KOUGA CATCHMENT

Towards a clearing strategy for black wattle

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Created for
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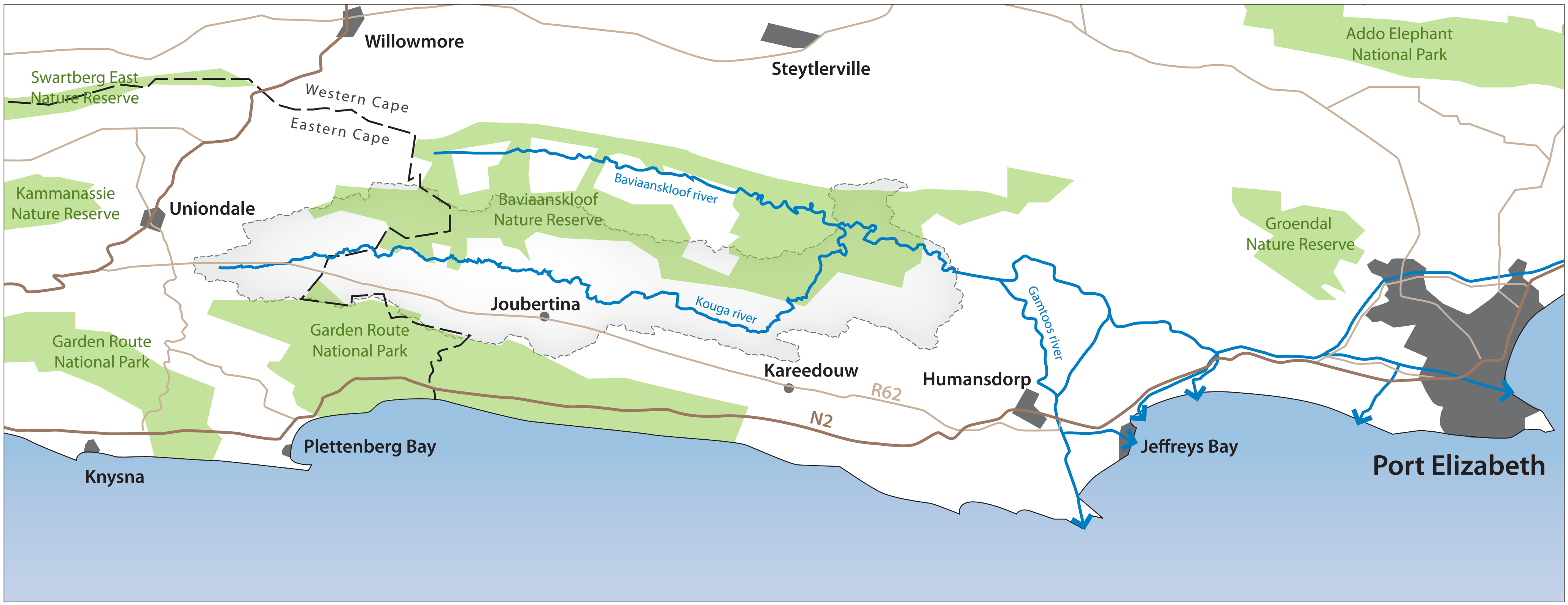
Contents



Context of Kouga catchment: main water supplier of Port Elizabeth, lying in between nature reserves / national parks.

1 Introduction

1.1 Background

In South Africa large areas are infested with invasive alien plants (IAPs). IAPs are considered as a major threat to biodiversity, human livehoods and economic development. In the Kouga catchment, situated in the Eastern and Western Cape of South Africa, the IAPs pose a serious threat to the native fynbos landscape as well as to the water security. The water security is not only an issue in the Kouga catchment itself, but extends as far as Port Elizabeth and surroundings which relies heavily on the Kouga for water.

To fight the IAPs the South African government has established the Working for Water (WfW) programme in 1995. The idea of the programme is to empower the most marginalized in society through job creation in the clearing of IAPs. The WfW programme is implemented in the Kouga catchment by the Gamtoos Irrigation Board (GIB). However, WfW is limited in their restoration work because of limited fundings from the government.

Since 2008 the WfW programme is phasing out managing work on private land. Instead they introduced land-owner incentive contracts to get private land-owners to manage IAPs on their land themselves. Landowners can submit a proposal for clearing of IAPs and receive a subsidy. With this new approach the government hopes that the land-owners will take ownership of the problem of IAPs, and that this will lead to a long-term sustainability in the control of the IAPs.

In addition to the efforts of the WfW programme, Living Lands and the Four Returns Development Company are exploring ways to upscale the clearing of IAPs by involving businesses. This could be achieved by designing a business model on added value creation from alien trees. By creating business out of the landscape restoration work, the work creates its own funding.

Before a business model can be made, a strategy for clearing of IAPs is needed. This strategy should cover the whole Kouga catchment and is a long-term step-by-step plan for how to proceed with the clearing of IAPs. This project is a first step towards a strategy for clearing IAPs in the Kouga catchment. The focus of the project is twofold: one objective is to collect information through literature review and mapping. The other objective is to create a zoning of the Kouga catchment as part of the clearing strategy and identify which criteria determine the zones.

The long-term objective for the Kouga catchment is to restore the indigenous vegetation, implement sustainable agricultural practices, secure water resources and increase water benefits for all the water users, especially for the farmers of the Kouga and for Port Elizabeth.

Kouga catchment

1.2 Problem statement

Invasive alien plants

Large areas of the Kouga have been infested with IAPs. Approximately 212.667 ha of the Kouga is infested with IAPs, of which 989 ha is highly infested. Especially along the Kouga river are dense infestations (Talmar, 2015). Most important IAPs in the Kouga catchment are black wattle (Acacia mearnsii), silky hakea (Hakea sericea) and several pine species. Black wattle grows in dense stands in river valleys and on mountain hills, silky hakea is mainly found on the mountain hills. Pine trees are found in the Tsitsikamma Mountains, coming down till the Langkloof. On the mountain hills where the fynbos grows, the biological diversity is threatened by the IAPs. The IAPs also pose a direct threat to water security. Especially black wattle uses a lot more water than the indigenous vegetation. Because of the infestations with IAPs a lot of water is lost that could have been used in a more productive way. Finally, IAPs are a threat to the ecological functioning of natural systems because they intensify the impact of fires and floods.

Black wattle

Black wattle is a highly invasive tree which is designated a category 2 invader under the Conservation of Agricultural Resources Act (1983) in South Africa (Henderson, 2001). Black wattle was introduced in South Africa in the early 1800s (Shaughnessy 1980) and it has been grown commercially since 1886 (Deacon, 1986). Black wattle produces vegetable tannin, especially suited for use in the manufacture of heavy leather goods. Other uses are paper pulp, cellulose for rayon, charcoal, and fuelwood (CABI, 2015). The alien tree now dominates much of the landscape despite considerable efforts to keep them under control.

Black wattle is a relatively short-lived tree with a life-span of 10-20 years. It produces a lot of seeds that accumulate in the soil. A large proportion of the seed may become dormant in the soil and seed may remain viable for more than 50 years (Dean et al., 1986). Seeds germinate after fire, but the tree can also reproduce vegetatively by forming root suckers (Weber, 2003).

Silky hakea

Silky hakea is a small tree or shrub that originates from Australia. Silky hakea has become highly invasive and problematic in South Africa, particularly in the mountain catchments of the Southwestern and Southern Cape Province. Silky hakea was introduced in 1858 from Australia as a hedge plant but was also planted for sand binding and firewood production (Phillips, 1938). Silky hakeas produce hard, woody fruits that accumulate on the plant throughout its lifetime. Large numbers of seeds are released following the death of the plant, usually by fire. The large seed production of H. sericea can result in estimated seed densities of up to 7500 seeds per m^2 in the ash bed following fires (Neser and Kluge, 1986).

Right now, an estimated 190 000 ha of land are infested to various degrees, while in 1979 an estimated 530 000 ha were infested (Esler et al. 2010). This decline is due to an active mechanical clearing campaign in the mountain catchment areas of the Western Cape (Fenn 1980). The techniques used to control H. sericea mechanically are largely effective but, as most of the infestations are in mountainous areas, clearing costs are high and many of the infestations are remote or inaccessible.

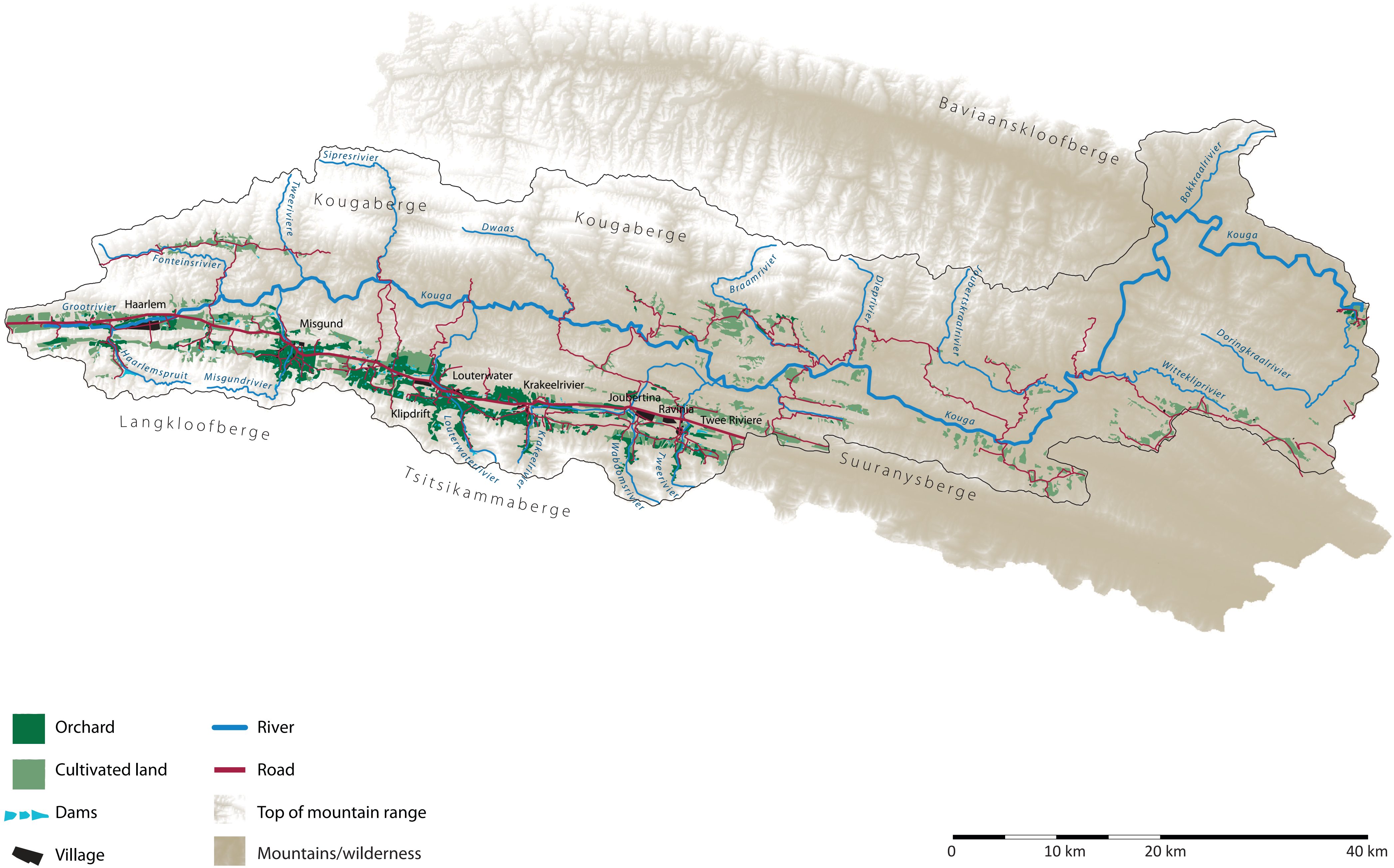
Strategy on catchment scale

The problem of IAPs needs to be addressed on a catchment scale. There are several reasons why the problem of IAPs can only be successfully addressed on a catchment scale. The spread of seeds by water makes that the seeds are spread throughout the whole catchment. So it's important to prioritize areas that need to be cleared first, for example areas that are the top of the catchment. Also the huge seedbank in the soil requires not only a long-term control, but also a catchment wide coördinated control.

