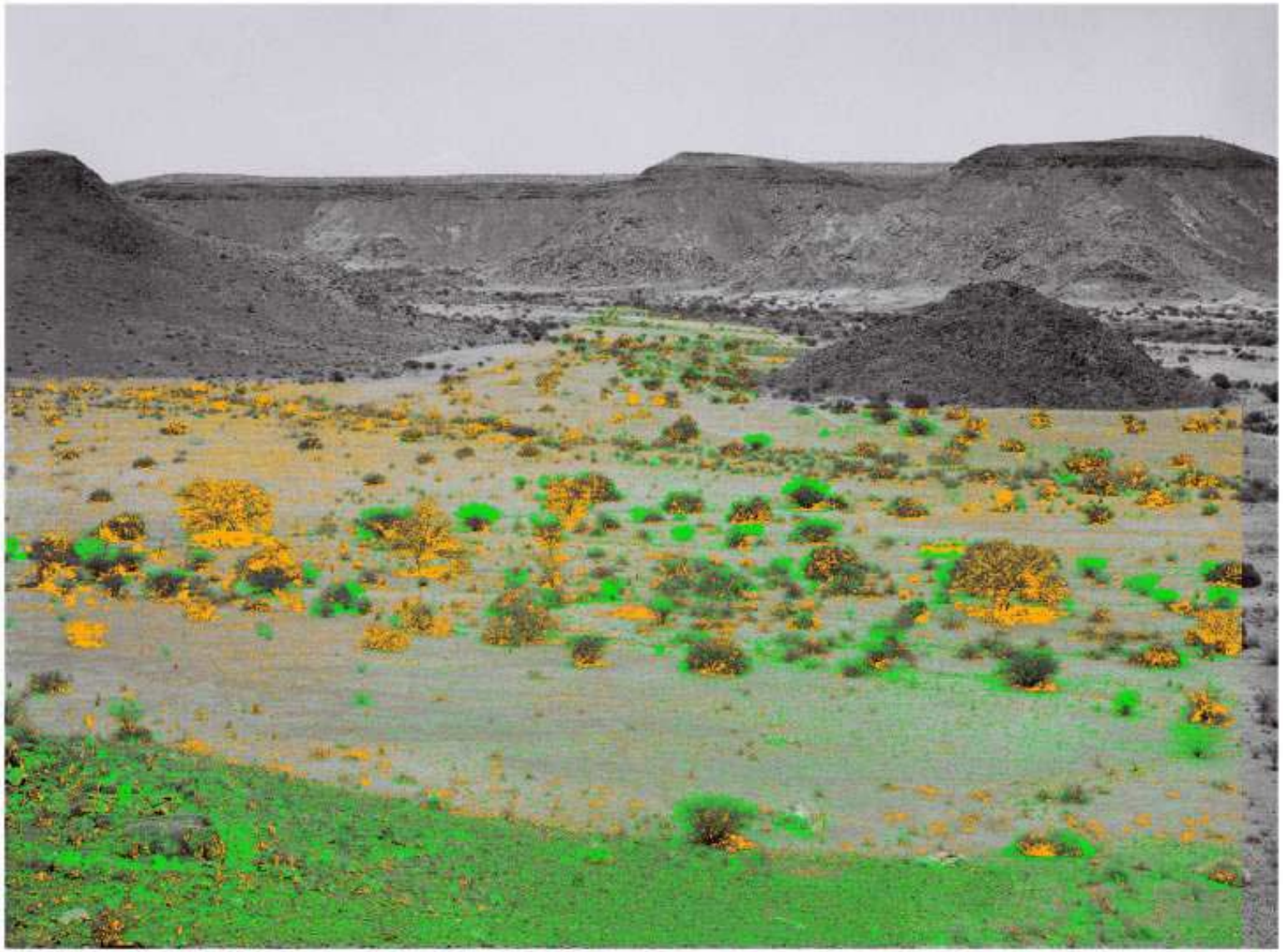
Table 15. Changes in the estimated % cover of different growth forms in Riemvasmaak between 1995 and 2005 for the sandy pediments (15a), rocky slopes (15b) and inselbergs (15c) at Photostation 15.

Growth form	Sandy pediment		Rocky slope & pediment		Inselberg	
	15a	15a	15b	15b	15c	15c
	1995	2005	1995	2005	1995	2005
Annuals/Forbs	1.1	0	0.1	0	3.1	0.1
Grasses	21.1	5.1	2.1	0.1	5.0	0.1
Low shrubs (<0.25 m)	0.1	0	-	-	-	-
Medium shrubs (0.25-1.5 m)	6.1	6.1	2.0	1.0	0.2	0.2
Tall shrubs (>1.5 m)	0.1	0.1	-	-	-	-
Leaf succulents	-	-	-	-	-	-
Stem succulents	0.1	0.1	6.0	4.0	2.0	2.0
Trees	8.1	8.1	0.1	0.1	0.1	0.1
Total cover %	**36.7**	**19.5**	**10.3**	**5.2**	**10.4**	**2.5**
No. species	**22**	**15**	**8**	**6**	**10**	**16**

15





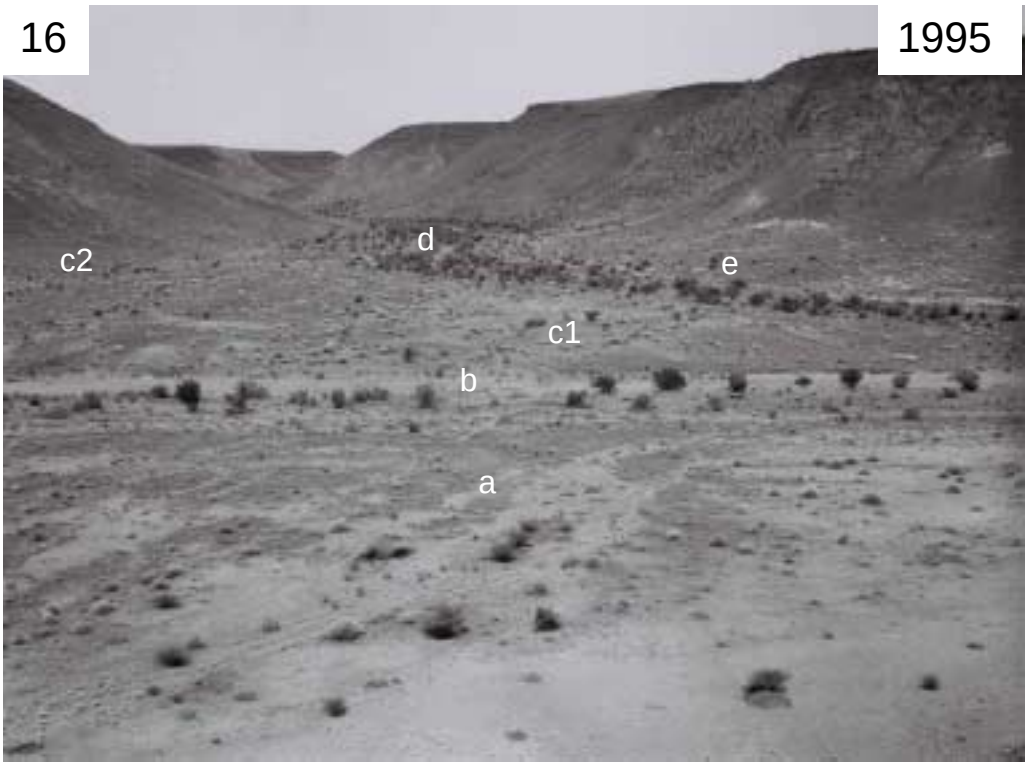


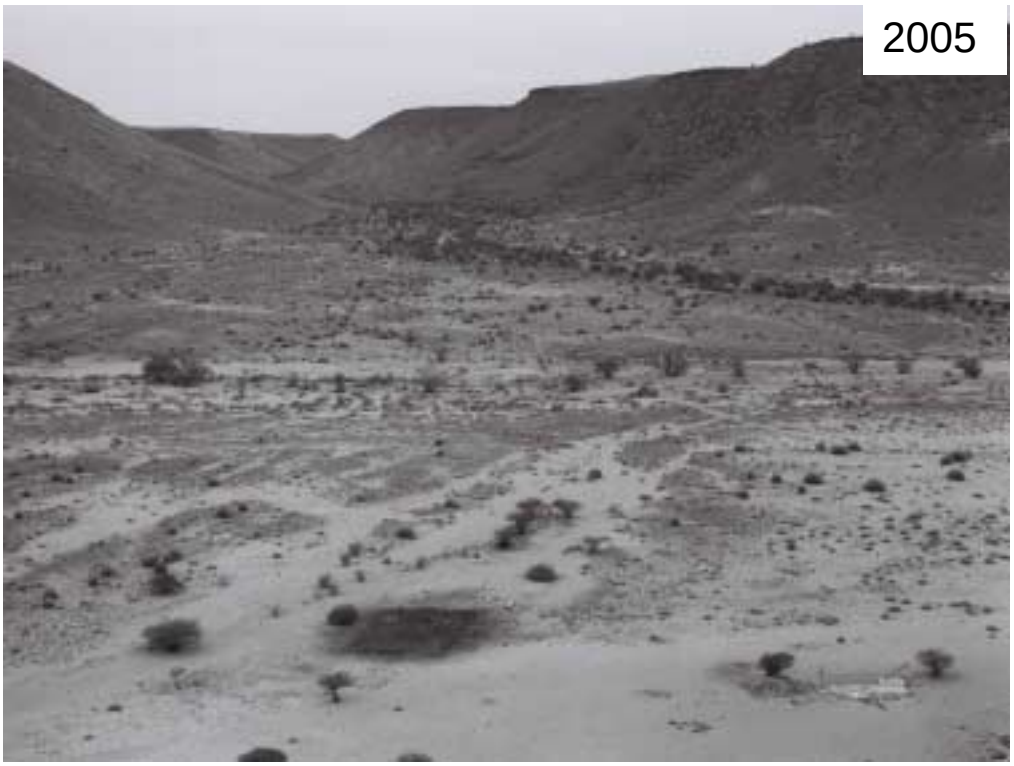
PHOTOSTATION 16: Upper Bak River (28.28978; 20.02119). Looking 104º ESE, the top photograph was taken at 16h20 on 23 January 1995 while the bottom photograph was taken at 15h23 on 11 January 2005. An abandoned kraal is visible in the 2005 photograph at the base of the koppie from which the image was taken. This landscape is rather complex with a number of landforms, each with a different suite of species dominating. Grass cover (*Stipagrostis hochstetteriana* (4-1%) and *S. uniplumis* (2-0.01%)) have decreased on the sandy pediments (16a) in the foreground while the salinity-tolerant, medium shrub, *Salsola aphylla* (4-10%) has increased in cover. The river channel (16b) which bisects the photograph in the middle, shows a clear loss of tree cover, particularly of *Acacia karroo* (5-1%) and *Euclea pseudebenus* (2-0.01%) although the cover of other trees such as *Acacia mellifera* and *Schotia afra* remains unchanged at 1% each. *Salsola aphylla* (0-5%) has increased in the river channel while *Stipagrostis namaquensis* (7%) remains unchanged and *S. hochstetteriana* (7-0.1%) has decreased significantly. Just beyond the river is a patch of Kalahari sand (16c1) which shows a decline in the tall shrub, *Lycium prunus-spinosa* (1-0.01%) and the spread of the stem succulent, *Sarcostemma viminale* (0-1%) onto this site. Both rocky pediments (16c2, 16e), although quite different in their total cover and species composition, show a decrease in grass cover, especially of *Stipagrostis uniplumis*. While the rocky river channel (16d) at the base of the slope in the right background has lost grass cover (especially *S. uniplumis* (10-0.1%)), medium shrubs and a diversity of trees have changed little since 1995. The tall shrub, *Cadaba aphylla* (0.1-1.0%) appears to have increased in cover over this period in this landform.

