UPPER OLIFANTS RIVER SURVEY

An assessment of woody riparian and alien vegetation

Sam Jack[1], Greg Nicolson[2] & Ian Durbach[3]

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Plant Conservation Unit

1. Corresponding author. Plant Conservation Unit, Department of Biological Sciences, University of Cape Town, Private Bag X3, Rondebosch, 7701, Cape Town. T: 021 650 2483, E: samjackpcu@gmail.com
2. Greg Nicolson Consulting, 9 Recreation Road, Muizenberg, 7945, Cape Town
3. Centre for Statistics in Ecology, Environment, and Conservation, Department of Statistical Sciences, University of Cape Town, 7701, Cape Town

Introduction

The perennial Olifants Rivers system arises in the high-elevation Agter-Witzenberg Valley north of Ceres and flows for over 250 km in a north-westerly direction to its mouth near the West Coast town of Papendorp (Figure 1). Along its course to the sea the Olifants is supplemented by several smaller perennial rivers, such as the Thee, Noordhoek, Boontjies, Rondegat, Jan Dissels, and the non-perennial Sout. Its main tributary is the Doring River feeding in from the east at around 2/3rd's of its length. Two significant dams, namely the Clanwilliam and Bulshoek Dams, are situated along the mid-course of the river.

The Olifants River is central to the presence and success of an extensive agricultural industry in the Olifants River basin. This mainly comprises citrus orchards, vineyards and potatoes, which require year round water. The river (and dams) also supplies water to several major towns along its length, namely Citrusdal, Clanwilliam, Vanrhynsdorp, Vredendal and Lutzville, and serves as an important focal point for water-related recreational activities and tourism in the West Coast District. Increasing demand for water, including more reliable supply to farmers to the north, have led to the current raising of the Clanwilliam dam wall by 13 m, which will increase capacity by over 50% to 191 800 000 cubic metres (DEADP, 2011).

Figure 1. The Olifants River system from its source in the Agter-Witzenberg Valley to its mouth near Papendorp. The surveyed section is coloured red, while the remainder of the river course is coloured blue. Other areas or points of interest are shown as green pins. The map is oriented west-east.

The Olifants River catchment is situated in the unique and biodiverse Fynbos Biome and contains several indigenous, endemic and endangered plant and fish species (Hamman *et al.*, 1991). For example, the rare and beautiful buchu species, *Agathosma insignis*, grows in patches beside the water in the upper channel, while *Ixianthes retzioides* is a larger shrub which manages to survive growing between rocks and boulders within the river. This species is confined to the Olifants River and a few other rivers emanating from the Grootwinterhoek Mountains. Higher upslope one finds the recently described striking protea species *Serruria confragosa* and *Serruria reflexa.*

In terms of fish species, the presence of *Barbus serra* (Clanwilliam sawfin), *Barbus calidus* (Clanwilliam redfin) and *Labeobarbus capensis* (Clanwilliam yellowfish) are ascribed to the "ideal" water quality in the upper catchment. However, there are currently significant threats to water quality in the middle and lower catchments. Threats include nutrient rich (phosphate) return flows from agriculture and treated domestic wastewater and saline inflows from tributaries arising in the Tankwa Karoo. 'Overwatering' in order to leach out salts from soils under cultivation also contributes to increased salinity levels in the lower reaches of the river.

While the upper catchment is in relatively good shape in terms of water quality, the presence of invasive alien plant species in this part of the river, particularly *Acacia mearnsii* (Black wattle), represents a growing threat to water supply and the integrity of indigenous riparian vegetation (Dye & Jarmain, 2004). Both government and privately sponsored ad hoc alien clearing programmes have made some gains, but the frequency and extent of these efforts have not kept pace with the increasing growth of aliens. Furthermore, the ruggedness of the terrain has meant that large stretches of river have remained inaccessible to clearing teams.

The socio-ecological importance of the Olifants River System suggests that monitoring of river health should be carried out on a regular basis along all sections of the river course. Regular monitoring is easier to achieve in the middle and lower catchment due to ease of access via an established road network. The same cannot be said for the upper catchment, which is accessible only on foot and is therefore monitored only infrequently, and usually by coarse means such as aerial or satellite photography.