With the newly introduced land-owner incentive contracts landowners can manage the clearing on their own land. To give landowners control over the management of IAPs on their own land is important for the long-term continuation of the management of IAPs. But it's important that the landowners coöperate and coördinate their actions. A strategy on catchment scale offers a framework that helps landowners to coördinate their actions. A strategy and inventory on catchment scale also gives insight in location and accessibility of availabe biomass for a possible business model.

Biological control measures, especially for Hakea sericea, are already available and seem to be effective. The two main conservation management problems are the lack of funds and the lack of one single controlling agency (Moll and Trinder-Smith, 1992). The restoration project in the Kouga aims to tackle these two problems by creating a clearing strategy on catchment scale that could be implemented by a farmer association and designing a business model on added value creation from black wattle.

Topography Kouga catchment



1.3 Project objectives

One objective of the project is to collect information through literature research on biocontrol and mapping of IAPs. The other objective is to create a zoning of the Kouga catchment as part of the clearing strategy and identify which criteria determine the zones:

1. Mapping of infestations of black wattle in the Kouga catchment.

There is a lot of literature about IAPs in South Africa. But there is not so much information available over the extent of infestations of IAPs. Inventory of the spread of IAPs on national scale exists, the National Invasive Alien Plant Survey (Kotzé et al., 2010) gives an overview of the infestations of IAPs on a quaternary catchment level. But this data is not suitable for planning and decision making on a lower scale level.

Within this project black wattle will be mapped in the Kouga catchment. Black wattle is mapped first because it is one of the most invasive IAPs in the Kouga catchment responsible for significant water losses. Black wattle will also be the main product for a business model.

2. Literature review on biocontrol of black wattle and silky hakea.

Because large areas of the Kouga are difficult to access, biocontrol will be an important part of the strategy for clearing IAPs. Also the scale of the problem makes that biocontrol will have to play a major role in any strategy. Not only the extent of infestations, but also the large quantities of seed that are produced by the IAPs and the accumulation of the seed to high densities in the seedbank contribute to the scale of the problem.

Research on biocontrol has been ongoing for nearly 50 years in South Africa and there have been good results with several biocontrol agents. A literature review will give an overview of the most recent research findings on biocontrol of black wattle and silky hakea.

3. Zoning the Kouga catchment.

First step in developing a strategy for clearing IAPs on catchment scale is to zone the Kouga catchment. Zoning helps to prioritize areas and provide insight in what methods should be applied where. Also zoning helps to break down a large area into smaller sub areas or units. This makes it possible to design a strategy for a whole catchment, that is tailored to each unit at the same time.

4. Estimation of (in)accessible infestations and available biomass.

For the business model an estimation of the available biomass is important information. Therefore it's important to know how much of the infestations are accessible and what part is inaccessible. The mapping of the infestations of black wattle combined with the zoning will give an idea of the available biomass in the Kouga catchment for a biomass plant. By localizing the available biomass, possible locations for a biomass plant could be indicated as well.

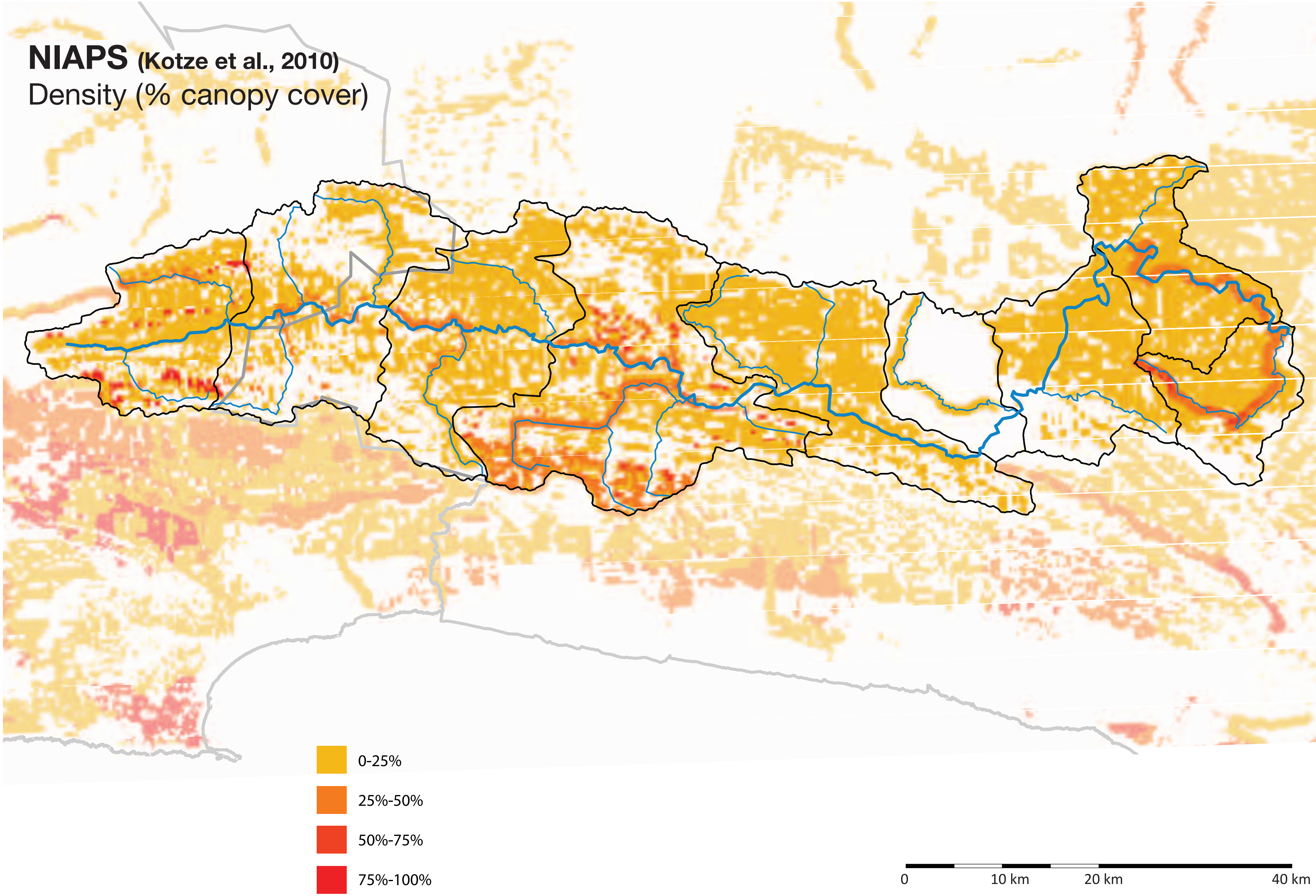
1.4 Introduction Kouga catchment

The Kouga catchment is mainly situated in the Eastern Cape, the most western part lies in the Western Cape. The Kouga catchment covers an area of 282.000 hectares (Powell and Mander, 2009) and consists for the biggest parts of mountains. In the north the catchment is bounded by the Kouga and Baviaanskloof Mountains and in the south it's bounded by the Tsitsikamma Mountains and the Suuranys Mountains.

The river Kouga runs from west to east, dammed by the Kouga Dam in the east of the Kouga catchment. South of the Kouga river lies a long stretched floodplain, the 'Langkloof', that continues all the way into the Kromme catchment. The wetlands that used to be in the Langkloof are mostly drained and most of the floodplain has been cultivated for agricultural land. Most important landuse in the Langkloof is deciduous fruit production. Tributaries run from south to north towards the Kouga river, finding their way through the mountain ranges that run parallel with the Kouga river. Many of the tributaries have been dammed. Farmers use the water to irrigate their orchards. They keep the water from the tributaries in large basins throughout the Langkloof.

The Suurveld, or Suuranys, is an area in the east of the Kouga catchment that's rather different from the rest of the catchment. Different characteristics of geomorphology, climate and soil lead to another type of vegetation and consequently another kind of landuse. The landscape is more open and hilly and acidic soils and summer rainfall lead to a sour grassland vegetation. Extensive livestock farming, especially sheep farming, is the most important landuse in the Suuranys Mountains.