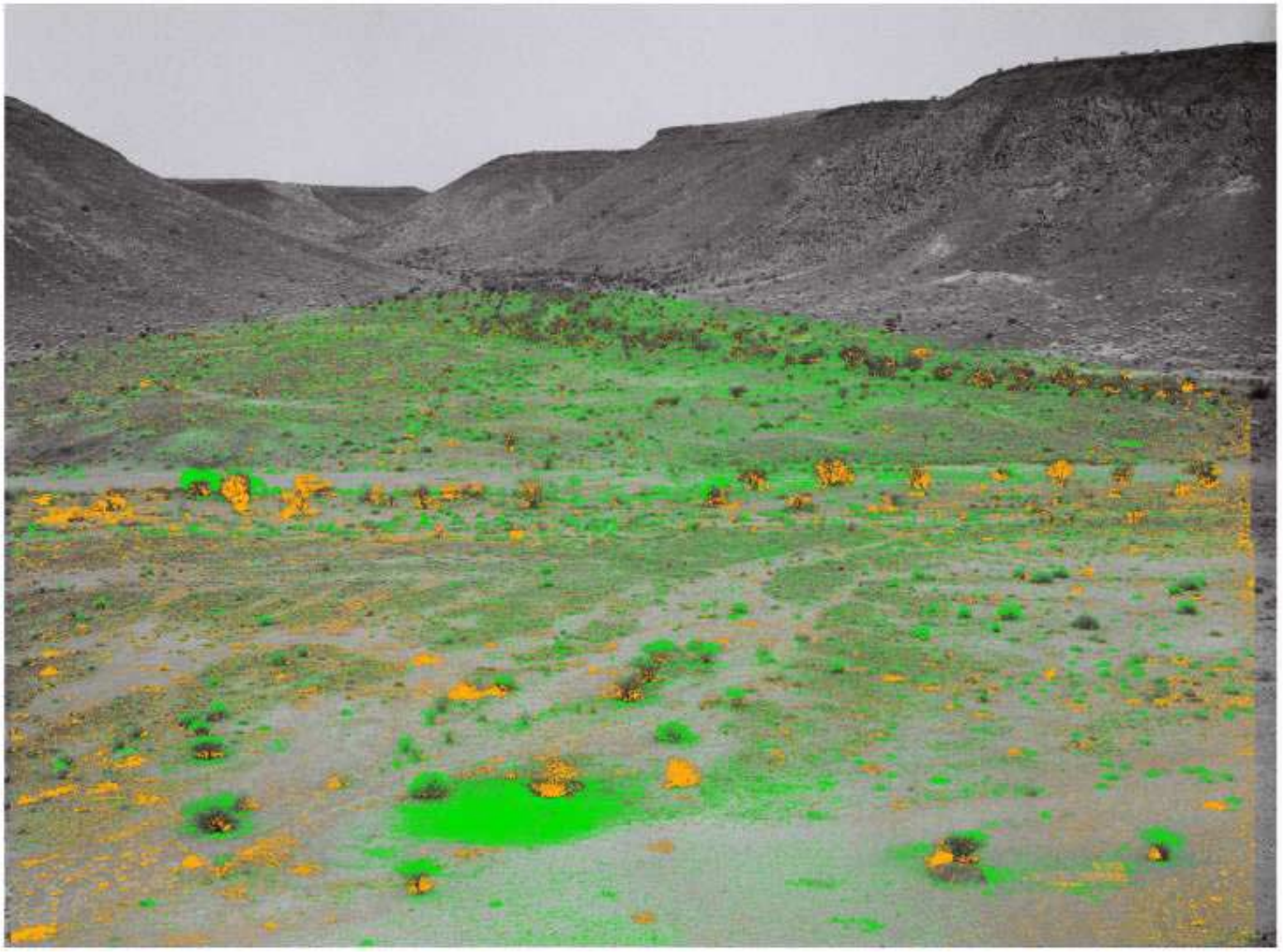
Table 16. Changes in the estimated % cover of different growth forms in Riemvasmaak between 1995 and 2005 for the sandy pediments (16a, 16c1), rocky slopes (16c2, 16e) and river channels (16b, 16d) at Photostation 16.

Growth form	Sandy pediments				Rocky slopes & pediments				River channels			
	16a	16a	16c1	16c1	16c2	16c2	16e	16e	16b	16b	16d	16d
	1995	2005	1995	2005	1995	2005	1995	2005	1995	2005	1995	2005
Annuals/Forbs	0.1	0	-	-	0.1	0.1	0.1	0.1	0.1	0.1	-	-
Grasses	6.0	1.0	10.3	10.3	2.2	1.0	5.1	0.2	14.3	7.2	18.3	10.3
Low shrubs (<0.25 m)	-	-	0.1	0	-	-	-	-	-	-	0.1	2.0
Medium shrubs (0.25-1.5 m)	4.0	10.0	1.2	1.2	5.1	5.0	19.1	13.1	0.2	5.0	2.1	2.2
Tall shrubs (>1.5 m)	-	-	1.0	0	-	-	-	-	1.0	2.0	0.1	1.0
Leaf succulents	0.1	1.0	-	-	-	-	-	-	0.01	0.01	0	0.01
Stem succulents	4.0	4.0	5.0	6.0	10.0	10.0	15.1	15.1	1.0	0.1	-	-
Trees	0.1	0.1	2.0	2.0	1.0	1.0	0.1	0.1	9.1	3.1	25.2	25.2
Total cover %	**14.3**	**16.1**	**19.6**	**19.5**	**18.4**	**17.1**	**39.5**	**28.6**	**25.7**	**17.5**	**45.8**	**40.7**
No. species	**10**	**7**	**14**	**15**	**12**	**12**	**13**	**18**	**24**	**19**	**18**	**25**

16





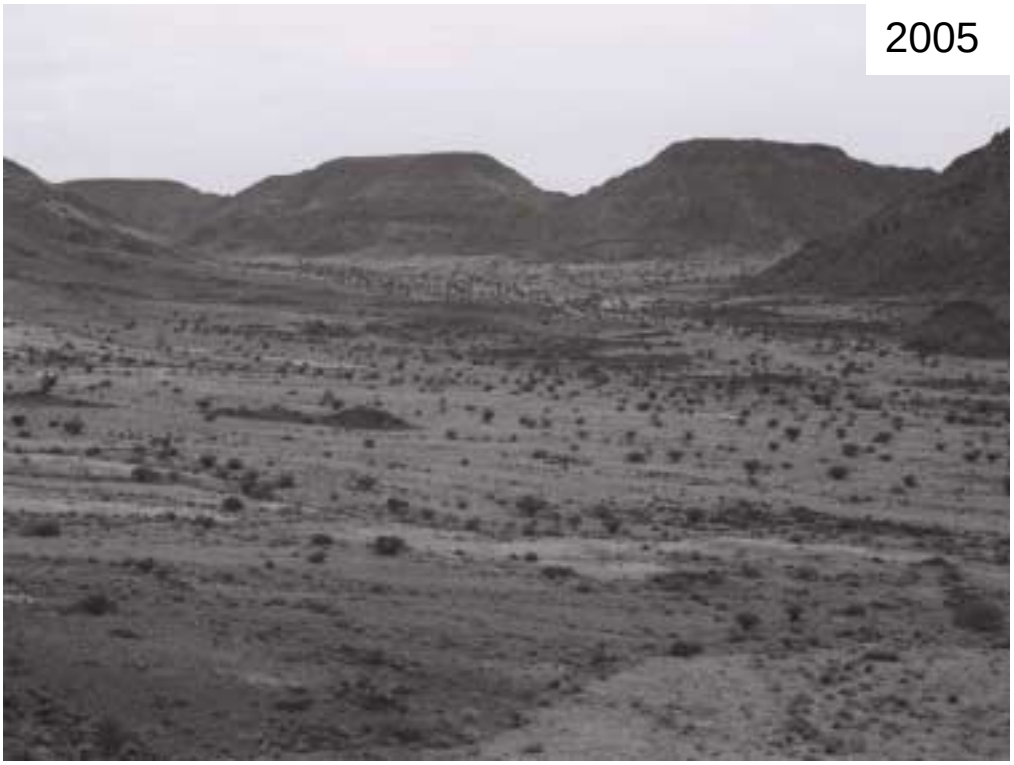


PHOTOSTATION 17: Donkiemond (28.35203; 20.01629). Looking 180º S, the top photograph was taken at 08h32 on 24 January 1995 while the bottom photograph was taken at 07h47 on 12 January 2005. A quartz mine now exists to the left of this image with a significant but local impact. Grass cover has more than halved since 1995 on the sandy pediment (17a) in the foreground largely through the decline in *Stipagrostis hochstetteriana* (10-5%) and *Enneapogon scaber* (1-0.1%). While the medium shrub, *Monechma spartioides* has not changed from its original 1% cover, the relatively palatable medium shrub, *Petalidium lucens* was 2% in 1995 but was not recorded in 2005. *Acacia mellifera* (8%), *Boscia foetida* (2%) and *B. albitrunca* (1%) have not changed in cover since 1995 on the sandy pediments. Grass cover has dropped significantly on the rocky pediments in the background (17b) with the decline in *Enneapogon scaber* (8-1%) the main reason for this. The relatively palatable medium shrub *Phaeoptilum spinosum* has declined from 4-0.1% while tree cover (e.g. *Acacia mellifera*, *Boscia foetida*) has remained low on this landform at 0.1% cover for both species.

Table 17. Changes in the estimated % cover of different growth forms in Riemvasmaak between 1995 and 2005 for the sandy pediments (17a and rocky pediments (17b) at Photostation 17.