Objectives

This survey aimed to address the above situation by studying the upper Olifants River in greater detail. Our goal was to collect up-to-date information on the health of the upper river course with respect to the diversity and dominance of indigenous woody riparian species, as well as the abundance, distribution and stage class spread of invasive alien vegetation. In addition, we established regularly-spaced fixed point photographic panoramas facing both up and downriver as a 2016 summer season baseline of vegetation condition and abundance in the river channel and adjacent slopes. The survey included a cumulative list of all observed species, as well as an assessment of the abundance of *Prionium serratum* (Palmiet) as a proxy for force of flow and accumulation of sediment in the channel.

Methods

The study was carried out between the 5th and 9th of January 2016 during which time a team of three researchers hiked/hopped/swam down the surveyed length of river. The surveyed section ran from the cement bridge crossing the upper Olifants River above the farm Visgat (S33.0766, E19.2168, 639 m.a.s.l.) and terminated after 35 km adjacent to the farm Keerom where the river begins to braid on the sandy plains south of Citrusdal (S32.82505, E19.07285, 234 m.a.s.l.; Figure 2). Half-kilometre sampling intervals were pre-plotted and loaded onto a handheld Garmin GPS device. Actual sampling locations often differed slightly from these pre-plotted points due to the requirement for baseline photographs to be taken from an elevated position (usually a large boulder) within the river channel.

Assessment of invasive alien species type, distribution, abundance, stage class and description of habit was made at a 500 m interval. At 1 km intervals we considered by consensus which three non-aquatic riparian woody species had been most dominant during the preceding kilometre. The dominant species was then assigned a score of 1 and the ratio of the second and third dominant species (relative to the most dominant) was estimated. Vegetation density, the abundance of Palmiet, and recently burnt area visible from the river channel was subjectively scored out of five for the preceding kilometre. For vegetation density, a score of 1 indicated ‘extremely low density’ and 5 indicated ‘extreme density’. For Palmiet, an abundance score of 1 indicated ‘rare’, through to 5 which indicated ‘extreme abundance’. For fire, a score of 1 = <1 ha burnt, 2 = 2-10 ha burnt, 3 = 11-100 ha burnt, 4 = 101-1000 ha burnt, and 5 = >1001 ha burnt.

Figure 2. Surveyed section of the Olifants River indicating fixed point photograph and indigenous riparian vegetation sampling stations at approx. 1 km intervals. Invasive alien abundance and stage class was sampled on a more regular interval of 500 m. The map is oriented west-east.

Fixed-point photograph stations were established at 1 km intervals as follows. A tripod with a pan-tilt head fitted with a spirit level was set up on a rock platform (Figure 3). The tripod legs were adjusted such that the head was as level as possible. A Nikon AW100 waterproof camera was mounted to the tripod using a square mounting plate and positioned facing up the river channel. The height of the camera lens, as measured vertically from the rock surface immediately below the centre of the tripod to the centre of the camera lens was recorded such that this height could be replicated in future. A central, left (rotated -30º) and right (rotated +30º) photograph was taken (re-levelling after each rotation), after which the camera was rotated to face downstream, where the same procedure was duplicated. If invasive alien species were present in significant numbers, an additional 30º rotation to either side was made and two additional photographs taken. A photograph(s) of the tripod location was then taken in order to aid the accurate positioning of the tripod in future. A checklist of species was maintained between recording stations and, where possible, photographs of distinguishing characteristics taken.

Figure 3. Tripod with pan-tilt head and spirit level positioned on rocky platform. Tripod legs are set such that the tripod head is as level as possible.

Individual photographs of the view up-river or down-river at each station were stitched together with the aid of Adobe Photoshop CS5. Unknown species were placed on Ispot (http://www.ispotnature.org/communities/southern-africa) for identification.

Results and Discussion

Physical characteristics

The vertical profile of the Olifants River suggested a generally steeper upper and more gradual lower section to the river, and a possible knick-point near the top of the surveyed section between Stations 11 and 17 (Figure 4a). The upper half of the river dropped by approx. 27 m/km, while the drop for the lower half was only about a quarter of this at 7 m/km. The knick-point is possibly attributable to the additional erosive energy derived from the inflow of two prominent tributaries to the east of the upper Olifants River. The first tributary is unnamed and joins from the Grasberg/Skurweberg area, while the lower tributary joins at Onderboskloof. Vegetation density was lowest around this knick-point and had a generally negative relationship with the steepness of the fall gradient ($R^2 = 0.43$) (Figure 4b). The decline in vegetation density at the bottom of the surveyed section probably had to do with recent invasive alien clearing programmes and burning.