NIAPS (Kotze et al., 2010)
Density (% canopy cover)



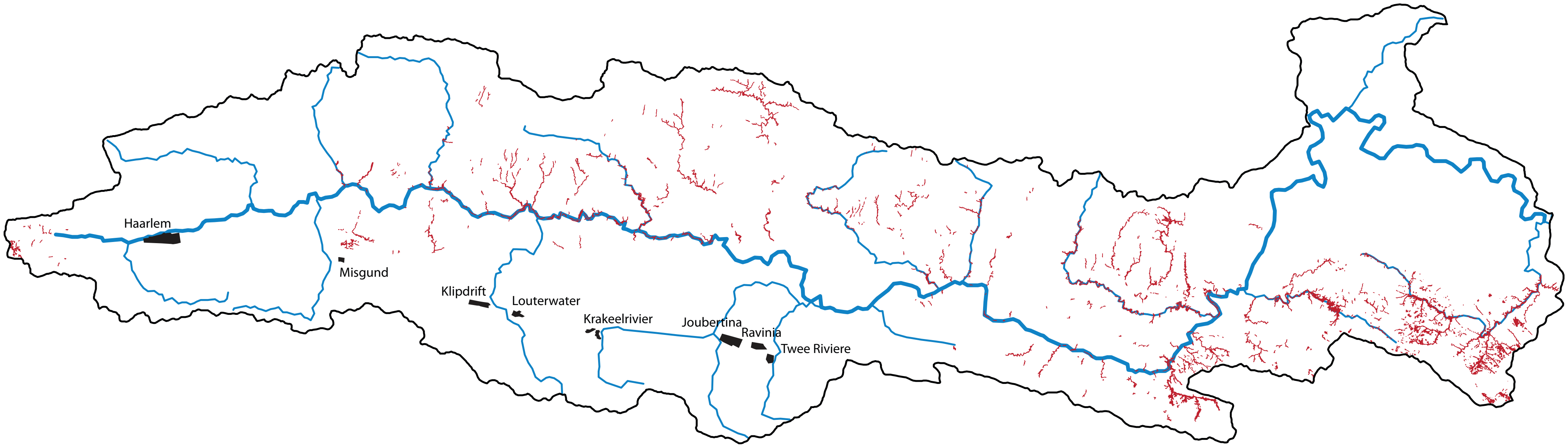
2 Inventory of black wattle in the Kouga catchment

2.1 Infestations IAPs: NIAPS

The National Invasive Alien Plant Survey (NIAPS) is a project initiated by the WfW programme and implemented by the Agricultural Research Council (ARC). The project objective was to establish and implement an IAP monitoring system for South Africa, Lesotho and Swaziland at a quaternary (4th order) catchment level. The NIAPS uses remote sensor technology to estimate the spread of invasive plants in an area. By quantifying the infestations of IAPs, planners and decision makers can use this information for policy decisions and the strategic allocation of funding. The project started in 2005 and was finished in 2010.

The map *NIAPS (Kotze et al., 2010)* shows the NIAPS for the Kouga catchment. The most infested areas are found along the rivers, in the river valleys. The Kouga river in the east of the Kouga catchment, the Naboomsrivier and Doringkraalrivier are heavily infested with IAPs with a canopy cover of 25-50%. The upper catchments of the Waboomsrivier, Naboomsrivier and Tweerivier are also quite heavily infested with IAPs with a canopy cover of 25-50%. A large part of the Kouga catchment is infested with IAPs with a canopy cover of 0-25%. However, the subcatchment of the Joubertskraalrivier is remarkably clean.

Infestations black wattle
(2013)



2.2 Mapping black wattle

The NIAPS gives an insight in the extent of alien infestations on a quaternary catchment level. Inventory of IAPs at this scale is useful for policy decisions at a national and provincial level. But to determine clearing priorities on a catchment level, the NIAPS is not sufficient. More detail in distribution and type of IAPs is needed. Therefore a first detailed inventory is carried out of the spread of black wattle in the Kouga catchment. For the mapping of black wattle aerial pictures from 2013 are used. There where the canopy cover was 50% or more, the area was mapped as infested. Other densities of canopy cover were not included in this project.

Most dense infestations are to be found in the river valleys of the tributaries and the Kouga river. Also higher up in the mountains in dry watercourses are dense infestations. The northeast of the catchment seems to be free from infestations with black wattle. Because only areas with a canopy cover of more than 50% were mapped, a lot of infestations with a lower canopy cover are not shown on the map. Therefore it might seem that only the river valleys are infested, but in fact many slopes are infested with lower densities of black wattle as well. [Mapping black wattle incomplete: to be continued]

0 10 km 20 km 40 km

Infestations with black wattle in a river valley in the Kouga catchment

Seedpods of black wattle (photo by Forest & Kim Starr)

Leaves of black wattle

Black wattles growing along a tributary

Small black wattle tree (photo by Forest & Kim Starr)


Very dense infestation with black wattle in a river valley in the Kouga catchment


Solitary black wattle (photo by Forest & Kim Starr)


Silky hakea


Fynbos infested with silky hakea


The fruit of silky hakea

3 Prevention and control of black wattle and silky hakea

Methods to remove IAPs can be manual, mechanical, chemical, biological or with fire. Usually a combination of measures is used. Paragraph 3.1 will give a short overview of these methods. Because large areas of the Kouga are inaccessible, biological control will be an important part of any clearing strategy for the catchment. Therefore the emphasis in this chapter will be on biocontrol methods. Paragraph 3.2 will give a summary of the last findings of research on biocontrol of black wattle and silky hakea.

3.1 Methods of clearing

Most control programmes consist of the following 3 phases:

1. Initial control: first clearing with a drastic reduction of the existing population;
2. Follow-up control: control of seedlings, root suckers and coppice growth;
3. Maintenance control: sustain low alien plant numbers with annual control;

Regardless of which method is used for clearing, a follow-up/maintenance control will always be necessary until the IAPs are under control. There are several ways of clearing. Which type of clearing is chosen, depends on the location of the IAPs and on possible secondary use of the IAPs.

Manual control

The plant can simply be pulled out by hand.

Mechanical control

Mechanical control can be carried out through:

- Ring barking: The bark is removed from the bottom of the stem to a height of 0.75-1.0 m. For good results all bark must be removed to below ground level. If complete de-barking is not possible due to crevices for example, a combination of bark removal and basal stem treatments should be carried out.
- Frilling: Cuts are made into the cambium layer through the bark in a ring around the stem. Then herbicide can be applied into the cuts.

Chemical control

Chemical control can be carried out using environmentally safe herbicides. There are different ways to apply chemical control:

- Basal bark: This method involves mixing an oil-soluble herbicide in diesel and spraying the full circumference of the trunk or stem of the plant. The herbicide enters underground storage organs and slowly kills the targeted weed. The entire circumference of the stem or trunk should be sprayed or painted with herbicide solution from ground level to a height of 30 cm.

- Cut stump treatment: Stems are cut as low as practical. The herbicide can then be applied on the stump to prevent the tree from resprouting.
- Stem injection: This is a method of target precise application of pesticides, into the xylem vascular tissue of a tree. Holes are made in the entire circumference of the lower stem and the herbicide is directly injected into the tree (DWA, 2015).

Fire

Fires are a natural ecosystem process on many landscapes. Fire can also be used as a tool to control IAPs. Most scientific studies have focused on the responses of specific invasive plants to fire and largely disregard how the plant community as a whole responds. This is an important lack of information because the final goal of controlling IAPs with fire is to reduce the IAPs and increase the dominance of the native vegetation again. If these results are not achieved, then using fire to control IAPs may not be worth the effort (Brooks and Lusk, 2008).

Using fire as a tool to control IAPs is not without risks. Fires can lead to the loss of soils and the associated nutrients and can change the hydrology and regional climate. IAPs often benefit from these changes as they typically flourish in the human transformed systems and then penetrate the natural ecosystems, particularly when these are under stress.

Fires that occur before the invading trees have a chance to set seed results in their removal from the landscape. But the problem is the huge seedbank in the soil. Those seeds survive fires and make sure that the IAPs will spread again after fire. Therefore, fire can only be used succesfully as a control method when it is part of an integrated approach.

Biocontrol

Biological control involves the use of species-specific insects and diseases from the alien plant's country of origin. These natural enemies will remove the plant's competitive advantage until its vigour is reduced to a level comparable to that of the natural vegetation.

In the control of invasive plants, the biocontrol agents used most frequently are insects, mites and pathogens. Biocontrol agents target specific plant organs, such as the vegetative parts of the plant (its leaves, stems or roots) or the reproductive parts (flowers, fruits or seeds).

3.2 Biocontrol

There are a lot of advantages using biocontrol. It is environmentally friendly because it only affects the target plant, it does not cause pollution, It is self-sustaining and it does not have a big immediate impact on the environment that disturbs the soil or leaves a large empty space behind where other invaders can establish. Instead it kills the IAPs gradually which allows the native vegetation also to recover gradually.

But biological control works relatively slowly. On average, at least five years should be allowed for a biocontrol agent to establish itself successfully before causing significant damage to its host plant.

Another aspect of biocontrol that one should keep in mind is that biocontrol will never completely exterminate IAPs. At best, they can be expected to reduce the IAPs density to an acceptable level or to reduce the vigour and/or reproductive potential of the IAPs. A few host plants will always survive, in spite of the attack by a biocontrol agent. That there are always a few IAPs that survive, ensures that the agent does not die out as a result of a lack of food. The small population of biocontrol agents that persists will disperse onto any regrowth or newly-emerged seedlings of IAPs.

If biological control is combined with other methods of clearing like mechanical or chemical control, then this might eliminate the biocontrol agents that are present on the IAPs in the cleared area. It is therefore important that small reserves of mature plants are kept in the area so that the biocontrol agents can survive and reproduce (DWA, 2015).

3.2.1 Biocontrol agents for black wattle

Since the 70s there has been done research on biological control of invasive Acacia species in South Africa. The focus of research was on nine insect species in three genera, namely, five Melanterius seed-weevil species two Dasineura gall-fly species and two Trichilogaster gall-wasp species. All of these species were introduced from Australia. The goal was to reduce the reproductive capacity of the acacia species without affecting the growth of the tree, so there would be no negative impact for the wattle industry. The restriction on the type of agent (seed-attacking) has limited the control. Because of the persistent seed bank, biological control with just seed-attacking agents will not result in short-term reductions in densities of Acacia stands. Therefore it may seem that biological control of Acacias has not been successful. But seed-reducing agents could become a valuable part of an integrated approach by contributing to the reduction of spread of black wattle.

FLOWER-GALLING FLIES

- **Dasineura rubiformis**

Description

D. rubiformis is a gall midge that is very small, usually only 2–3 mm in length. The larvae of the gall midge feed within plant tissue, creating abnormal plant growths called galls.

Background

A. mearnsii is an important agro-forestry product in South Africa. So the useful attributes of A. mearnsii should not be affected by the introduction of D. rubiformis. Therefore Impson et al. (2008) have tested whether D. rubiformis is affecting the growth of A. mearnsii. They concluded that galling does not cause a reduction in vegetative growth of A. mearnsii. use of this biological control agent will not affect the wattle industry. Permission for manual distribution of D. rubiformis was granted, with the proviso that there should be consultation and agreement with representatives of the wattle industry before the midge is distributed in areas nearby plantations in KwaZulu-Natal and in Mpumalanga. D. rubiformis has the potential to become an excellent seed-reducing biological control agent of A. mearnsii. The midge is already established in the surroundings of Stellenbosch, where it is increasing in abundance (Impson et al., 2008).

Impact on A. mearnsii

D. rubiformis induces development of galls in the flowers of A. mearnsii, thereby preventing pod development and reducing the reproductive capacity of the plants. D. rubiformis has virtually stopped pod production in some areas and offers an encouraging prospect for gaining control through a combination of mechanical clearing and seed reduction through biological control (Impson et al., 2008).

SEED-FEEDING WEEVILS

- **Melanterius maculatus**

Description

The weevils are brown or black beetles with long snouts approximately 3-5mm long. The larvae are found inside developing seeds. The weevils have only one generation per year which coincides with the time of the annual seed maturation of A. mearnsii. Adults can be found between September and November when they feed on the developing seeds. Mating and egg laying also occurs during this period. The females lay eggs on the young seeds. When the larvae are fully developed after 4-6 weeks, they leave the pods and drop to the ground where they pupate in cocoons made from the soil. Fully developed adult weevils emerge from the soil 6-8 weeks later (December - March). The adults remain inactive for most of the cooler months until the start of the breeding season in spring (Impson, n.d.).