Growth form	Sandy pediment		Rocky slope & pediment	
	17a	17a	17b	17b
	1995	2005	1995	2005
Annuals/Forbs	2.3	0.2	2.1	2.2
Grasses	11.1	5.2	8.2	1.1
Low shrubs (<0.25 m)	-	-	0.1	0
Medium shrubs (0.25-1.5 m)	3.3	1.3	4.3	0.3
Tall shrubs (>1.5 m)	0.1	0.0	-	-
Leaf succulents	-	-	-	-
Stem succulents	0.1	0.1	0.01	0.01
Trees	11.1	11.1	0.2	0.2
Total cover %	**28.0**	**17.9**	**14.9**	**3.8**
No. species	**30**	**26**	**16**	**19**

17

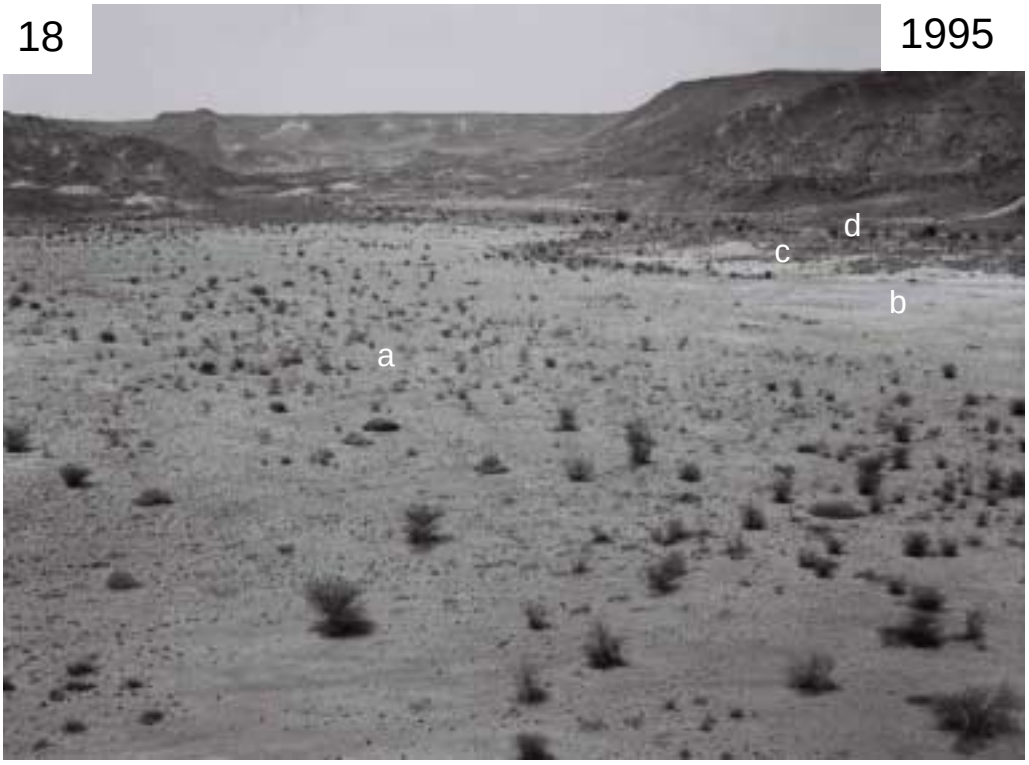


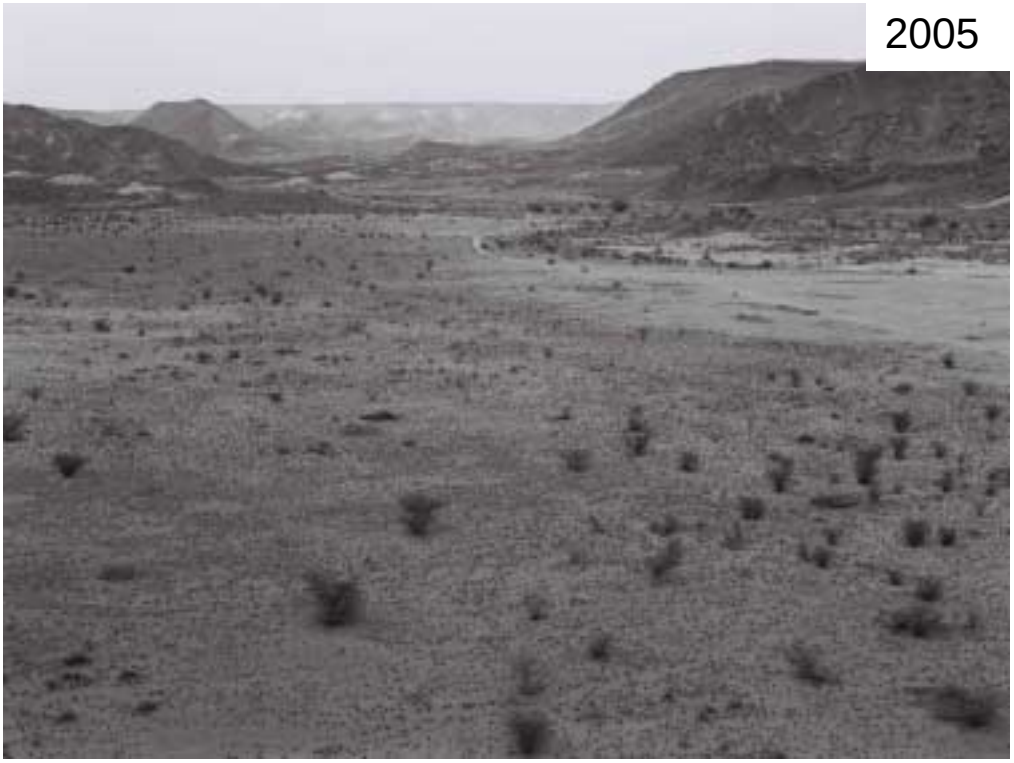
PHOTOSTATION 18: Near Bok se Puts (28.32617; 20.03810). Looking 258º WSW, the top photograph was taken at 10h19 on 24 January 1995 while the bottom photograph was taken at 09h11 on 12 January 2005. This is the only photostation which has not experienced a decline in grass cover since 1995 despite there being a stock post (centre background) and mining site (left and out of frame) at this location. *Stipagrostis hochstetteriana* (10%), *S. uniplumis* (0.1%) and *Schmidtia kalahariensis* (0.1%) dominate the sandy pediment in the foreground and together with the tree, *Acacia mellifera* (5%), have not changed over the 10 years. Interestingly, the first two grass species both declined from 1-0.1% on the rocky pediment (18c) in the right background and were the only growth form to change appreciably on this landform. The decline in cover on the sandy pediment (18a) of medium shrubs such as *Rhigozum trichotomum* (5-0.1%) and *Monechma spartioides* (0.1-0%) and the visible physical impact on shrubs such as *Ceraria namaquensis* on the rocky pediment (18c) suggests that despite the heavy grazing intensity, grass cover has not been affected. In fact, a closer look at the image suggests that in some areas of 18a, basal cover of *S. hochstetteriana* has increased significantly. The sandy pediment in the right midground (18b) is significantly more saline as evidenced by the abundance of *Augea capensis* in 1995 although this declined from 3-0.1% over the 10 years. The river channel in the right background (18d) has changed little since 1995 with the grass *S. uniplumis* (2-0.1%) the only element to decline appreciably over this period. Other grasses which are common in the river channel such as *S. namaquensis* (5%), *S. hochstetteriana* (1%), *S. obtusa* (1%) and even the highly palatable, *Cenchrus ciliaris* (1%) have also not been affected by grazing.

Table 18. Changes in the estimated % cover of different growth forms in Riemvasmaak between 1995 and 2005 for the sandy pediments (18a & 18b), rocky pediments (18c) and river channel in the distance (18d) at Photostation 18.

Growth form	Sandy pediments				Rocky slope & pediment		River channel	
	18a	18a	18b	18b	18c	18c	18d	18d
	1995	2005	1995	2005	1995	2005	1995	2005
Annuals/Forbs	0.1	0	0.1	0	-	-	0.1	0.1
Grasses	10.2	10.2	0.1	0.1	2.0	0.2	10.1	8.2
Low shrubs (<0.25 m)	2.0	0	-	-	0.1	0	-	-
Medium shrubs (0.25-1.5 m)	5.1	0.1	0.1	0.1	4.2	4.2	1.0	1.0
Tall shrubs (>1.5 m)	-	-	-	0.1	-	-	10.0	10.0
Leaf succulents	0.1	0	3.0	0.1	0.01	0.01	0.01	0.01
Stem succulents	0.1	0.1	0	0.01	8.1	8.1	0.01	0
Trees	5.1	5.1	-	-	0.1	0.1	12.1	12.1
Total cover %	**22.7**	**15.5**	**3.3**	**0.4**	**14.5**	**12.6**	**33.3**	**31.4**
No. species	**13**	**10**	**4**	**5**	**13**	**18**	**21**	**19**

18





PHOTOSTATION 19: Deurspring (28.40874; 20.14266). Looking 246º WSW, the top photograph was taken at 15h31 on 24 January 1995 while the bottom photograph was taken at 14h19 on 12 January 2005. Located in the lower Kourop Valley this site is a few km from a stock post. Grasses have been most impacted by grazing and *Stipagrostis uniplumis* (4-0.1%) and *S. ciliata* (2-0.1%) have been particularly negatively affected on the sandy pediment in the foreground and to the left (east) of the river channel (19a). While the medium shrub *Monechma spartioides* (1%) has not changed in cover, the legume, *Indigofera heterotricha* has increased from 0.01-1% since 1995 as has the tall shrub, *Sisyndite spartea* (5-10%). Although grass cover has remained fairly constant in the river channel some species have decreased while others have increased. For example, *Stipagrostis namaquensis* has declined by half (10-5%) but the sedge, *Cyperus marginatus* has increased in cover from 2-5%. The medium shrub, *Zygophyllum microcarpum* has declined from 1-0.01% while the tall shrub, *Sisyndite spartea* has increased in cover (as it did in landform 19a) from 1-5% in the river channel and along its banks. Trees, such as *Tamarix usneioides* (10%), *Euclea pseudebenus* (5%), *Acacia mellifera* (3%), *A. erioloba* (1%), *Ziziphus mucronata* (1%) and *Schotia afra* (1%) have not changed in cover since 1995.

Table 19. Changes in the estimated % cover of different growth forms in Riemvasmaak between 1995 and 2005 for the sandy pediments (19a), and river channel and the vegetation along its banks (19b) in the right midground at Photostation 19.

Growth form	Sandy pediment		River channel	
	19a	19a	19b	19b
	1995	2005	1995	2005
Annuals/Forbs	0.3	0.1	0.2	0
Grasses	6.2	0.3	12.3	10.3
Low shrubs (<0.25 m)	-	-	-	-
Medium shrubs (0.25-1.5 m)	1.3	2.3	1.1	0.2
Tall shrubs (>1.5 m)	5.1	10.1	1.0	5.0
Leaf succulents	-	-	-	-
Stem succulents	0.01	0.01	-	-
Trees	7.1	7.1	21.0	21.0
Total cover %	**20.0**	**19.9**	**35.6**	**36.5**
No. species	**22**	**18**	**18**	**18**