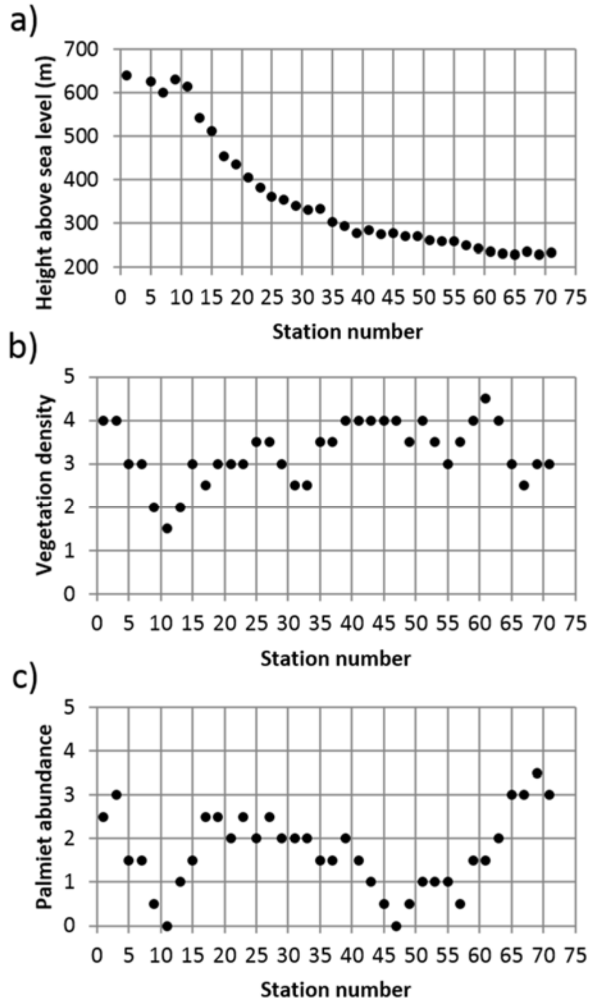

Figure 4a-c. (a) Vertical profile of the surveyed section of the Olifants River. Inconsistencies in height can be attributed to differences in the height of the camera station above the river, as well as inaccuracies in GPS triangulation due to the narrowness of the channel. (b) Vegetation density and (c) Palmiet abundance as subjectively scored out of 5 for the surveyed section of the river.

The correlation between Palmiet abundance and fall gradient of the river channel (also thought to be negatively correlated, as slower flow means more deposition of sand in which Palmiet can take root) was less clear, probably due to the influence of woody riverfront vegetation (both indigenous and alien) which overtopped Palmiet in the second half of the surveyed section and reduced/excluded it despite otherwise favourable conditions (Figure 4c). However, there were certain sections of the lower river where Palmiet was very abundant, sometimes to the exclusion of all other vegetation.

Different sections of the river were typified by certain channel and vegetation characteristics. For example, the upper reaches of the river were deeply incised into bedrock material and contained very little vegetation (Figure 5). This changed as the river course widened downstream; here one found large boulders and a dearth of vegetation. Gradually vegetation started to increase as the river formed a pool-drop-pool pattern. In the lower reaches the flow slowed down considerably, allowing vegetation to dominate the riverbank. As the river emerged onto the plains it became largely depositional, creating sandy banks and facilitating the growth of dense but low growing vegetation.


Station 5
Station 9
Station 13
Station 17
Station 29
Station 33
Station 43
Station 57
Station 65
Station 71

Figure 5. Examples of the typical nature of the river channel at different stages of the descent down the studied section of river. Stations 5 and 9 show the uppermost part of the channel carved deeply into bedrock. Stations 13 and 17 show the wider channel of the upper-mid river filled with large boulders and lower vegetation density. Stations 29 and 33 about midway down the studied section show a greater abundance of vegetation and the typical pool-drop-pool pattern of this part of the river. At Stations 43 and 57 – the lower-mid river - the banks become overhung with vegetation (often alien) and the pools are typically longer and shallower. Finally at Stations 65 and 71 the river broadens laterally as it opens onto the plains and the riverbank vegetation becomes shorter.