Background

Melanterius maculatus was first released on A. mearnsii in 1993 (Dennill et al., 1999). First it establised at the release sites and from there it was distributed to other areas. During the past ten years the level of seed damage has been monitored at selected sites. There were initial concerns from the wattle industry that the weevils would affect the seed availability within the plantations and distribution of the weevil was restricted. But research showed that M. maculatus was posing no threat to the plantations and since 2005 there are no restrictions anymore for the distribution of M. maculatus. Only constraint is that there should be consultation and agreement with representatives of the wattle industry, when the weevil is going to be distributed nearby plantations in KwaZulu-Natal and in Mpumalanga. M. maculatus is now established on A. mearnsii in the Western Cape, Eastern Cape, KwaZulu-Natal, Mpumalanga, Limpopo and North West provinces (Impson et al., 2011).

Impact on A. mearnsii

Adult feeding damage is seen on developing and on mature seed pods as a small hole above the middle of a seed. The seed below is damaged and undeveloped. Seeds with larvae are usually hollowed out, with a small round exit hole at one end. Because M. maculatus only feeds on the seeds, the appearance of the trees is not affected. Like other Melanterius species, seed damage levels caused by M. maculatus on A. mearnsii are not consistent, ranging from 4 –78 % (mean 49 %) at 12 sites which have been monitored since 2000 (Impson et al., 2011). But any reduction in seed viability will reduce the rate of spread of A. mearnsii and its ability to re-grow after it has been cleared by conventional methods (Impson, n.d.).

Application

The best time for distribution of M. maculatus is around September – October (Impson, n.d.).

PATHOGENS

- **Cylindrobasidium laeve**

Description

C. laeve is a wood rot fungus native to South Africa. The fungus is quite distinct when it is young, forming round patches with a pinkish brown centre fringed with white. These patches gradually merge together into a larger structure. In some forms the top edge grows outwards to form miniature brackets. The structure is soft and can be smooth up to 1mm thick.

Background
The PPRI Weed Pathology Unit in Stellenbosch has researched the effectiveness of C. laeve as a biological control agent of cut wattle stumps. The fungus is applied after felling after which it kills the stump. C. laeve appeared to be a very efficient and the product StumpoutTM was registered in 1997 for use as a fungal inoculant to treat and kill wattle stumps. Because the market is limited, the product was not produced on a large scale. But there is a regular demand for the product from conservation organizations and landowners. To meet this demand, StumpoutTM is produced in a small factory on the premises of PPRI Weed Pathology Unit and distributed to clients on request (Lennox et al., 1999).

Impact on A. mearnsii
Results of field trials showed mortality of treated stumps of both A. mearnsii to be greater than 80% (reaching 90 and 100% in some cases) within 6-12 months of treatment (Lennox et al., 1999).

Application
StumpoutTM is delivered in small sachets that contain live basidiospores of the fungus C. laeve in an oil formulation. The product is diluted in sunflower oil and 1-2 ml is painted onto the fresh cut surface of the tree stump. The stumps die within a year of treatment (Lennox et al., 1999).

Conclusion
It is unlikely that any meaningful reduction in host-plant density of A. mearnsii will be achieved using only seed-reducing agents. This because of the abundant annual seed-production of A. mearnsii, which results in vast accumulations of long-lived seeds in the soil (Pieterse & Cairns 1986; Holmes 2002; Marchante et al. 2010). Seed-reducing agents do have the potential to limit rates of spread of A. mearnsii. But biological control using seed-reducing agents should not be the only control mechanism. The full potential of seed-reducing agents is best realised when they are part of an integrated management. The combined effect of the suppression of seed production through biocontrol and the destruction of the parent plant through mechanical clearing and use of pathogens, is probably the most effective.

3.2.2 Biocontrol agents for silky hakea

Research on biological control against silky hakea in South Africa, has been ongoing for nearly 50 years. In 1970 biological control on H. sericea started with the release of a seed-feeding weevil, Erytenna consputa and a seed-moth, Carposina autologa. E. consputa and C. autologa were introduced together, because they complement one another by destroying fruits in different stages of development. The introduction of E. consputa and C. autologa, together with an indigenous fungus, Colletotrichum acutatum and manual clearing have reduced the abundance of H. sericea. But large infestations remain in the Western and Eastern Cape provinces of South Africa (Gordon and Fourie, 2011).

SEED-MOTH
- **Carposina autologa**

Description
C. autologa is a seed-moth native to Australia. The larvae feed on the seeds of H. sericea.
The wingspan is about 10 mm. The forewings are white with a black stripe along the edge of the forewing, the hindwings are white.

Background
The moth C. autologa was released in 1970 to destroy the seeds in the mature fruits of H. sericea. After a long period of releases, it has recently established thriving colonies in the field (Gordon and Fourie, 2011).

Impact on H. sericea
The most obvious limitation of C. autologa is that it slowly colonize regenerating silky hakea populations. Also populations of C. autologa increase very slowly (Dennill et al. 1987, Gordon 1993), allowing the plants to set fruits before the agents have taken full effect.

SEED-FEEDING WEEVIL
- **Erytenna consputa**

Description
Erytenna consputa is a seed-feeding weevil that attacks the immature fruits. Adult weevils may live for two or three years, and are present on their host plant throughout the year. They shelter mostly in the dry husks of fruits attacked by larvae in previous seasons. The weevil feeds on buds and young growth and on flowers and young fruits when these are available. They lay eggs in or near young developing fruits in spring and early summer. Larvae develop and destroy one or more young ruts. A new generation of adults appears within three months. Eggs are only laid during the following fruiting season. Eggs are produced during the period when flowering and/or young fruits are present. Adults are capable of escaping fires by flying off and locating surviving host plants from which they start new colonies. Even in absence of host plants, healthy adults may survive for several weeks without food (Neser, 1968).

Background
From surveys of natural enemies in Australia (Neser, 1968) two complementary seed-attacking species were selected and tested for release in South Africa. E. consputa was one of them, the other was the moth C. autologa. The aim of using seed-attackers was to reduce the numbers of seeds released after fires. This would allow the indigenous vegetation to compete more successfully with regenerating H. sericea seedlings. E. consputa was released in South Africa in 1970 and is the most widespread of the agents. The weevil is now widely established and is contributing substantially to the reduction of the seed crop (Kluge and Neser, 1991).

Impact on H. sericea
Kluge (1983) showed that it was destroying up to 72% of the developing fruits annually. A natural abortion of fruits accounts for an additional 22% of the annual fruit loss (Kluge & Siebert 1985). Surveys between 1998 and 2003 at six sites showed that E. consputa continue to destroy most of the seeds produced by H. sericiea. But in most situations the damage is not resulting in declines in the density of H. sericea in areas where fire has destroyed the original infestations (Le Maitre et al., 2008; Gordon and Fourie, 2011).
A limitation of E. consputa is that it slowly colonizes regenerating silky hakea (Dennill et al. 1987, Gordon 1993), allowing the plants to set fruits before the agents have taken full effect.

PATHOGENS

- **Colletotrichum acutatum**

Description
Colletotrichum acutatum is an indigenous fungus and is a common pathogen of a wide array of crops and noncultivated plant species. The fungus is cosmopolitan in its distribution and causes extensive crop losses every year. Disease symptoms range from fruit rots to shoot, leaf, and flower blights. Common hosts include, apple, citrus, and stone fruits, but is most important as a fruit rot of strawberry. Colonies of C. acutatum are usually white initially and later become pink to orange (Peres et al., 2005).

Background
There has been done research to assess the natural occurrence of the fungus and its impact on H. sericea in South Africa. Spot-sampling at 32 sites throughout the range of H. sericea in the Western Cape Province during 2008, showed that the fungus was present at 23 (72 %) sites and that on average, 40 % (range 10–97 %) of the silky hakea trees showed disease symptoms, with an average mortality rate of 15 % (range 5–75 %) (Fourie, unpubl.). In a number of areas, there was a particularly high occurrence of the gummosis disease with an average of 97 %, 87 % and 90 % of the trees infected, respectively, accompanied by extensive dieback (average 28.7 %). These three areas all received early rains followed by regular rainfall during the winter of 2008, conditions which favour the development and spread of C. acutatum. By contrast, the fungus was scarce (<10 % infection rate) at Stettynskloof where it may be worth using the mycoherbicide formulation at regular intervals, especially following fires or after exceptionally dry summers, to increase inoculum loads and promote natural spread of the disease (Gordon and Fourie, 2011).

Impact on H. sericea
C. acutatum is an agent that is substantially contributing to the decline of H. sericea. Especially in areas with a high rainfall it can kill H. sericea in large numbers without any outside intervention.
But the establishment of C. acutatum is dependent on suitable environmental conditions. In dry areas, and in high rainfall areas after dry periods or fires, manual applications of the fungus may be needed to ensure sufficient inoculum loads (Morris 1982b, 1983, 1989, 1991; Morris et al. 1999).

- **Glomerella cingulata**

Description
Glomerella cingulata is a fungus that causes gummosis on H. sericea. Gummosis is the formation of patches of a gummy substance on the surface of the plant. This happens when sap drips from wounds or cankers as a reaction to outside stimuli such as adverse weather conditions, infections, insect problems, or mechanical damage.

Background
Gummosis and die-back disease occurs on silky hakea in many areas of the Cape Province. Morris (1981) has isolated the fungus Glomerella cingulata from stem cankers and infected shoot tips and inoculated onto stems of healthy H. sericea. Canker developed and the infected shoot tips died back. According to Morris (1981) has G. cingulata potential as a biological control agent of H. sericea.

Impact on H. sericea
H. sericea seedlings growing in soil that is inoculated with a spore suspension of G. cingulata, were infected with the

Silky hakea taking over the fynbos in the Kouga catchment fungus after 9 days. Part of the tips of seedlings that were inoculated with the spore suspension would die and eventually the whole seedling was killed. There were also representatives of 11 indigenous genera of the Proteaceae inoculated with the fungus, but no symptoms developed on these plants (Morris, 1981).

Conclusion

The combination of the seed-destroying agents E. consputa and C. autologa, the fungus C. acutatum and manual clearings, has had a great effect on the spread of H. sericea. Since 1979 the distribution of H. sericea in South Africa has been signifantly reduced by an estimated 64%. In 1979 an area of 530 000 ha was infested with H. sericea. In 2001 the infested land had dropped to about 190 000 ha (Esler et al. 2010). During the same period the density of H. sericea in an area of 230 000 ha decreased from high or moderate levels of infestation to low levels of infestation or absence (Esler et al. 2010).

But to evaluate the effectiveness of each of the agents that are already well established on H. sericea is complicated because the insect species and the fungus all interact with each other. Therefore it's very difficult to evaluate the effects of each agent on H. sericea independently (Gordon and Fourie, 2011).