19 1995

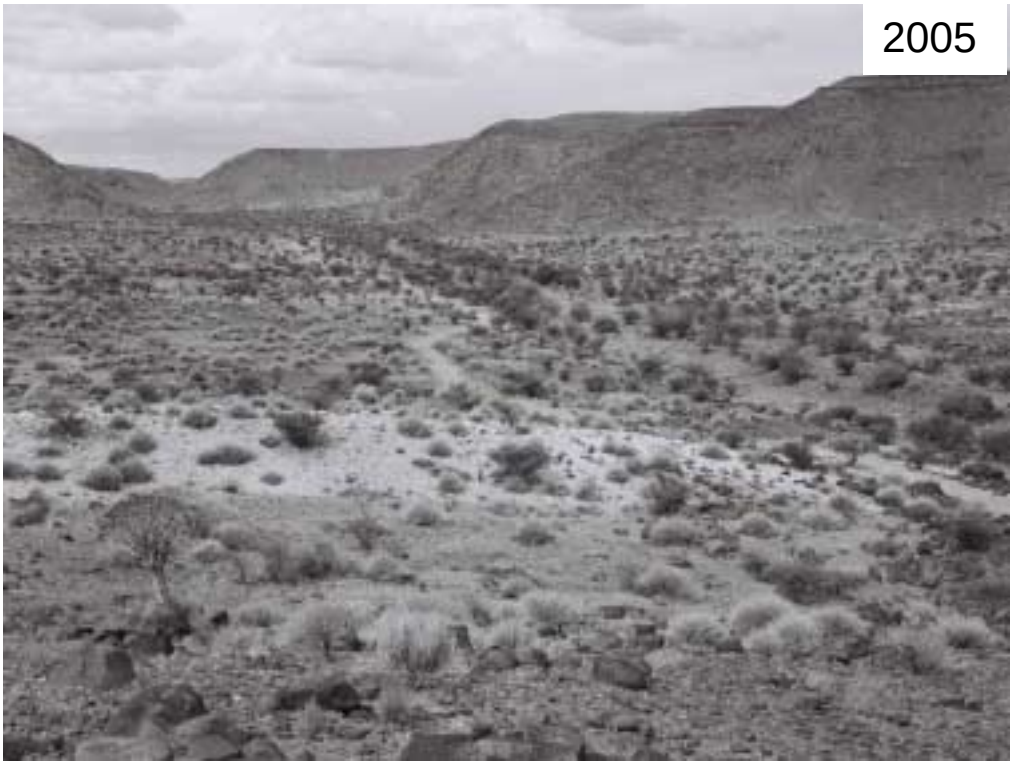
2005

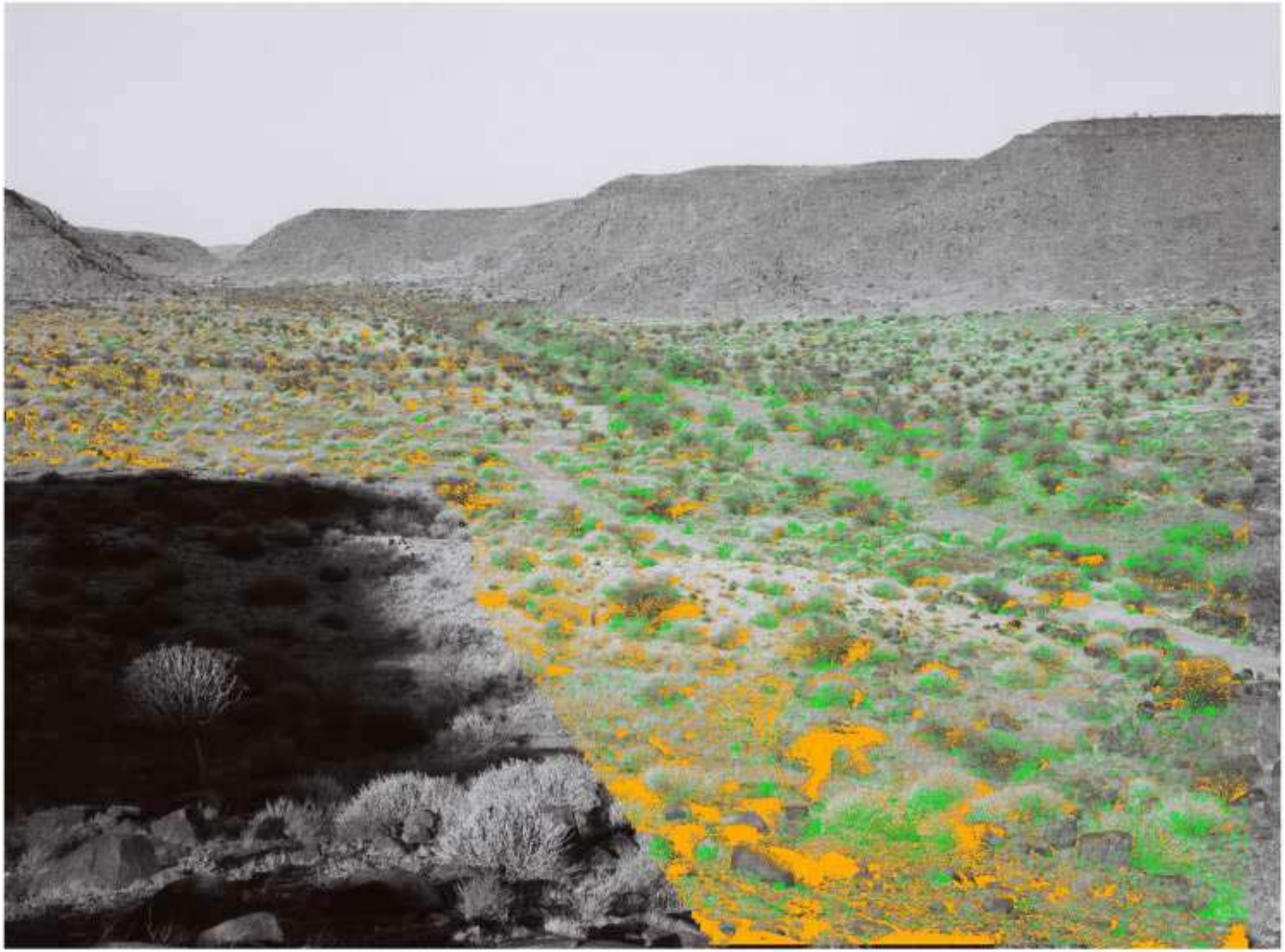
PHOTOSTATION 20: Deksel East (28.35883; 20.17697). Looking 80º ENE, the top photograph was taken at 18h08 on 24 January 1995 while the bottom photograph was taken at 16h44 on 12 January 2005. A water point and stock post are located close to the photostation and signs of grazing are clearly evident, particularly on grasses which have declined significantly at this site since 1995. The biggest casualty on the rocky foreground slope (20a) has been *Stipagrostis uniplumis* (15-2%) and to a lesser extent *S. hochstetteriana* (2-0.1%). While the medium shrub, *Monechma spartioides* (2-0.1%) has declined, *Zygophyllum suffruticosum* (1%) has remained constant. The same is true for *Euphorbia gregaria* (10%) on this landform (20a) which has not changed in cover since 1995. Trees such as *Acacia mellifera* (20%) and *Boscia foetida* (1%) have also not declined in cover over the ten years. In the river channel (20b), the sedge *Cyperus marginatus* has stayed the same at 2% cover but the grasses, *Stipagrostis uniplumis* (3-0.1%), *S. hochstetteriana* (1-0.1%) and *S. ciliata* (1-0%) have all declined in cover since 1995. The medium shrub *Monechma spartioides* (5-0.1%) has similarly declined in the river channel but trees such as *Schotia afra* (25%), *Tamarix usneioides* (10%), *Acacia mellifera* (5%) and *Euclea pseudebenus* (1%) have not changed.

Table 20. Changes in the estimated % cover of different growth forms in Riemvasmaak between 1995 and 2005 for the rocky slopes and pediments (20a), and river channel (20b) on the right of the image at Photostation 20.

Growth form	Rocky slope & pediment		River channel	
	20a	20a	20b	20b
	1995	2005	1995	2005
Annuals/Forbs	0.2	0	-	-
Grasses	17.1	2.1	7.1	3.2
Low shrubs (<0.25 m)	0	0.1	-	-
Medium shrubs (0.25-1.5 m)	3.1	1.2	5.1	0.2
Tall shrubs (>1.5 m)	0.1	0	0.1	0.1
Leaf succulents	-	-	-	-
Stem succulents	10.0	10.0	1.0	1.0
Trees	21.1	21.0	41.1	41.1
Total cover %	**51.6**	**34.4**	**54.4**	**45.6**
No. species	**17**	**19**	**17**	**18**

20





PHOTOSTATION 21: Above Molopo Gorge (28.45384; 20.29285). Looking 215º SW, the top photograph was taken at 07h52 on 25 January 1995 while the bottom photograph was taken at 07h43 on 13 January 2005. This site is close to the Riemvasmaak mission station and to a permanent spring. It was visited by John Acocks in May 1952 (sample no. 1647) although he did not photograph this site. There were eight annual species recorded in 1995 with *Cleome oxyphylla* (1%) the most dominant, but only four annuals recorded in 2005, all with very low cover values. The most important change at this site since 1995 is the reduction in grass cover, particularly of *Stipagrostis uniplumis* (4-0.1%) and *Enneapogon scaber* (1-0.1%). The medium shrub, *Monechma spartioides* has also decreased in cover from 2 to 1% but other shrubs such as *Hermannia stricta* (1%) and *Indigofera heterotricha* (1%) have not changed. Dominant trees such as *Acacia mellifera* (5%) and *Schotia afra* (2%) and have also not changed in cover since 1995. Acocks recorded 71 species in 1952 and the 1995 sample found just under half of those (33 species) with an additional 17 "new" species (i.e. not recorded by Acocks). We listed 44 species in 2005. Several of the more palatable species that were noted as rare (cover <1%) in 1995 were not found in 2005 (e.g. *Limeum aethiopicum*, *Monechma genistifolium*, *Salsola aphylla*, *Sericocoma avolans*).

Table 21. Changes in the estimated % cover of different growth forms in Riemvasmaak between 1995 and 2005 for the rocky slopes and pediments (21a) at Photostation 20.

Growth form	Rocky slope & pediment	
	21a	21a
	1995	2005
Annuals/Forbs	1.4	0.1
Grasses	5.4	0.4
Low shrubs (<0.25 m)	0.6	0.3
Medium shrubs (0.25-1.5 m)	4.8	3.7
Tall shrubs (>1.5 m)	2.0	2.0
Leaf succulents	0	0
Stem succulents	0.3	0.3
Trees	7.3	7.3
Total cover %	**21.8**	**14.1**
No. species	**51**	**44**

21

1995

2005

PHOTOSTATION 22: Droeputs (28.44608; 20.24869). Looking 317º NW, the top photograph was taken at 11h55 on 25 January 1995 while the bottom photograph was taken at 11h35 on 15 January 2005. There are now two active stockposts at this location (left midground and left out of frame). The rocky slope in the foreground has lost the grass *Stipagrostis uniplumis* (2-0%) and has also seen a decline in *Enneapogon scaber* (2-0.1%). The most significant change in shrub cover for this landform is the 2% decline in the spiny shrub *Indigofera spinescens* from 12-10% since 1995. *Euphorbia gregaria* continues to dominate this slope (10%). The rocky pediment to the left and behind the stock post (22e) has also lost *S. uniplumis* and the medium shrub, *Monechma spartioides* has declined from 1-0.1%. *Zygophyllum microcarpum* (2%) has stayed the same while *Euphorbia gregari*a has increased on this slope from 0.1-5%. The sandy pediment in the right midground (22c) has lost *Stipagrostis uniplumis* (7-0.1%) although *S. namaquensis* appears to have increased significantly from 0.1-10% at this location accounting for the increase in grass cover in this landform in Table 22. *Zygophyllum microcarpum* also appears to have increased from 4-5% on this landform as well as on the sandy pediment in the centre of the image (22d) where it increased from 1-2%. The wide river channel (22b) shows a decline in the dominant grass *S. namaquensis* from 12-10% (perhaps this decline is even greater than this) and also an increase in the medium shrub *Zygophyllum microcarpum* (0-1%). A detailed analysis of the photograph shows several trees (particularly *Acacia mellifera*) that have been removed and others that have grown significantly taller since 1995.

Table 22. Changes in the estimated % cover of different growth forms in Riemvasmaak between 1995 and 2005 for the rocky pediments in foreground (22a) and left midground (22e), the sandy pediments to the right (22c) and centre (22d) midground and the wide river channel (22b) running through the image at Photostation 22.