Indigenous and alien riparian vegetation

A total of 40 riparian species were recorded for the surveyed section of river, including 7 invasive alien species (2 of which were weeds that were noted, not counted) (Table 1). Most indigenous species contributed only a small fraction to the general abundance of vegetation along the banks, as much of the vegetation was comprised of about a half-dozen dominant species (e.g. *Metrosideros angustifolia, Morella integra, Freylinia lanceolata, Salix mucronata subsp. mucronata, Cliffortia strobilifera and Brabejum stellatifolium*).

Table 1. Species list (not comprehensive) of riparian vegetation for the studied section of the Olifants River. Invasive alien species are marked with an asterisk.

Family	Genus	Species	Common name
Achariaceae	Kiggelaria	africana	Wild Peach
Anacardiaceae	Heeria	argentea	Kliphout
Anacardiaceae	Searsia	angustifolia	Wilgerkorentebos
Aponogetonaceae	Aponogeton	distachyos	N/A
Aquifoliaceae	Ilex	mitis	Cape holly
Araliaceae	Hydrocotyle	bonariensis	Perdekloutjies
Asteraceae	Brachylaena	neriifolia	Waterwitels
Casuarinaceae	Casuarina	sp.	N/A
Celastraceae	Maytenus	oleoides	Klipkershout
Cunoniaceae	Cunonia	capensis	Rooiels
Cyperaceae	Isolepis	prolifera	N/A
Droseraceae	Drosera	capensis	Sundew
Ebenaceae	Diospyros	cf. glabra	Bloubessiebos
Ericaceae	Erica	caffra subsp. caffra	Water heath
Fabaceae	Psoralea	sp.	N/A
Fabaceae*	Acacia*	mearnsii*	Black wattle*
Fabaceae*	Acacia*	Longifolia*	Long leaf wattle*
Gunneraceae	Gunnera	perpensa	River Pumpkin
Juncaceae	Juncus	sp.	N/A
Lamiaceae	Mentha	aquatica	Water Mint
Myricaceae	Morella	integra	False-lance leaf waxberry
Myrtaceae	Metrosideros	angustifolia	Cape gum/Smalblad
Myrtaceae*	Eucalyptus*	sp.*	N/A*
Onagraceae	Ludwigia	octovalvis	N/A
Orchidaceae	Disa	sp.	N/A
Osmundaceae	Osmunda	regalis	Royal Fern
Pinaceae*	Pinus*	sp.*	Pine tree*
Poaceae	Pennisetum	macrourum	Riverbed grass
Poaceae	Phragmites	australis	Common Reed
Podocarpaceae	Podocarpus	elongatus	Breeriviergeelhout
Polygonaceae	Persicaria	serrulata	Vleiblommetjie
Proteaceae	Leucadendron	salicifolium	Common stream conebush
Proteaceae	Brabejum	stellatifolium	Wild almond
Rosaceae	Cliffortia	strobilifera	N/A
Salicaceae	Salix	mucronata subsp. mucronata	Cape willow
Scrophulariaceae	Freylinia	lanceolata	Heuningklokkiesbos
Solanaceae	Solanum	nigrum	N/A
Stilbaceae	Ixianthes	retzioides	River bells
Stilbaceae	Halleria	cf. elliptica	Tree Fuschia
Thurniaceae	Prionium	serratum	Palmiet

Morella integra and *Metrosideros angustifolia* were by far the most common indigenous plant species in the studied section of the Olifants River (in that order) (Figure 6). In the upper section of the river *M. angustifolia* outcompeted *M. integra* and was usually the primary dominant species. However, in the middle to lower section *M. integra* was usually more abundant at the expense of *M. angustifolia*. *Freylinia lanceolata* was often secondarily dominant to *M. angustifolia* in the upper river, while *Salix mucronata subsp. mucronata* was secondarily dominant to *M. integra* in the lower river. A handful of other species contributed to the top three species in each 1 km transect. These included *Cliffortia strobilifera* and *Brabejum stellatifolium* in the lower river, and *Ixianthes retzioides* and *Cunonia capensis* in the upper river.