However, Le Maitre et al. (2008) have studied what the effects are of the combination of E. consputa and C. autologa on H. sericea. With a simulation model they show that the biocontrol agents have an effect on the dispersal of H. sericea, making it less invasive. But field studies show that regenerating seedlings still exceeded the parent population in existing stands in most cases (Le Maitre et al. 2008; Gordon & Hoffmann, unpubl.). To also affect the density of H. sericea, seed-destroying agents can best be combined with agents that destroy the parent plants. For example seed-destroying agents can be combined with a stem-boring beetle and a fungal pathogen to kill the parent plant.

Two new biological control agents, a stem-boring beetle, Aphanasium australe and a flowerbud feeder, Dicomada rufa, were released in 2001 and 2006, respectively, to enhance the levels of biological control. These new biological control agents still have to prove how effective they are, and studies about their impact are not yet available. With the use of new biocontrol agents, the hope is that biological control will take over most of the manual clearings, which require much more labour (Gordon and Fourie, 2011).

Supply of biocontrol agents

Institution: National Department of Agriculture: Directorate of Agricultural Land and Resource Management (DALRM), Eastern Cape
Address: Private Bag X3917, Port Elizabeth 6056
Telephone: (041)571734
Fax: (041)544552
Contact person: E.C. Feyt

4 Zoning of the Kouga catchment

4.1 Introduction zoning

Zoning is one of the steps in the development of a strategy for clearing IAPs on a catchment scale. Zoning helps to define which areas need to be cleared first and what methods need to be applied where. In general: zoning helps to break down a large area into smaller units. This makes it possible to create a strategy for the whole catchment, that is tailored to each unit at the same time. In the next paragraph the criteria for zoning will be presented.

4.2 Criteria for zoning

There are 5 different criteria for zoning: accessibility, prioritisation, natural values, society and WfW clearing activities. Each criterion consists of 1 or more subcriteria. Each subcriterion is displayed in a map.

- **Accessibility**

Due to the high mountain ranges, steep gorges and mountain slopes, a large area of the Kouga catchment is difficult to access. The accessibility of the different areas will define which method of clearing can be applied where. Biocontrol will be a suitable measure in the inaccessibe areas, while in better accessible areas biocontrol can be combined with mechanical control.
One of the project objectives is to make an estimation of the available biomass to see if it's feasible to start a biomass plant in the Kouga catchment. The biomass should be accessible within a certain range of the biomass plant in order to make it profitable. Accessibility is therefore a very important criterion for the business model.
The criterion Accessibility consists of two maps. One map shows the road network in the Kouga catchment. The second map shows the cultivated (accessible) areas versus the wilderness in the Kouga catchment.

Maps: *Roads + 1km zone* *p. 26*
Wilderness - Cultivated areas *p. 27*

- **Prioritisation**

Within the Kouga catchment there are areas with different clearing priorities. These priorities can stem from for example landscape characteristics like relief: it's best to start clearing at the top of the catchment because IAPs also spread by water. Also the degree of infestation with IAPs plays of course an important role in prioritising areas for clearing operations. Le Maitre et al. (2012) have developed
a generic species- and area-based prioritisation model for the WfW programme for prioritising invasive alien plant control operations in South Africa. This model shows per subcatchment the clearing priority.

Maps: *Subcatchments + relief* *p. 28*
Degree of infestation with black wattle *p. 29*
Generic synthesis prioritisation model *p. 31*

- **Natural values**

The criterion Natural values consists of two maps. One map shows the nature reserves in the Kouga catchment. The second map shows the different vegetation types of the Kouga. The type of vegetation can be of importance for the measures to be applied. This also applies to the areas that have been designated as nature reserves. For example the use of fire will not be possible within nature reserves.

Maps: *Nature reserves* *p. 32*
Vegetation *p. 33*

- **Society**

The criteria discussed until now are part of the natural layer like vegetation and relief, the anthropogenic layer like the road network, or an administrative layer like nature reserves. There is another important layer that is formed by society, the social layer. Communities are important for the implementation of the clearing plan. People of the same community feel more connected with each other and are probably more willing to collaborate. Collaboration is important for implementing a catchment wide clearing strategy that exceeds individual land properties.

Maps: *Communities* *p. 34*
Farms *p. 35*

- **WfW clearing activities**

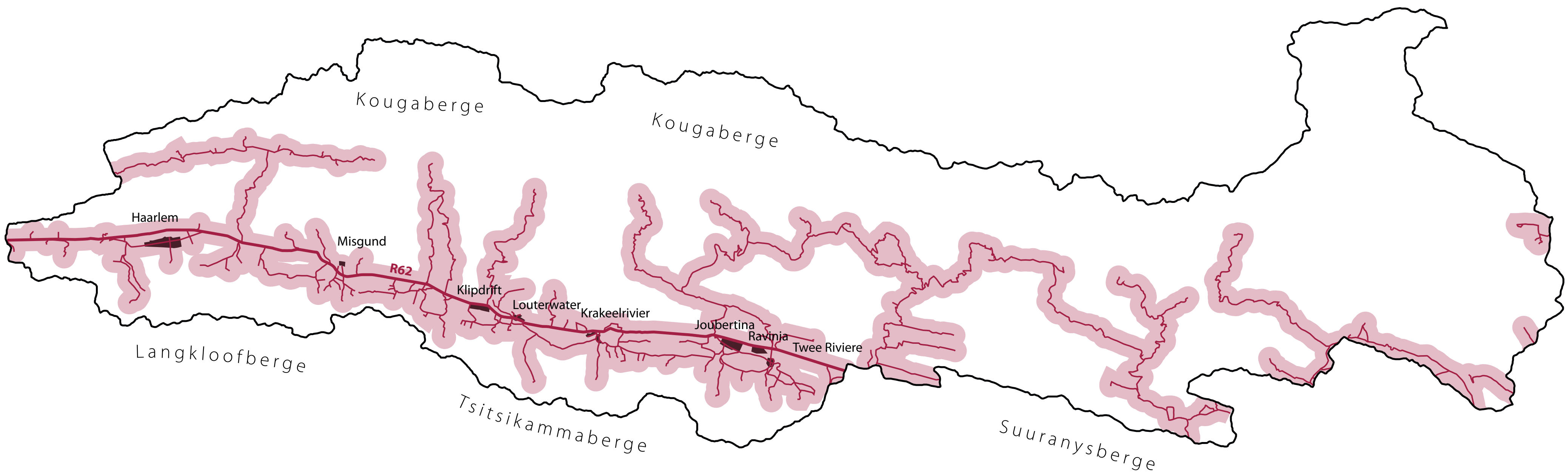
WfW has carried out clearings of IAPs during the last ten years, mainly in the Langkloof. A catchment wide clearing strategy should anticipate these past clearing efforts of WfW.

There are two diferent sets of maps with the clearing history for black wattle and silky hakea. The first set of maps gives an overview of all clearing activities from 2002 untill 2015 for black wattle and from 2004 untill 2014 for silky hakea. But it's important to know how many follow-ups there have been on a certain plot. If a plot was just cleared once in 2004, it's probably fully infested again with IAPs. So this first set of maps shows only on which areas WfW has focused.

The second set of maps gives an overview of the most recent (between 2011 and 2015) clearing activities of WfW. The legenda categorizes the clearing plots per year when the last follow-up (or initial clearing) was carried out. Per year the legenda shows how many follow-ups there have been for the different plots: in between 0 or 10. How many follow-ups there have been for each plot separately, is not further indicated in this map. However, most of the plots only had 1 or 2 follow-ups.

Maps: *Clearing activities WfW: Acacia mearnsii (black wattle)* *p. 36-37*
Clearing activities WfW: Hakea sericea (silky hakea) *p. 38-39*

Roads + 1km zone



Roads + 1km zone

Map *Roads + 1km zone* shows the road network in the Kouga catchment. The main road is the R62, running eastwest through the Langkloof. The road network is most dense in the Langkloof, the main cultivated area in the Kouga. There are several roads going north, but none of them cross the Kougaberge that form a natural barrier in the north. In the south the Langkloofberge and Tsitsikammaberge are the natural boundary. The roads are extended with a zone of 1 km. The assumption is that the area close to the road is still quite well accessible.

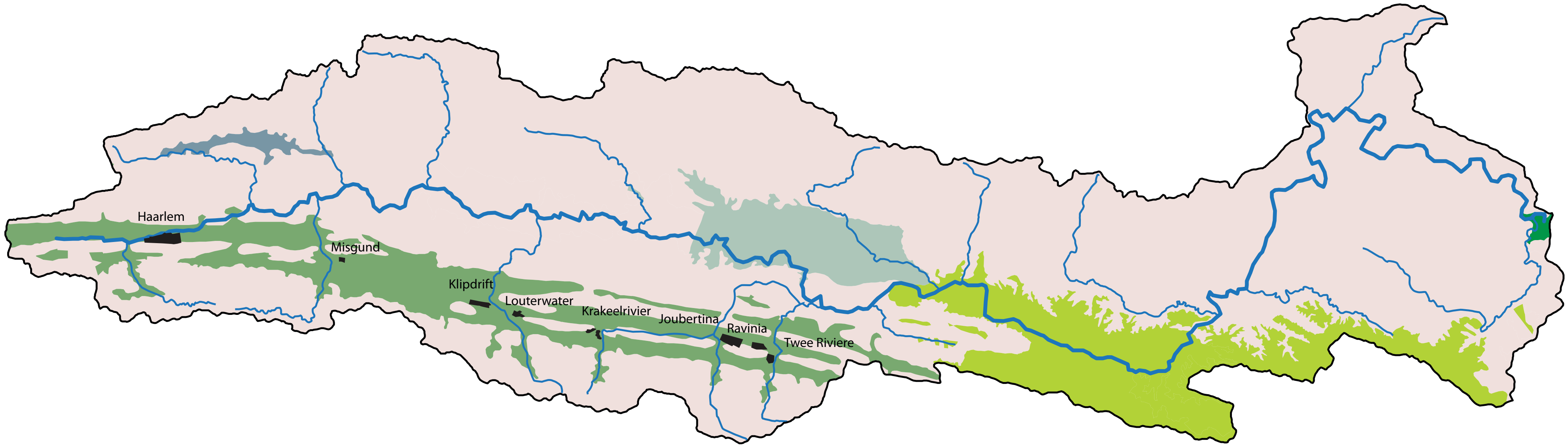
There are many more tracks and hiking trails that lead further into the mountains. These tracks are often accessible by car. So this would expand the area that is accessible considerably. Within the scope of this project only the asphalt roads are taken into account.