Growth form	Rocky slopes & pediments				Sandy pediments				River channel	
	22a	22a	22e	22e	22c	22c	22d	22d	22b	22b
	1995	2005	1995	2005	1995	2005	1995	2005	1995	2005
Annuals/Forbs	0	0.1	0.2	0.2	0.2	0	0.2	0	0.4	0.2
Grasses	4.1	0.1	1.0	0	7.3	10.2	0.1	0	12.1	10.0
Low shrubs (<0.25 m)	0.1	0.1	0.2	0.1	0.1	0.0	0.1	0	-	-
Medium shrubs (0.25-1.5 m)	13.3	11.3	3.0	2.1	5.1	6.0	1.1	2.0	0	1.0
Tall shrubs (>1.5 m)	-	-	-	-	-	-	-	-	-	-
Leaf succulents	-	-	-	-	-	-	-	-	-	-
Stem succulents	10.0	10.0	0.1	5.0	-	-	0.01	0	-	-
Trees	0.0	0.02	4.0	0.1	6.1	6.1	9.0	9.0	2.0	3.0
Total cover %	**27.5**	**21.6**	**8.5**	**7.5**	**18.8**	**22.3**	**10.5**	**11.0**	**14.5**	**14.2**
No. species	**18**	**18**	**16**	**14**	**17**	**13**	**10**	**11**	**11**	**14**

22 1995

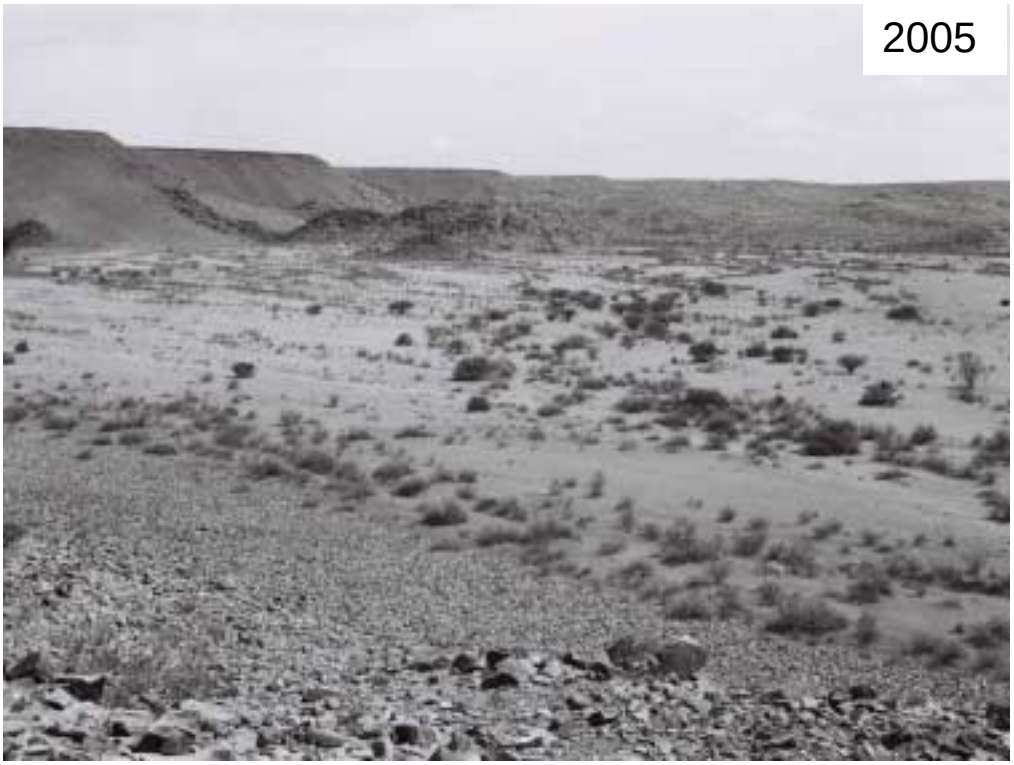
2005

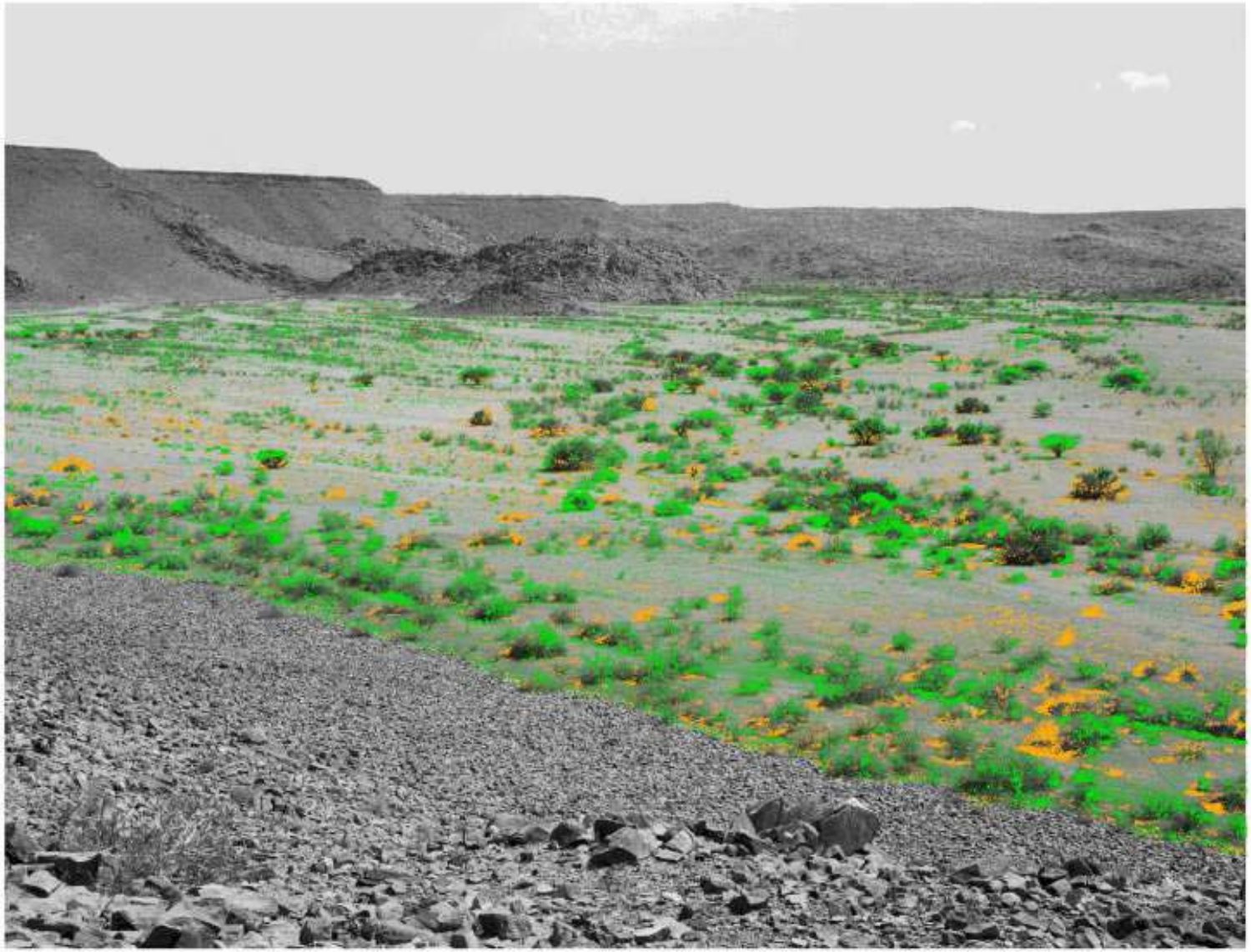
PHOTOSTATION 23: Perdepoort (28.39931; 20.39785). Looking 26º NNE, the top photograph was taken at 09h54 on 26 January 1995 while the bottom photograph was taken at 10h30 on 13 January 2005. A farmhouse has been erected just to the right and out of view. The sandy pediment in the right midground (23b) has seen a shift in grass species since 1995 with a decline in *Stipagrostis uniplumis* (3-1%) and *S. hochstetteriana* (3-1%) and an increase in the less palatable *Schmidtia kalahariensis* (0.1-3%). The same is true for the sandy pediment in the left midground (23c) with changes in *S. uniplumis* (5-1%), *S. hochstetteriana* (5-2%) and *Schmidtia kalahariensis* (0.1-1%) showing the same trends. *Rhigozum trichotomum* is the dominant medium shrub on both landforms and has not changed in cover (3% and 10% respectively). Major changes on the inselberg (23d) in the centre distance were a decline in the grass *Triraphis ramossisima* (6-1%) but not a decline in the palatable grass *Panicum arbusculum* (6%). The medium shrub *Monechma spartioides* (0.1-5%) has increased significantly at this site, particularly on the northern slope out of view. The river channel (23a) has seen a decline in grasses, particularly *Stipagrostis hochstetteriana* (5-1%) and *S. uniplumis* (1-0.1%). Other growth forms are little changed except for the trees where *Acacia mellifera* (5-8%) accounts for the increase in cover within this growth form. Seven annual species e.g. *Sesamum capense* (1%) were located in the river channel in 1995 but none of these were recorded in 2005.

Table 23. Changes in the estimated % cover of different growth forms in Riemvasmaak between 1995 and 2005 for the rocky pediments in foreground (22a) and left midground (22e), the sandy pediments to the right (22c) and centre (22d) midground and the wide river channel (22b) running through the image at Photostation 23.

Growth form	Sandy pediments				Inselberg		River channel	
	23b	23b	23c	23c	23d	23d	23a	23a
	1995	2005	1995	2005	1995	2005	1995	2005
Annuals/Forbs	0.2	0	0.3	0	0.1	0	1.1	0
Grasses	6.1	5.1	10.2	4.0	12.0	7.1	6.2	1.3
Low shrubs (<0.25 m)	0.2	0	0.2	0	-	-	0.2	0
Medium shrubs (0.25-1.5 m)	3.2	3.1	10.1	10.2	0.3	5.2	5.3	5.2
Tall shrubs (>1.5 m)	0.0	0	-	-	-	-	0.1	0.1
Leaf succulents	0.1	0	-	-	-	-	0.01	0
Stem succulents	0.01	0	-	-	0.01	0.01	0.01	0
Trees	0.01	0.01	0.2	0.2	0.1	0.1	6.2	9.1
Total cover %	**9.8**	**8.2**	**21.0**	**14.4**	**12.5**	**17.4**	**19.1**	**15.7**
No. species	**15**	**7**	**21**	**14**	**14**	**11**	**31**	**15**