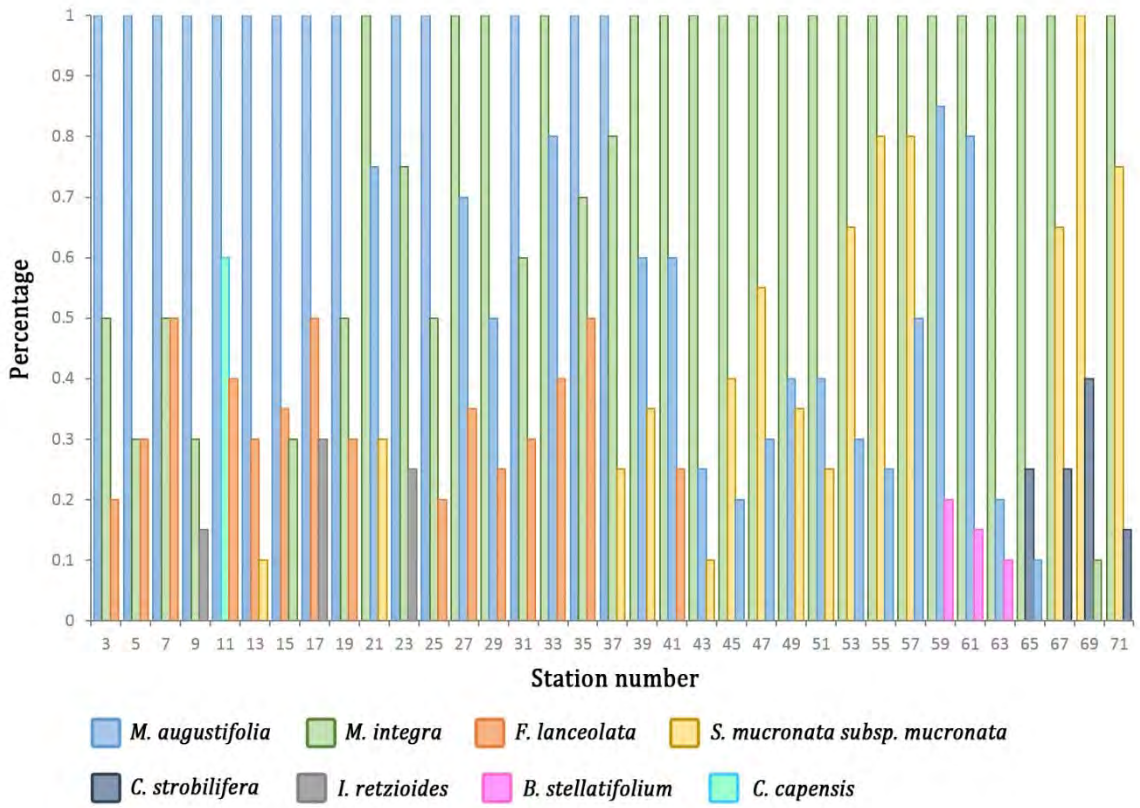

Figure 6. Graph illustrating dominance categories for indigenous woody riparian vegetation. A score of 1 indicates primary dominance. Second and third most dominant species are scored as a percentage relative to the primary dominant species. M. angustifolia *and* M. integra *were dominant in the upper and lower sections of the river, respectively. In addition,* Freylinia lanceolata *and* S. mucronata *subsp.* mucronata *were secondarily dominant in the upper and lower sections of the river, respectively.*

Alien invasive species are arguably the single greatest ecological threat in the studied section of the Olifants River channel (i.e. the upper reaches of the river) as they compete with indigenous riparian species, affect channel flow characteristics to the extent that aquatic flora and fauna are affected, and reduce water supply. In terms of woody invasive species, three were noted, namely *Acacia mearnsii*, *Acacia longifolia and Pinus sp.* (Table 1). While *A. longifolia* and *Pinus sp.* were present in isolated patches, *A. mearnsii* was by far the most abundant alien species occurring in the Olifants

River channel and therefore received specific attention in terms of the data gathering and analysis in this study (Figure 7). *A. mearnsii* occurred throughout the studied section of river, but with quite a broad range in abundance and stage class structure.