Road

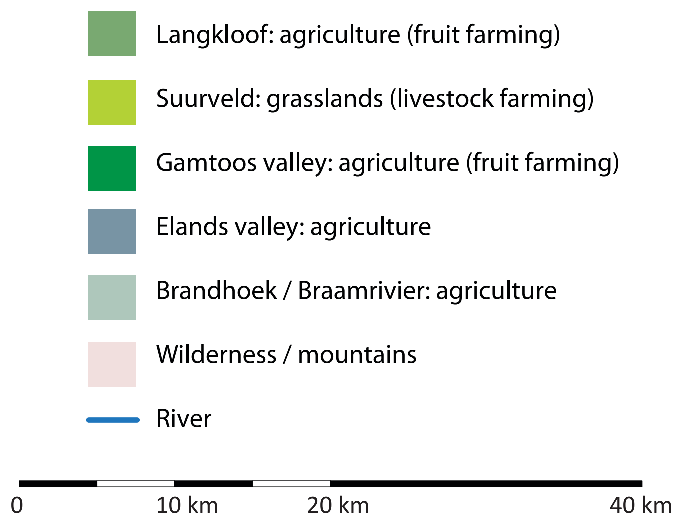
1 km zone

0 10 km 20 km 40 km

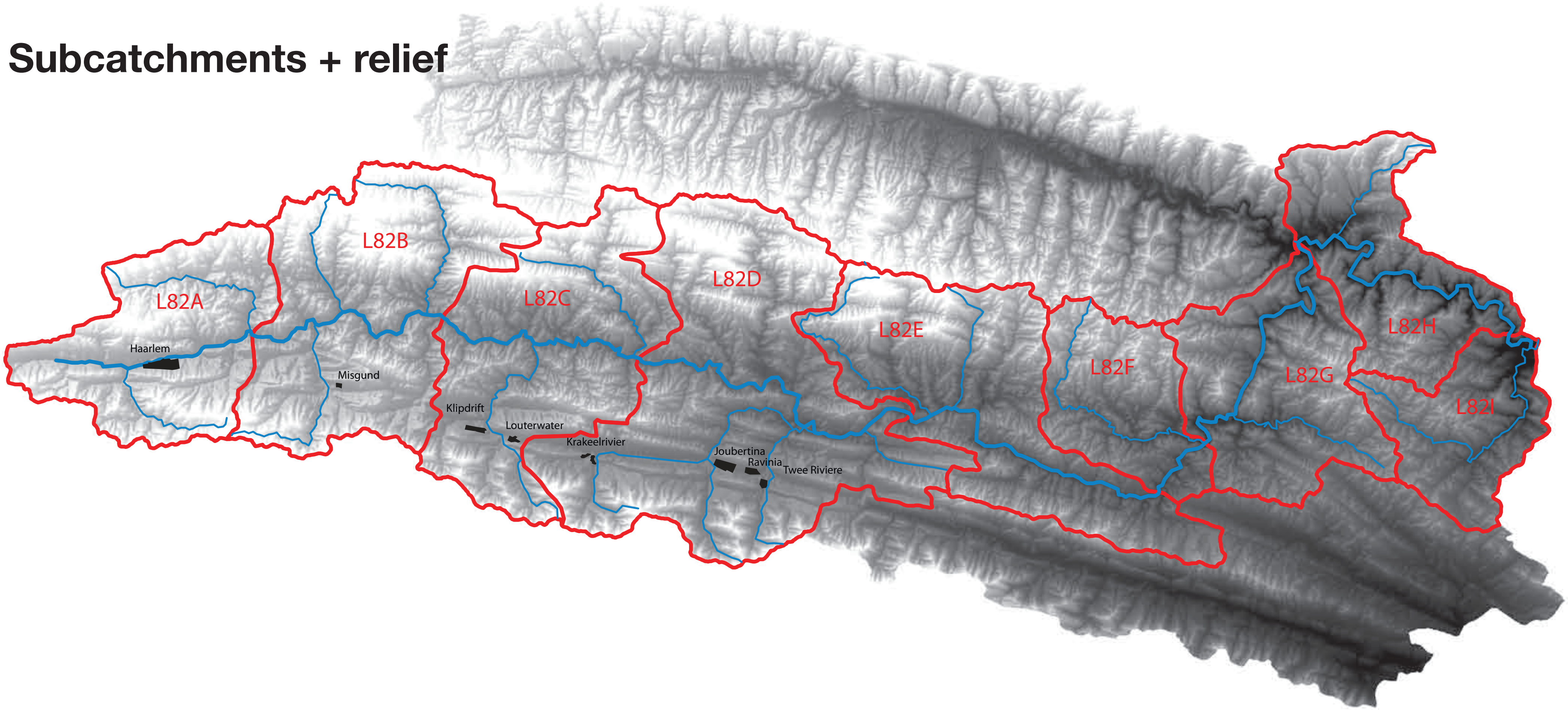
Wilderness - Cultivated areas



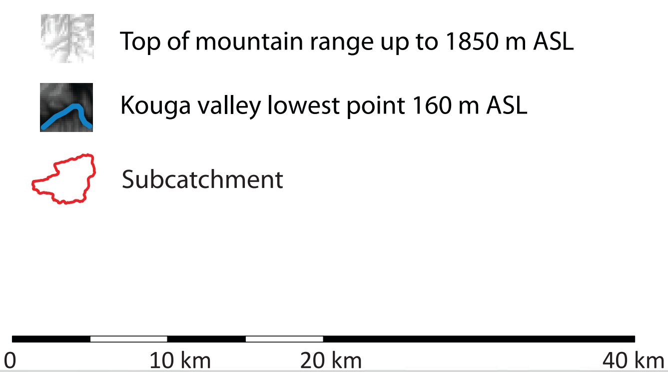
Wilderness - Cultivated areas
Map *Wilderness - Cultivated areas* shows the cultivated areas in the Kouga versus the uncultivated areas or wilderness. The largest part of the Kouga consists of high mountain ranges and is difficult to access. Five different cultivated areas can be distinguished in the Kouga catchment. The Langkloof is the main cultivated area, all the towns of the Kouga are situated here. The Langkloof, a 160 km long valley, is bounded by the Kougaberge in the north and by the Langkloofberge and Tsitsikammaberge in the south. The Langkloof is the best accessible part of the Kouga catchment.
The Suurveld, or Suuranys, is an area in the southeast of the Kouga catchment. The landscape here is more open and hilly with grasslands. The Suurveld is used for extensive livestock farming.
Next to the Suurveld, in the river valley of the Kouga, lies an area with two small villages called Brandhoek and Braamrivier surrounded by a few orchards and cultivated plots.
In the northwest of the Kouga catchment lies Elands valley, secluded by the Kougaberge in the north and Witte Berg in the south. There are a few small villages in Elands valley with some cultivated plots.
In the most eastern part of the Kouga catchment, near the Kouga Dam, lies the Gamtoos valley. After the Kouga Dam the river Kouga continues as ‘Gamtoos river’, flowing through Gamtoos valley to end up in the ocean near Jeffreys Bay. The beginning of Gamtoos valley falls just within the borders of the Kouga cathment. In Gamtoos valley there are orchards as well as cultivated plots.