23



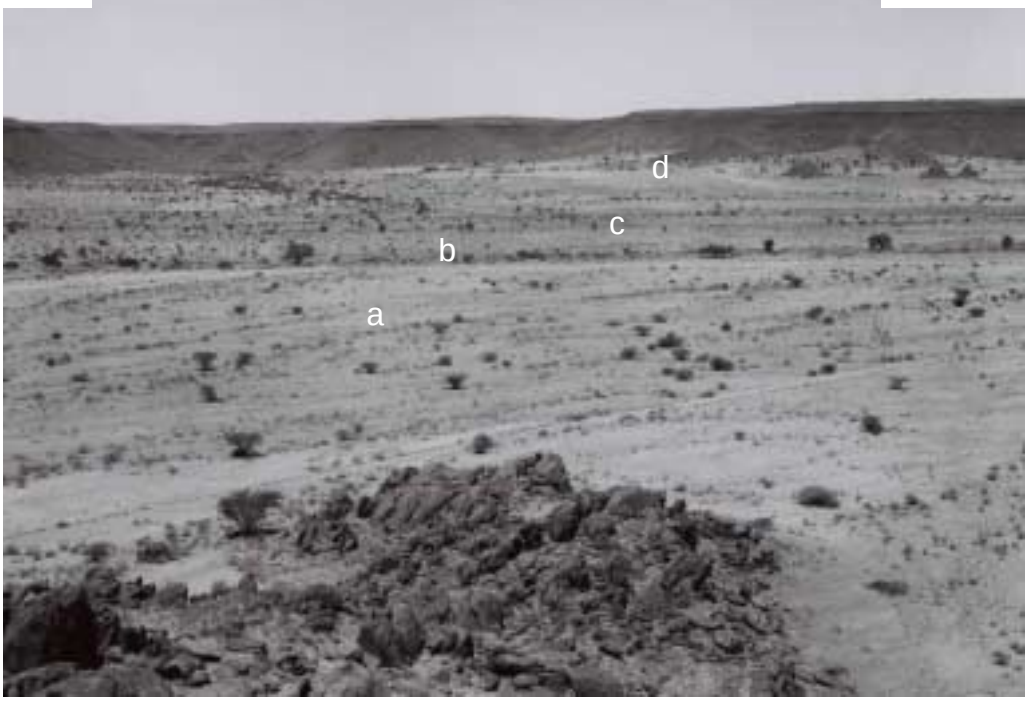


PHOTOSTATION 24: Gyam/Vaalputs (28.37387; 20.36583). Looking 126º SE, the top photograph was taken at 14h12 on 26 January 1995 while the bottom photograph was taken at 15h00 on 13 January 2005. The sandy pediments 24a and 24c have both lost grass cover but the species involved and starting cover values are somewhat different for the two landforms. While 24a has seen a decrease in *Stipagrostis hochstetteriana* (4-2%) and S. uniplumis (1-0.1%), in 24c only *S. hochstetteriana* (3-0.1%) was present in 1995. *Rhigozum trichotomum* is the dominant shrub on these pediments and has not changed in cover in 24a (4%) or 24c (10%) since 1995. *Salsola aphylla* (3-1%), *Zygophyllum microcarpum* (3-1%) and *Monechma spartioides* (1-0.1%) have all decreased in landform 24a while *Lebeckia sericia* (7-2%) has shown the greatest change for a shrub in landform 23c. In this latter region, however, *Zygophyllum microcarpum* has increased in cover since 1995 (1-5%). The sandy pediment (24d) in the centre right distance is comprised of a local patch of Kalahari sand which was dominated by *Schmidtia kalahariensis* in 1995 but the cover of this species has now declined from 4 to 0.1%. The medium shrub, *Rhigozum trichotomum* (0-1%) has increased in cover on 24d while *Acacia mellifera* has remained unchanged at 10% cover. Scattered *A. erioloba* (1%) also occur here on this patch of Kalahari sands. For the river channel (24b), grass cover, comprised of the single species, *Stipagrostis namaquensis* has increased from 5 to 10% over the 10 years. Tree cover has also increased as a result of an increase in *Acacia erioloba* (2-5%) and *Maerua gilgii* (0.1-4%) while the cover of *Acacia mellifera* has remained constant at 3%.

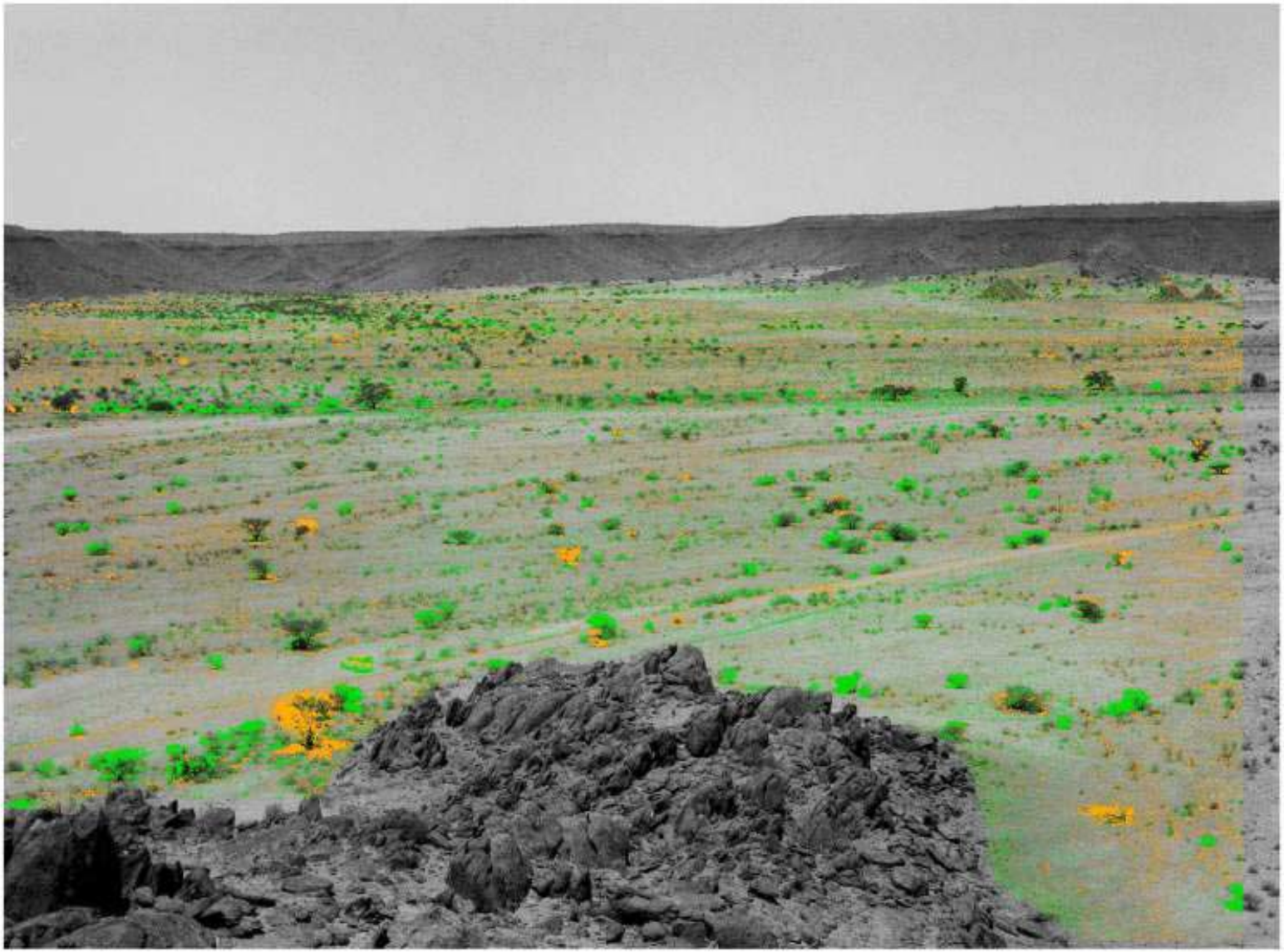
Table 24. Changes in the estimated % cover of different growth forms in Riemvasmaak between 1995 and 2005 for the sandy pediments (24a & 24c) and the patch of Kalahari sands (24d) in the right centre distance as well as the river channel (24b) at Photostation 24.

Growth form	Sandy pediments						River channel	
	24a 1995	24a 2005	24c 1995	24c 2005	24d 1995	24d 2005	24b 1995	24b 2005
Annuals/Forbs	0.2	0	3.2	0	0.1	0	0.1	0
Grasses	5.1	2.2	3.0	0.1	4.0	0.2	5.0	10.0
Low shrubs (<0.25 m)	0.2	0	0.1	0	-	-	0.2	0
Medium shrubs (0.25-1.5 m)	11.1	6.2	18.2	17.1	0	1.0	3.5	3.3
Tall shrubs (>1.5 m)	-	-	-	-	-	-	0.2	0.1
Leaf succulents	0.1	0.01	-	-	-	-	0.1	0
Stem succulents	0	0.01	-	-	-	-	-	-
Trees	3.1	3.1	1.1	1.1	11.0	11.0	5.1	12.0
Total cover %	**19.8**	**11.5**	**25.6**	**18.3**	**15.1**	**12.2**	**14.2**	**25.4**
No. species	**18**	**17**	**15**	**9**	**10**	**9**	**21**	**14**

24 1995



2005



PHOTOSTATION 25: Waterval South (28.53417; 20.33721). Looking 70º ENE, the top photograph was taken at 10h34 on 27 January 1995 while the bottom photograph was taken at 10h33on 14 January 2005. John Acocks sampled this site (sample no. 1648) in May 1952 and took three photographs, only one of which is shown here. This site remains under the management of the South African National Parks and has not been grazed by domestic stock since 1995 although zebra, springbok and other ungulates have continued to use the area but in relatively low numbers. This photostation therefore provides something of a control for the rest of Riemvasmaak. Unfortunately, the region is a little atypical of much of the broader region as it has never had an abundance of grasses. For landform 25a, however, the most significant change is that of *Stipagrostis uniplumis* which has declined from 1 to 0.1% since 1995. The cover of other species in all the growth forms has remained remarkably similar since the 1995 survey (e.g. for 25a, the medium shrubs *Zygophyllum suffruticosum* (1%), *Rhigozum trichotomum* (0.1%), *Salsola aphylla* (0.1%) and *Monechma spartioides* (0.1%) have not changed). The stem succulent, *Euphorbia rhombifolia* (2%) and tree, *Schotia afra* (5%) have also not changed in this landform. For the rocky slopes (25b), the cover of the grass, *Enneapogon scaber* (3%) is the same for both sampling dates as is that of the palatable leaf succulent, *Ceraria namaquensis* (5%) and the tree, *Schotia afra* (5%).

Table 25. Changes in the estimated % cover of different growth forms in Riemvasmaak between 1995 and 2005 for the rocky pediments (25a) and slopes (25b) at Photostation 25.

Growth form	Rocky slopes & pediments			
	a	a	b	b
	1995	2005	1995	2005
Annuals/Forbs	0.2	0	0.3	0.1
Grasses	1.6	0.5	3.2	3.2
Low shrubs (<0.25 m)	0.2	0.2	0.1	0.1
Medium shrubs (0.25-1.5 m)	1.8	1.7	0.1	0.2
Tall shrubs (>1.5 m)	0.2	0.2	-	-
Leaf succulents	0.01	0	5.0	5.0
Stem succulents	2.1	2.0	0.2	0.1
Trees	16.3	16.2	5.3	5.2
Total cover %	**22.4**	**20.8**	**14.2**	**13.9**
No. species	**50**	**38**	**29**	**26**