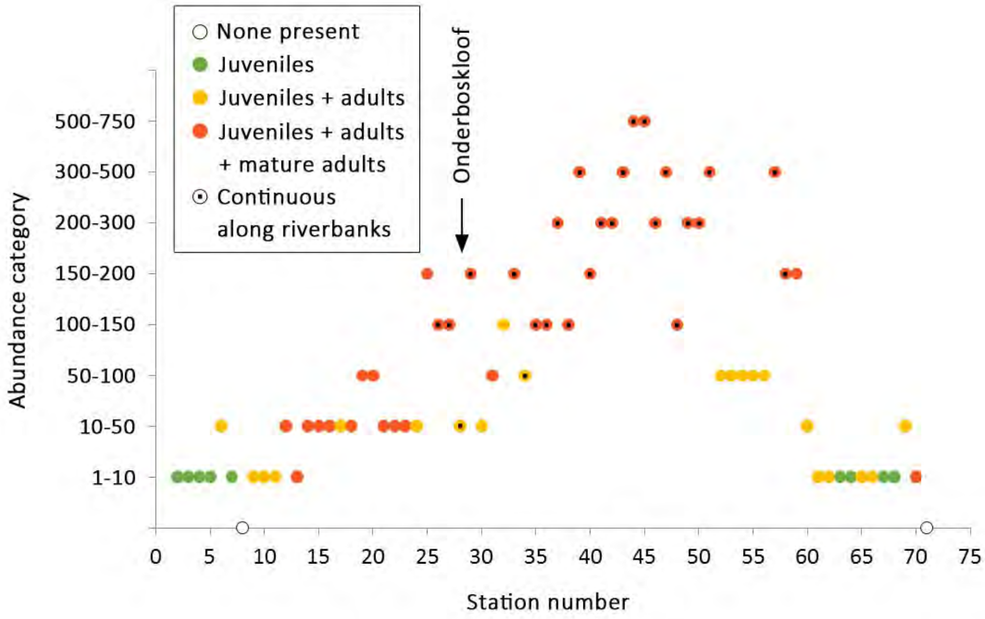

Figure 7. Acacia mearnsii *abundance levels for the surveyed section of the Olifants River. These estimates are based on in-channel observations for 500 m sections of river. The peak in* A. mearnsii *numbers is about 2/3rd of the way down the surveyed section of river. This section also has the greatest density of established populations, as determined by the consistent presence of large mature adult individuals.*

The uppermost reaches of the river were relatively free of *A. mearnsii*, with only the occasional isolated juvenile visible. Some signs of previous clearing were evident here. This and the canyon-like character of the river probably contributed to the low number of *A. mearnsii* in this part of the river. The narrow, down-cut channel is likely to be too dark and the flow-force too powerful for anything other than specialist riparian vegetation to survive. However, as soon as the channel widened into a more V-shaped valley (after approximately Station 12) the presence of *A. mearnsii* increased abruptly and steadily (despite more evidence of recent clearing).

The peak in *A. mearnsii* abundance and stage class were in the mid to lower half of the studied section. Here *A. mearnsii* was often continuously distributed along both banks and was considered to be the dominant riparian vegetation. It also sometimes 'crowded out' the riverfront vegetation entirely and occasionally occurred higher upslope behind the riparian corridor within fynbos. After Station 59 in the lower reaches of the river, *A. mearnsii* abruptly declined almost to the point of complete absence. This was very likely due to ongoing clearing efforts, which became increasingly visible further downstream (e.g. burnt areas and cut stumps). The remainder of the studied section was almost free of *A. mearnsii*.

In some sections of the river between Visgat and Keerom the battle to keep *A. mearnsii* numbers in check appears to be succeeding, sometimes despite very difficult terrain. These areas include the very upper reaches of the river between Stations 1 and 13, and the lower reaches from Station 60 onwards. Total elimination of the remaining individuals (relatively easily achieved) and ongoing monitoring on an annual basis is strongly advised for these areas.