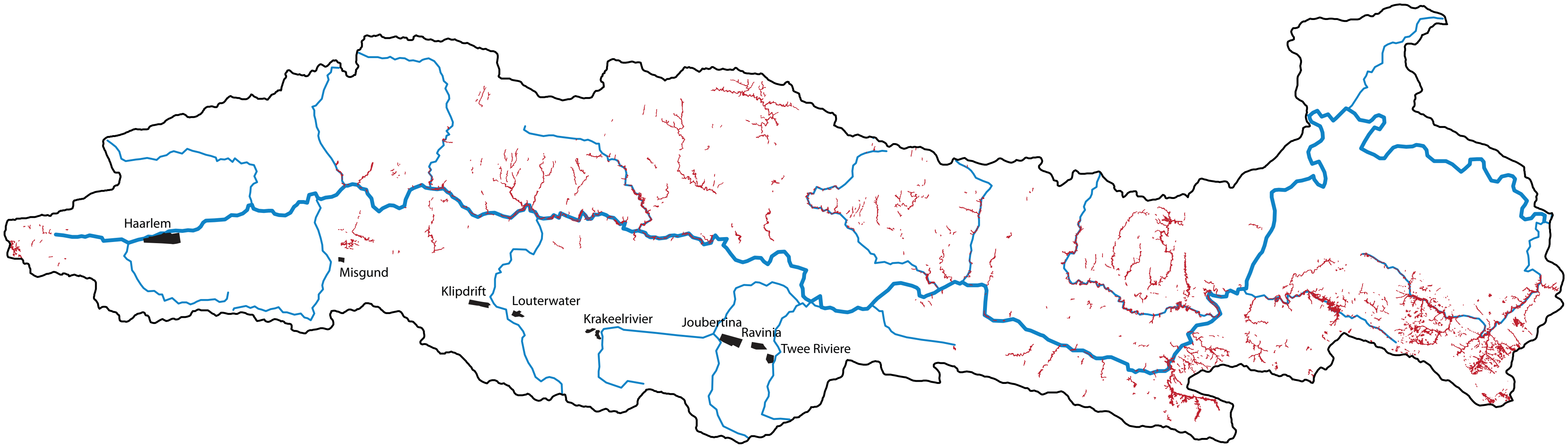
Subcatchments + relief



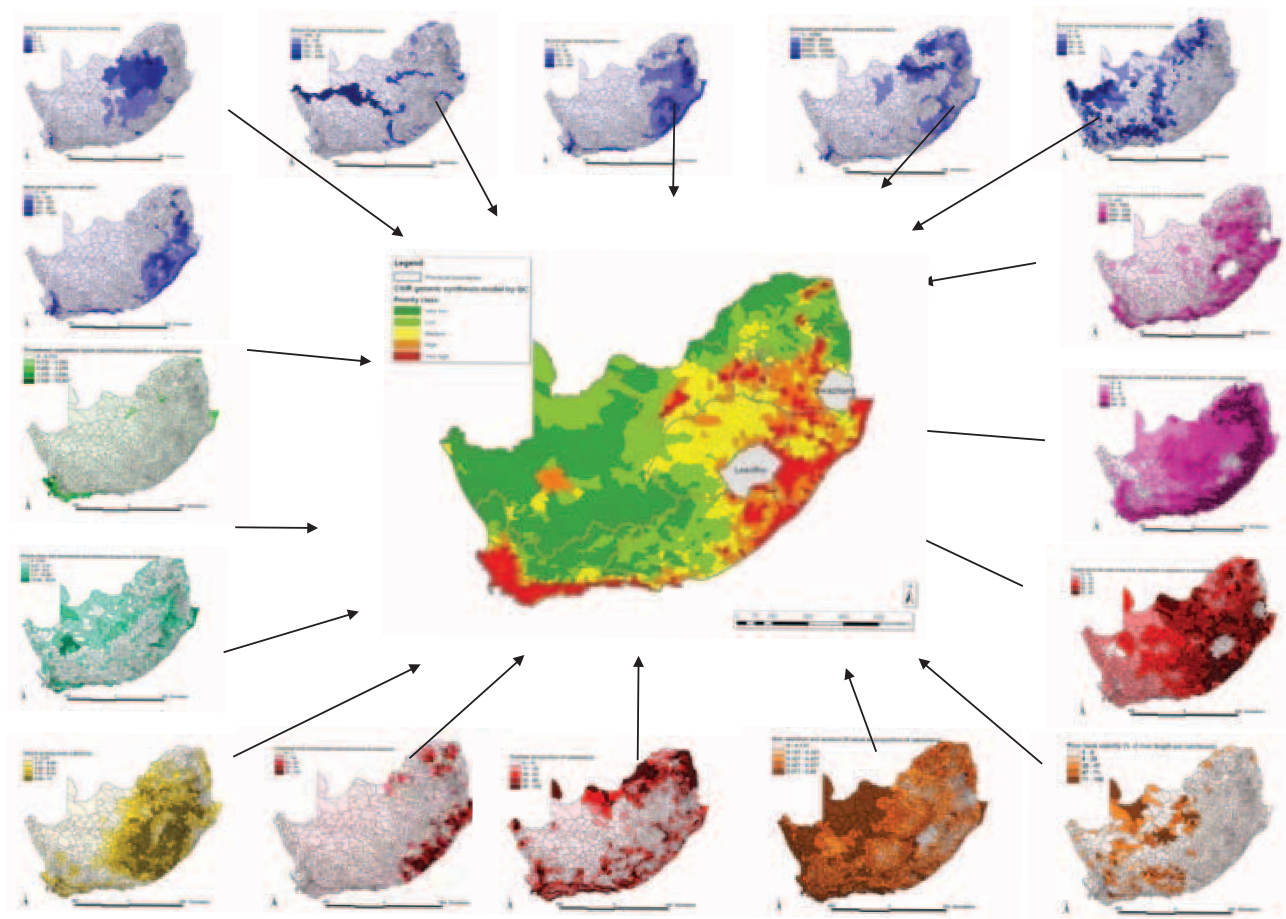
Subcatchments + relief
Map *Subcatchments + relief* shows the relief together with the nine subcatchments of the Kouga catchment. Because rainfall is low in South Africa, the catchments are the main water supply. Most of the country's surface water is generated by catchments (Egoh et al., 2008). The national catchments are therefore divided into different water management units to ensure an effective use of its water supply. The Kouga catchment (Catchment L82) is located in the Gamtoos River System (Catchment L). The Kouga catchment is further divided into nine quaternary catchments (L82A-I), the finest national scale catchment boundary.
The relief map shows the top of the catchment (white), the slopes (grey) and the river valleys (dark grey). The west of the catchment is the highest, the Grootrivier (Kouga river) originates here and flows towards the lower east side of the catchment.



Degree of infestation with black wattle

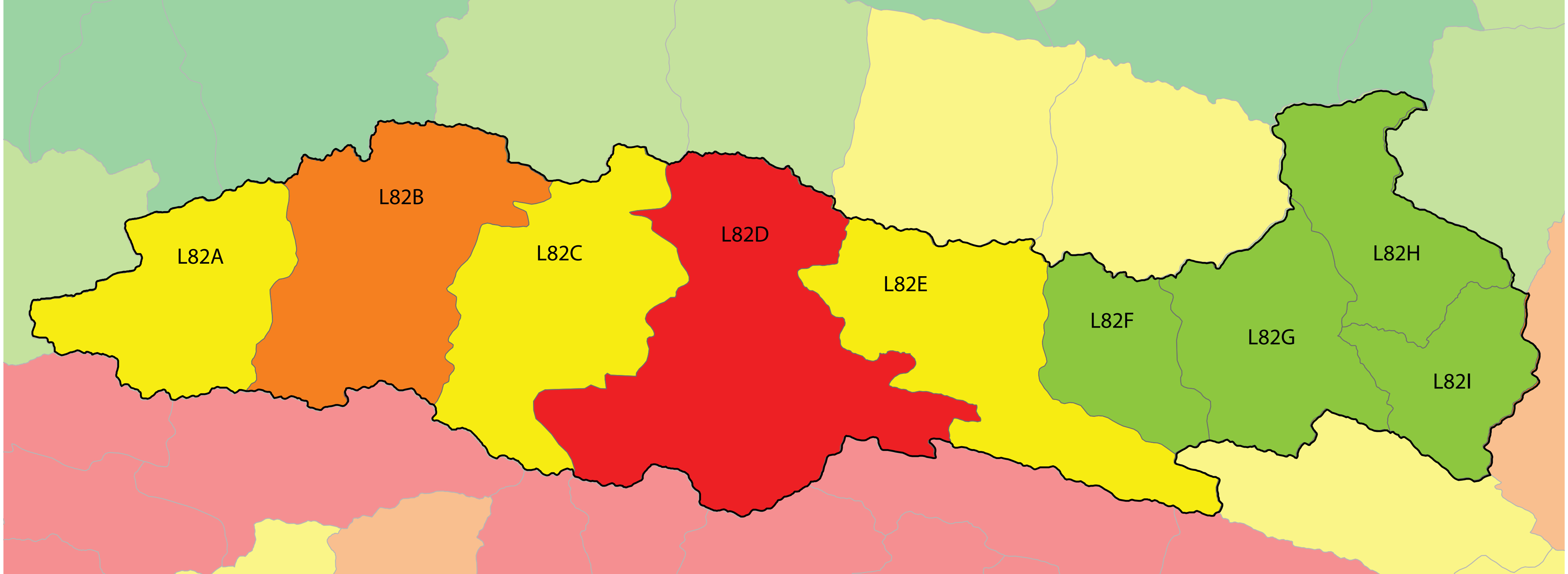


Degree of infestation with black wattle
The infestations with black wattle in the Kouga catchment is of course an important criterion for zoning. This project only covers the infestations with black wattle in one density (>50%). So the mapped black wattle covers only one zone. When there is more data available on infestations with different IAPs and in different densities, then there will be multiple zones based on the nature and the density of the infestations.
Most dense infestations with black wattle are to be found in the river valleys, in the valley of the Kouga river as well as in the valleys of the tributaries. The northeast of the catchment seems to be free from infestations with black wattle. [Mapping black wattle incomplete: to be continued]



The map in the middle shows the prioritisation of South Africa in terms of areas of importance for the control of invasive alien plants. The smaller maps show input datasets that were used to determine priorities. These included water yield and quality, groundwater recharge, terrestrial and aquatic biodiversity, natural resource utilization and ecosystem services, the distribution of invasive alien plants, and the presence of poverty: From "A national strategy for dealing with biological invasions in South Africa", by DEA, 2014, p.18.

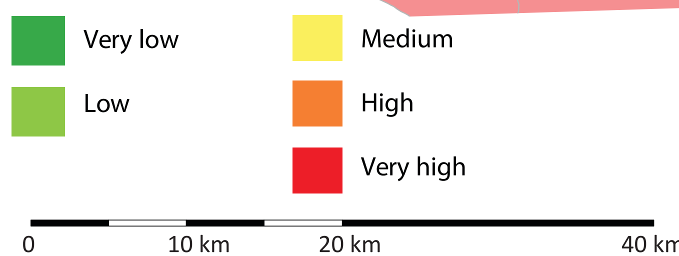
Generic synthesis prioritisation model (Le Maitre et al., 2012)



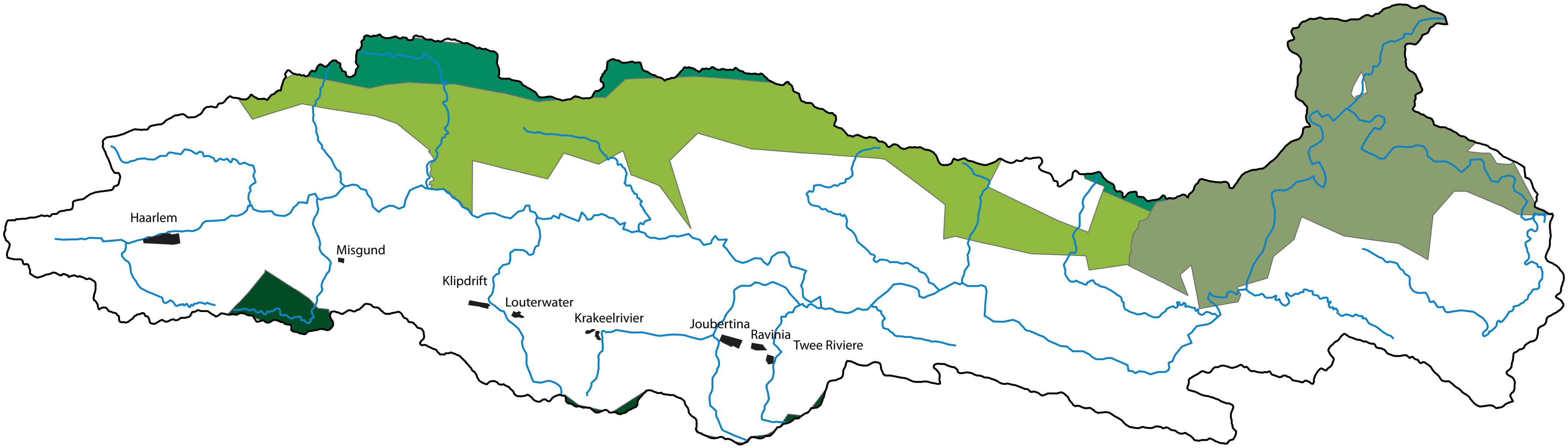
Generic synthesis prioritisation model (Le Maitre et al., 2012)
Between 2008 and 2012 the WfW programme commissioned a series of prioritisation exercises. The aim was to identify the areas where IAP control was most needed and where such control would bring the largest returns on investment. The prioritisation exercises were carried out at three different scales. At the highest level, South Africa's ten terrestrial biomes (savanna, grassland, nama karoo, fynbos, succulent karoo, albany thicket, Indian ocean coastal belt, desert and forest biomes) were considered. At the second level, priorities within primary catchments within each biome were analysed. And at the lowest level the prioritisation of quaternary catchments within primary catchments were analysed.

The input datasets that were used to determine priorities included water yield and quality, groundwater recharge, terrestrial and aquatic biodiversity, natural resource utilization and ecosystem services, the distribution of invasive alien plants, and the presence of poverty. After all the criteria had been identified in a series of prioritisation exercises, the criteria were pooled to develop a "generic" prioritisation model. This model identified 19 criteria that were judged to be the most important. These criteria were used to create an overall, national-scale map of priorities. From these exercises the fynbos areas of the Western and Eastern Cape provinces were one of the three broad areas that appeared to be the highest priority (Le Maitre et al., 2012).

The Generic synthesis prioritisation model gives the following priorities to the subcatchments of the Kouga: subcatchment L82D has a very high priority, L82B has a high priority, L82A, C and E have medium priority and subcatchments L82F, G, H and I have a low priority for clearing.