25
1995
b
a
a
b

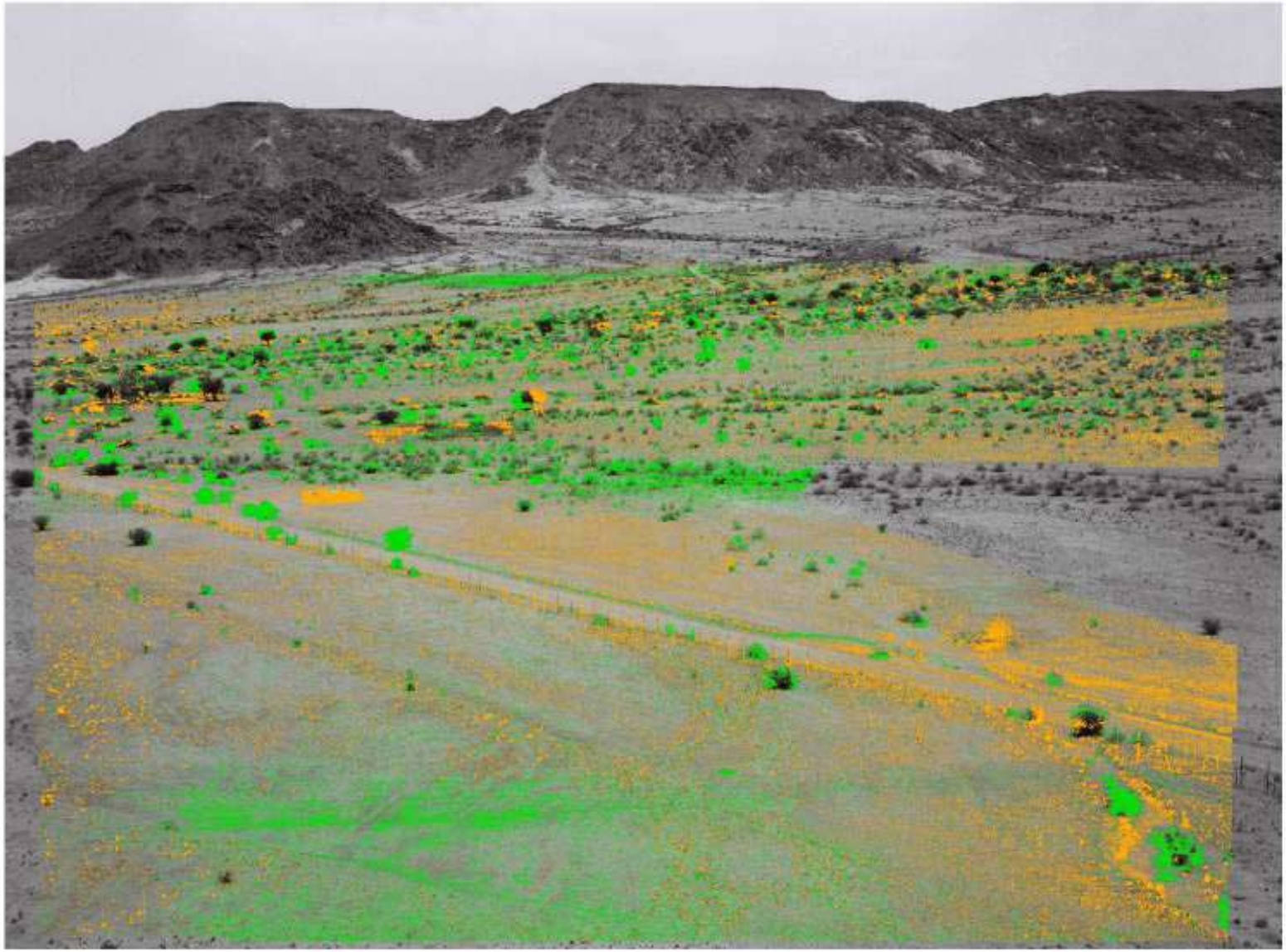

2005

PHOTOSTATION 26: Waterval North (28.43718; 20.34751). Looking 330º NNW, the top photograph was taken at 12h34 on 28 January 1995 while the bottom photograph was taken at 13h20 on 13 January 2005. Taken from a relatively high vantage point, the 2005 image was plagued by poor light conditions as a result of an approaching storm. Nonetheless the changes in the foreground (26a) are interesting and show little change in all growth forms except for grasses which have surprisingly increased in cover. This is largely as a result of *Stipagrostis uniplumis* which had a cover of 1% in 2005 but which was not recorded in 1995. Other grasses such as *S. hochstetteriana* (2%) and *Stipagrostis namaquensis* (1%) have not changed in cover while *S. obtusa* has declined from 1-0.01%. *Phaeoptilum spinosum* (10%), *Rhigozum trichotomum* (5%) and *Monechma incanum* (1%) are the dominant shrubs in this landform (26a) and their cover is unchanged as is the cover of *Acacia mellifera* (1%). However, closer scrutiny of the photographs shows that several new *A. mellifera* individuals have recruited since 1995, particularly along the road (the fence has been removed) and in the river in the foreground. Trampling by livestock at this site has made the river less identifiable in the image much like the observations made for Photostations 9 & 11. The most important changes in the river channel in the distance (26b) are the loss of grass cover, primarily *Stipagrostis uniplumis* (10-5%) and the decline in the medium shrub, *Indigofera heterotricha* (1-0.01). Other species such as *Phaeoptilum spinosum* (5%), *Acacia erioloba* (1%), *A. mellifera* (1%) and *Parkinsonia africana* (1%) are unchanged. The abandonment of the stockpost evident in the 1995 photograph, might explain the relative stability of this site which is, however, within site of the Riemvasmaak mission station to the left and out of view.

Table 26. Changes in the estimated % cover of different growth forms in Riemvasmaak between 1995 and 2005 for the sandy pediments (26a) and river channel (26b) at Photostation 26.

Growth form	Sandy pediment		River channel	
	26a	26a	26b	26b
	1995	2005	1995	2005
Annuals/Forbs	0.2	0	0.4	0.1
Grasses	4.2	5.0	20.4	15.2
Low shrubs (<0.25 m)	0.2	0.2	0.3	0
Medium shrubs (0.25-1.5 m)	16.3	16.2	6.4	5.3
Tall shrubs (>1.5 m)	-	-	-	-
Leaf succulents	-	-	-	-
Stem succulents	-	-	0	0.01
Trees	1.3	1.3	3.0	3.1
Total cover %	**22.2**	**22.7**	**30.5**	**23.7**
No. species	**31**	**28**	**32**	**29**

26



PHOTOSTATION 27: Perdepoort – Gyam/Vaalputs Crossroads (28.42395; 20.38605). Looking 30º NNE, the top photograph was taken at 15h53 on 28 January 1995 while the bottom photograph was taken at 16h40 on 13 January 2005. The most important changes on the sandy pediment (27a) since 1995 are the loss of annuals (primarily *Tribulis terrestris* (1-0%)), the loss of grass cover (especially *Stipagrostis uniplumis* (5-0.1%) and *Schmidtia kalahariensis* (1-0%)) and low shrub cover (primarily *Giseckia pharnaceiodes* (2-0.01%)). The medium shrub, *Rhigozum trichotomum* (7%) and the tree, *Acacia mellifera* (7%) have not changed in cover since 1995 although individuals of the latter species have developed a distinct browse line. Some of the shrubs along the river course in the photograph bottom right have disappeared. The most important change in the river channel in the left distance (27b) is the decline in the low shrub *Giseckia pharnaceiodes* (1-0%). Medium shrubs such as *Phaeoptilum spinosum* (4%) and *Rhigozum trichotomum* (8%) and the tree *Acacia mellifera* (8%) are unchanged in this landform. The dense woodland in the river channel in the centre distance (27c) is a main wood collection site and a donkey cart full of wood left the site during our survey in 2005. Despite this there has been very little change in this landform over the 10 years. *Stipagrostis namaquensis* (1%) still dominates the grass layer while the medium shrubs *Phaeoptilum spinosum* (2%) and *Rhigozum trichotomum* (2%) have also not decreased in cover since 1995. *Acacia erioloba* (1%) and *A. mellifera* (20%) are the dominant trees in this landform and have not changed in 10 years.

Table 27. Changes in the estimated % cover of different growth forms in Riemvasmaak between 1995 and 2005 for the sandy pediments (27a) and river channels (27b & 27c) at Photostation 27.

Growth form	Sandy pediment		River channels			
	27a	27a	27b	27b	27c	27c
	1995	2005	1995	2005	1995	2005
Annuals/Forbs	1.0	0	0.2	0	0.2	0.1
Grasses	6.1	0.2	0.2	0.2	1.1	1.1
Low shrubs (<0.25 m)	2.1	0	1.1	0	-	-
Medium shrubs (0.25-1.5 m)	7.2	7.2	12.3	12.2	4.3	4.3
Tall shrubs (>1.5 m)	-	-	0.1	0.1	0	0.1
Leaf succulents	-	-	-	-	-	-
Stem succulents	-	-	0.01	0.01	-	-
Trees	7.0	7.0	8.1	8.1	21.2	21.2
Total cover %	**23.4**	**14.4**	**22.0**	**20.6**	**26.8**	**26.8**
No. species	**15**	**14**	**22**	**20**	**21**	**17**