The middle section of the river represents a greater clearing challenge in terms of accessibility, density and size of individuals. Access to the middle reaches of the surveyed section is restricted to Onderboskloof (a third of the way down the studied section of river) and Beaverlac/Keerom. Our suggestion for an initial 'upper-mid river' clearing strategy would be to access the river via Onderboskloof, hike upriver to Station 12 (a distance of about 8 km), and commence clearing downriver from this point. The reason for this is that the density and size of *A. mearnsii* individuals from Station 12 to Station 25 remains manageable for a small team and represents the greatest gain to be made for effort invested. The density of *A. mearnsii* in this section of the river is likely to grow more rapidly than established areas downriver due to density dependent factors such as the number of mature or maturing adults, higher densities of rapidly growing juveniles surrounding adult trees, and more open habitat for further colonisation.

Station 25 represents the start of significant *A. mearnsii* densities and very large individuals (some individuals with basal circumferences of 50 cm and upwards). This continues all the way to Station 59 in the lower reaches of the studied section. Within this stretch Stations 37 to 51 and 57 to 59 represent the core of the worst infested parts of the surveyed section with a conservative estimate of between 4500-7000 individuals and the frequent presence of individuals with basal circumferences of 80 cm and upwards. These populations are quite old and probably fairly stable in terms of absolute numbers (i.e. they are not growing rapidly). We recommend that large, well-equipped teams approach from both the lower end (Keerom and Beaverlac) and Onderboskloof to commence clearing in these areas. While it will take time to make gains in this section of the river, clearing here would undoubtedly generate the greatest gains in terms of regaining lost water supply. Cleared areas would need annual monitoring (at the very least) in order to prevent recolonization.

Baseline photographic record

Panoramic photographs taken at 1 km intervals and stitched together form a view of in-channel riparian vegetation (Figure 8a & b). This collection of 36 photo-pairs (one facing up-river, one facing down-river) represents an important 2016 midsummer vegetation baseline for the upper Olifants River system. Repeating this series of photographs at intervals of 5 to 10 years will allow both direct and indirect assessments of change in channel characteristics and riparian vegetation. Examples of direct changes include shifts in dominant riparian species, thickening or thinning of vegetation, growth rate changes, change in the abundance of Palmiet, changes in invasive alien species abundances. Examples of indirect changes include changes in flow rates, nutrient loading, fires and higher sediment inputs after rain, etc. Monitoring of this nature is especially important given the uncertain impacts of global change (e.g. warming, drying, and possibly increases in C3 woody species due to elevated atmospheric CO_2) on water supply.

Figure 8. An example of a stitched panoramic view a) upriver and b) downriver. These particular views were from Station 35 in the middle reaches of the Olifants River. Note the tall Acacia mearnsii *on both sides of the river banks.*

Conclusions

In terms of vegetation, the studied section of the Olifants River between Visgat in the Agter-Witzenberg Valley and the Keerom area south of Citrusdal was found to be in a fair condition. Riparian vegetation, while not very biodiverse, was relatively undisturbed (i.e. low level invasive alien presence) for significant stretches of the river, especially in the uppermost and (surprisingly) lowermost sections. However, only 3 out of 71 transects were alien-free and virtually the entire middle section of the river was relatively heavily infested with *Acacia mearnsii*. In certain areas this infestation has reached its climax, with *A. mearnsii* being the dominant riparian vegetation, overtopping and 'crowding out' indigenous species. A concerted effort will be required to return these stretches of river to a more natural state, but the gains are likely to be significant in terms of water supply. Other parts of the river, notably the middle-upper reaches of the surveyed section (i.e. above Onderboskloof/Station 25), represent an emerging threat that could quickly lead to total infestation within the next 5 – 10 years if not dealt with immediately. In these areas the task of clearing would be less onerous but the long term gains in terms of clearing costs and water supply would be significant. Ongoing monitoring of the surveyed section is recommended in order to develop a better understanding of the rate of (especially alien) vegetation change.

Acknowledgements

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Appendix to report*

1) GIS folder containing
    a. GDB file to upload station points onto GARMIN device.
    b. Google Earth KML file.
2) Photographs folder containing
    a. Subfolders from each site/station (1-71) including individual photographs up-river and downriver, tripod shot(s) and stitches panoramas.
    b. A species folder containing all photographs taken of riverine species.
3) An XLSX file containing the raw data from which the results were compiled.
4) This report as a DOCX document.

*This information is archived at the Plant Conservation Unit, Rm 5.09, HW Pearson Building, University Avenue, Upper Campus, University of Cape Town.