27
1995
c
b
a

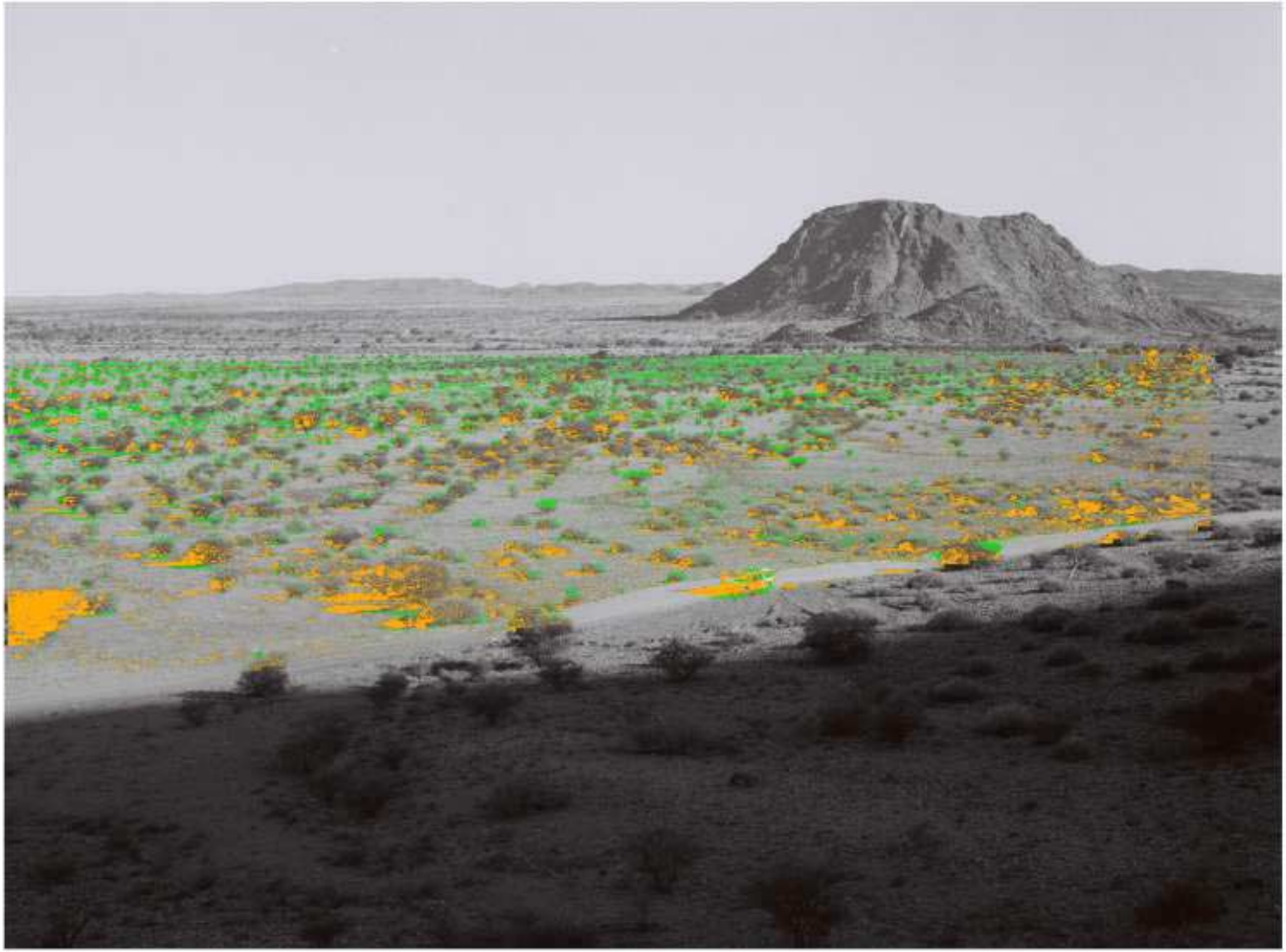

2005

PHOTOSTATION 28: Riemvasmaak Mission North (28.43402; 20.30684). Looking 170º S, the top photograph was taken at 17h49 on 28 January 1995 while the bottom photograph was taken at 16h40 on 10 January 2005. This photograph looks towards the Riemvasmaak Mission Station which is to the right and below the distant mountains. Vegetation cover in all three landforms has remained remarkably similar over the 10 years despite the proximity to the main settlement. Evidence of tree removal is present on the sandy pediment and in the river channel but this is not extensive. The most important change in the foreground rocky slope (28a) is the loss of the grass, *Enneapogon scaber* (1-0.1%) and palatable low shrub, *Limeum aethiopicum* (1-0%) and the presence in 2005 of *Geigaria ornativa* (0-1%) and other disturbance indicators such as the low shrubs, *Acanthopsis disperma* (0- 0.01%), *Solanum capense* (0-0.01%) and *Dicoma capensis* (0-0.01%) albeit with a relatively low cover. *Euphorbia gregaria* (10%) dominates this slope and has not changed in cover since 1995. Unlike most of the sandy pediments in Riemvasmaak, 28b has a thin covering of small stones and perhaps for this reason was never dominated by grasses. *Stipagrostis uniplumis* (0.1-0.01%) has declined but the medium shrub, *Monechma genistifolium* (0.1-1%) has increased in cover. The palatable medium shrub, *Salsola aphylla* (1-0%) was the dominant shrub in 1995 but was not recorded in 2005. The cover of *Acacia mellifera* (18%) has not changed on the sandy pediment or in the river channel (28c) where it forms 12 % of the cover and is the most common tree together with *A. erioloba* (1%). The main grass in the river channel, *Stipagrostis namaquensis* has increased from 8-10% since 1995 while the moderately-palatable, medium shrub, *Indigofera heterotricha* (1-0%) appears to have disappeared.

Table 28. Changes in the estimated % cover of different growth forms in Riemvasmaak between 1995 and 2005 for the rocky foreground slope (28a), the sandy pediment (28b) and the river channel (28c) at Photostation 28

Growth form	Rocky slope & pediment		Sandy pediment		River channel	
	28a	28a	28b	28b	28c	28c
	1995	2005	1995	2005	1995	2005
Annuals/Forbs	-	-	0.1	0	0.2	0
Grasses	1.1	0.2	0.1	0	8.2	10.0
Low shrubs (<0.25 m)	2.1	2.1	0.2	0.1	-	-
Medium shrubs (0.25-1.5 m)	2.1	2.2	1.3	1.3	1.2	0.1
Tall shrubs (>1.5 m)	-	-	-	-	-	-
Leaf succulents	-	-	-	-	0	0.01
Stem succulents	10.0	10.0	0.01	0.01	-	-
Trees	0.1	1.0	18.0	18.0	13.0	13.0
Total cover %	**15.4**	**15.5**	**19.7**	**19.4**	**22.6**	**23.2**
No. species	**17**	**22**	**14**	**16**	**20**	**16**

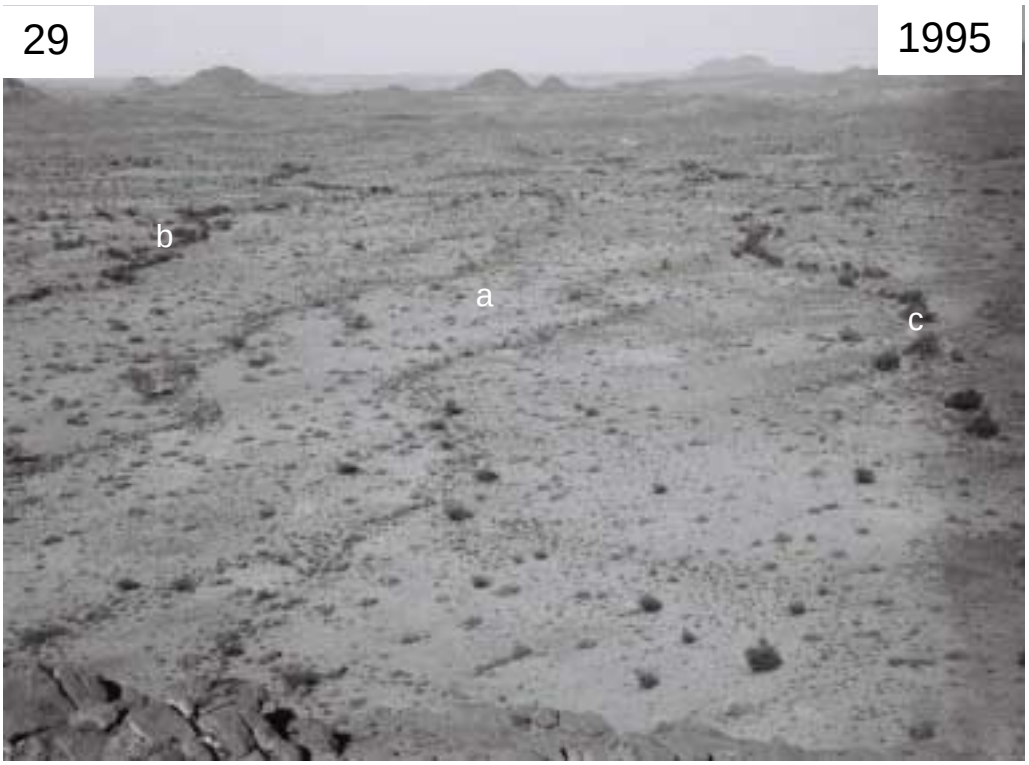
28

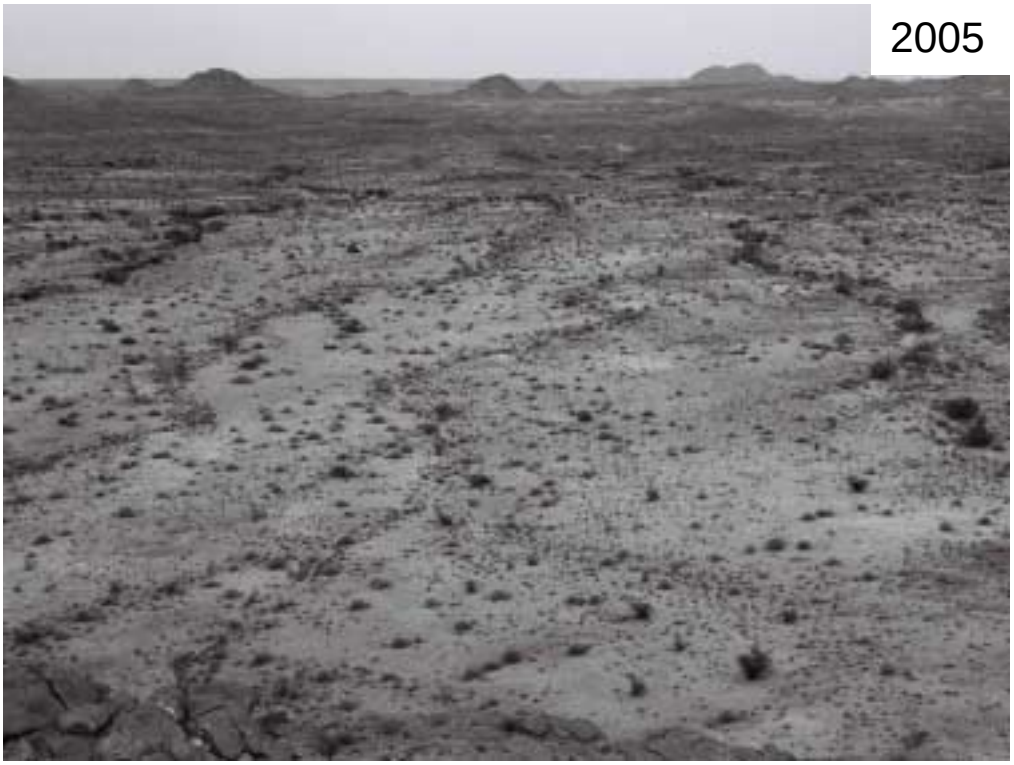


PHOTOSTATION 29: Blystaan (28.481975; 20.32329). Looking 278º W, the top photograph was taken at 08h42 on 29 January 1995 while the bottom photograph was taken at 08h53 on 13 January 2005. Although not far from the mission station this area appears not to have been heavily utilised by livestock over the 10 years. The stem succulent, *Euphorbia gregaria* (6%) dominates the rocky pediment in the fore and midground and has not changed in cover since 1995. A number of palatable medium shrubs such as *Monechma spartioides* (1%), *Salsola aphylla* (0.1%) and *Sericocoma avolans* (0.1%) have the same cover after 10 years while others such as *Petalidium lucens* (1-2%) and *Indigofera spinescens* (0-4%) have increased. The narrow river channel on the left (29b) has seen the loss of the grass, *Stipagrostis uniplumis* (1-0%) but an increase in other grasses such as *Heteropogon contortus* (0.1-1%) and *Cenchrus ciliaris* (0.1-1%). Medium shrubs have also increased in cover in this landform largely as a result of the presence in 2005 of *Tephrosia dregiana* (0-1%) which was not recorded in the earlier survey. The tall shrub, *Putterlickia pyracantha* (3%) has not changed and neither have the trees, *Euclea undulata* ((2%), *Pappea capensis* (5%) and *Schotia afra* (7%) in this landform. The river channel on the right (29c) has lost *Stipagrostis uniplumis* (1-0%) and there has been a decline in the cover of the medium shrub, *Monechma spartioides* (1-0.1%). However, *Petalidium lucens* (2%), *Euphorbia gregaria* (1%), *Pappea capensis* (1%) and *Schotia afra* (10%) have not changed in cover since 1995.

Table 29. Changes in the estimated % cover of different growth forms in Riemvasmaak between 1995 and 2005 for the rocky foreground slope (29a), and the two narrow river channels on either side (29b & 29c) at Photostation 29

Growth form	Rocky slope & pediment		River channels			
	29a	29a	29b	29b	29c	29c
	1995	2005	1995	2005	1995	2005
Annuals/Forbs	0.1	0	-	-	-	-
Grasses	0.2	0.1	1.4	2.2	1.3	0.2
Low shrubs (<0.25 m)	0.1	0.1	0.1	0.1	0.2	0.2
Medium shrubs (0.25-1.5 m)	2.4	7.4	1.3	2.2	3.3	2.4
Tall shrubs (>1.5 m)	0.1	0	3.1	3.1	0.2	0.2
Leaf succulents	-	-	-	-	0.01	0
Stem succulents	6.0	6.0	0.1	0.1	4.0	4.0
Trees	1.0	1.0	14.2	14.2	11.2	11.2
Total cover %	**9.9**	**14.6**	**20.2**	**21.9**	**20.2**	**18.2**
No. species	**26**	**26**	**29**	**32**	**28**	**26**


29
1995
b
a
c


2005