Nature reserves

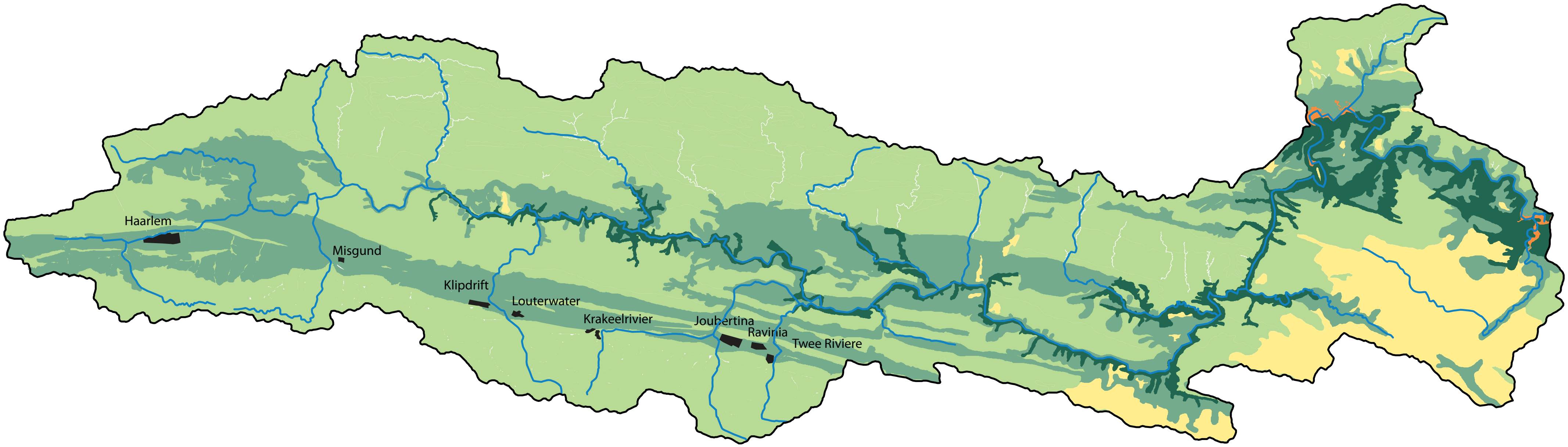


Nature reserves
There are four different nature reserves that fall into the Kouga catchment. In the north of the catchment these are the Kouga, Baviaanskloof and the Cockscomb Nature Reserve. In the south a small part of the Formosa Nature Reserve falls within the catchment.
Map *Nature reserves* shows the location of the nature reserves. If an area is designated as a nature reserve, it may affect the measures to be applied. For example grazing or fire as a control measure are not possible within a nature reserve.

Kouga Nature Reserve
Cockscomb Nature Reserve
Baviaanskloof Nature Reserve
Formosa Nature Reserve

0 10 km 20 km 40 km

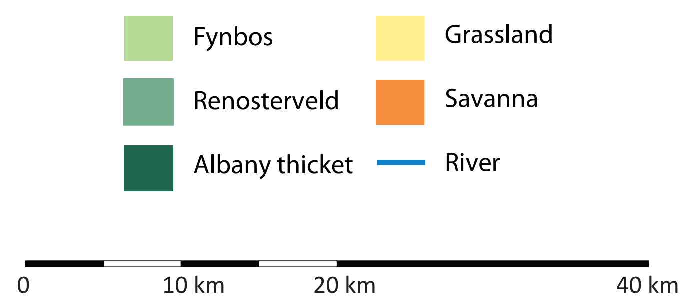
Vegetation



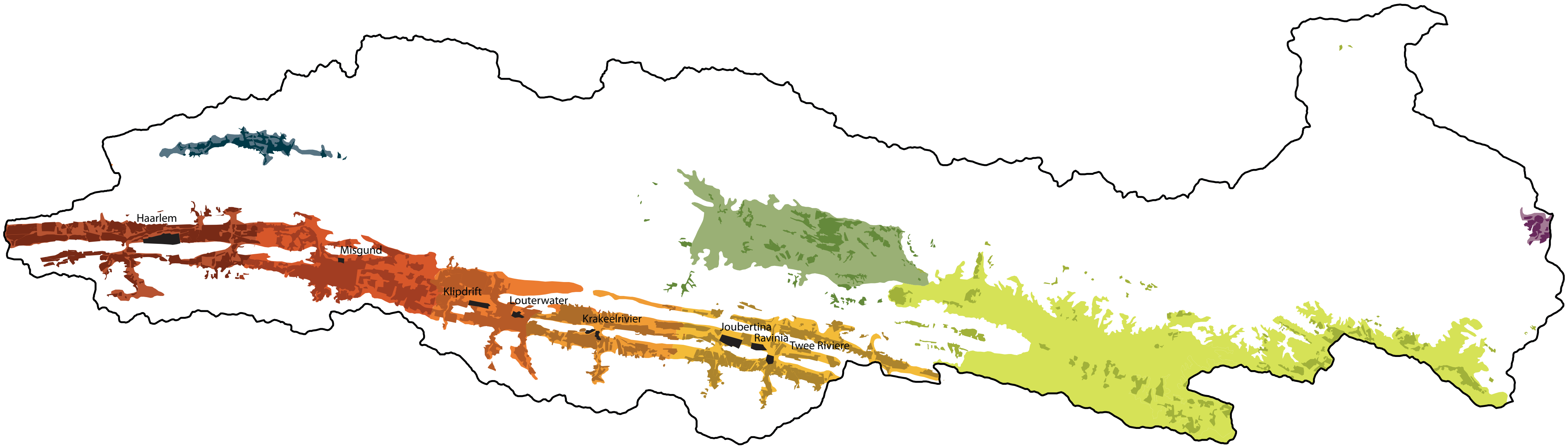
Vegetation

Map *Vegetation* shows the different vegetation types in the Kouga catchment. In total there are five types of vegetation: fynbos, renosterveld, albany thicket, grassland and savanna. The largest part of the Kouga is covered with fynbos vegetation. Fynbos is known for its exceptional degree of biodiversity and is endemic to South Africa. It's found on the mountains where it grows on soils which are very limited in nutrients. Fynbos depends on fire for regeneration, in the mountains there are regular fires caused by lightning.
Renosterveld, literally 'Rhinoceros veld', is characterized by the dominance of members of the Daisy Family, specifically one species – Renosterbos (Rhinoceros bush), from which the vegetation type gets its name. Grasses are also abundant in the Renosterveld. Renosterveld is part of the fynbos biome, but it grows on more fertile soils. Therefore much of the renosterveld has been converted to agriculture.

The albany thicket vegetation is characterized by evergreen, woody, semi-succulent and thorny shrubs and low trees. Albany thicket grows on soils with higher nutrient concentrations. However, fertile soils are limited in the Kouga, so it mainly grows at lower altitude on the slopes of the mountains and along the Kouga River and its tributaries on alluvium depositions. In the northeast of the catchment the thicket vegetation gets more abundant, because of summer rainfall and slightly increased soil fertility.
In the southeast of the catchment the landscape is more open and hilly. Grassland is here the dominant vegetation type. The acidic character and higher loam content of the sandstone mountains lead to a sour grassland vegetation. Savanna covers the smallest area in the Kouga. It is only found at some alluvial valley floors in the Baviaanskloof Mountains. Savanna is characterized by a grassy ground layer and an upper layer of woody plants. This shrub-tree layer may vary from 1 to 20 m in height.
The Langkloof used to be covered by wetlands. But nowadays only some smaller wetlands are left and often invaded by alien plants. The biggest (palmiet) wetland that is left, is between Joubertina and Heights (Mucina and Rutherford, 2006; Veerkamp, 2013).



Communities



Communities

Map *Communities* shows the different communities in the Kouga catchment. These communities correspond with the cultivated areas of the Wilderness – Cultivated areas map. The Elands valley in the northwest of the catchment is a clearly secluded community. The Langkloof is a long stretched valley that is divided into different communities around each village. The farmers of the Suurveld form a clearly distinct group, because of the different kind of landuse (livestock farming) in relation to the rest of the catchment. Due to the landscape the Gamtoos valley is also very much separate from the rest of the catchment and thus forming another community in the catchment. The small villages Brandhoek and Braamrivier form a more loosely spread community on small plains in between the mountains and river valleys.

Langkloof: Haarlem community
Langkloof: Misgund community
Langkloof: Louterwater community
Langkloof: Krakeelrivier community
Langkloof: Joubertina community
Suurveld community
Brandhoek / Braamrivier community
Elands valley community
Gamtoos valley community
Cultivated land

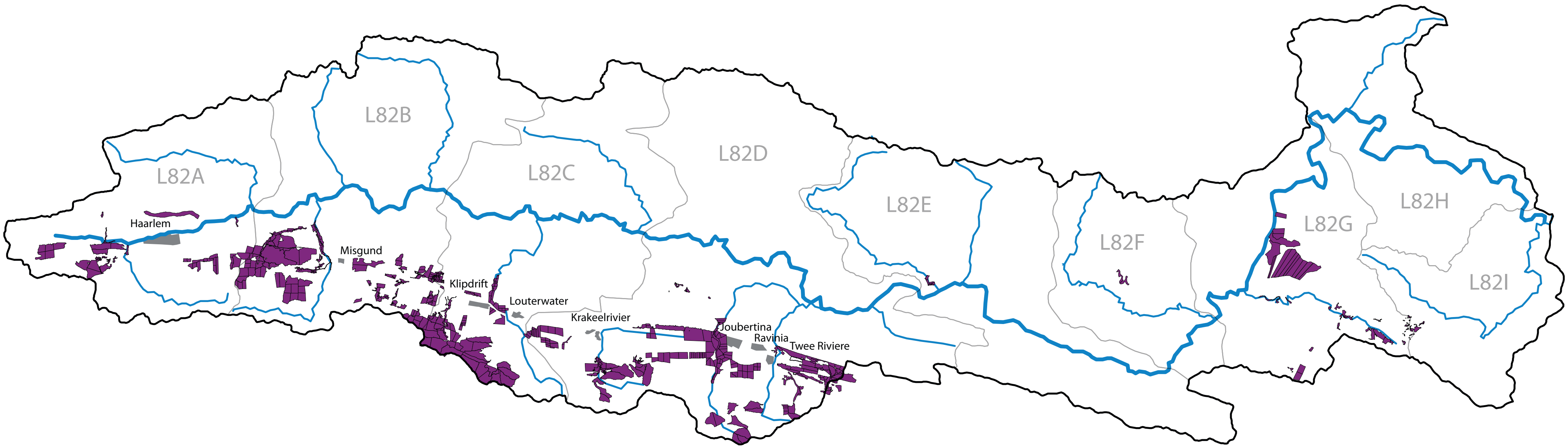
0 10 km 20 km 40 km

Farms

Farms
Map *Farms* shows the land properties in the Kouga catchment. This map indicates only the amount and spread of the properties and their subdivision in different plots.

Clearing activities WfW: Acacia mearnsii (black wattle)

From 2002 until 2015



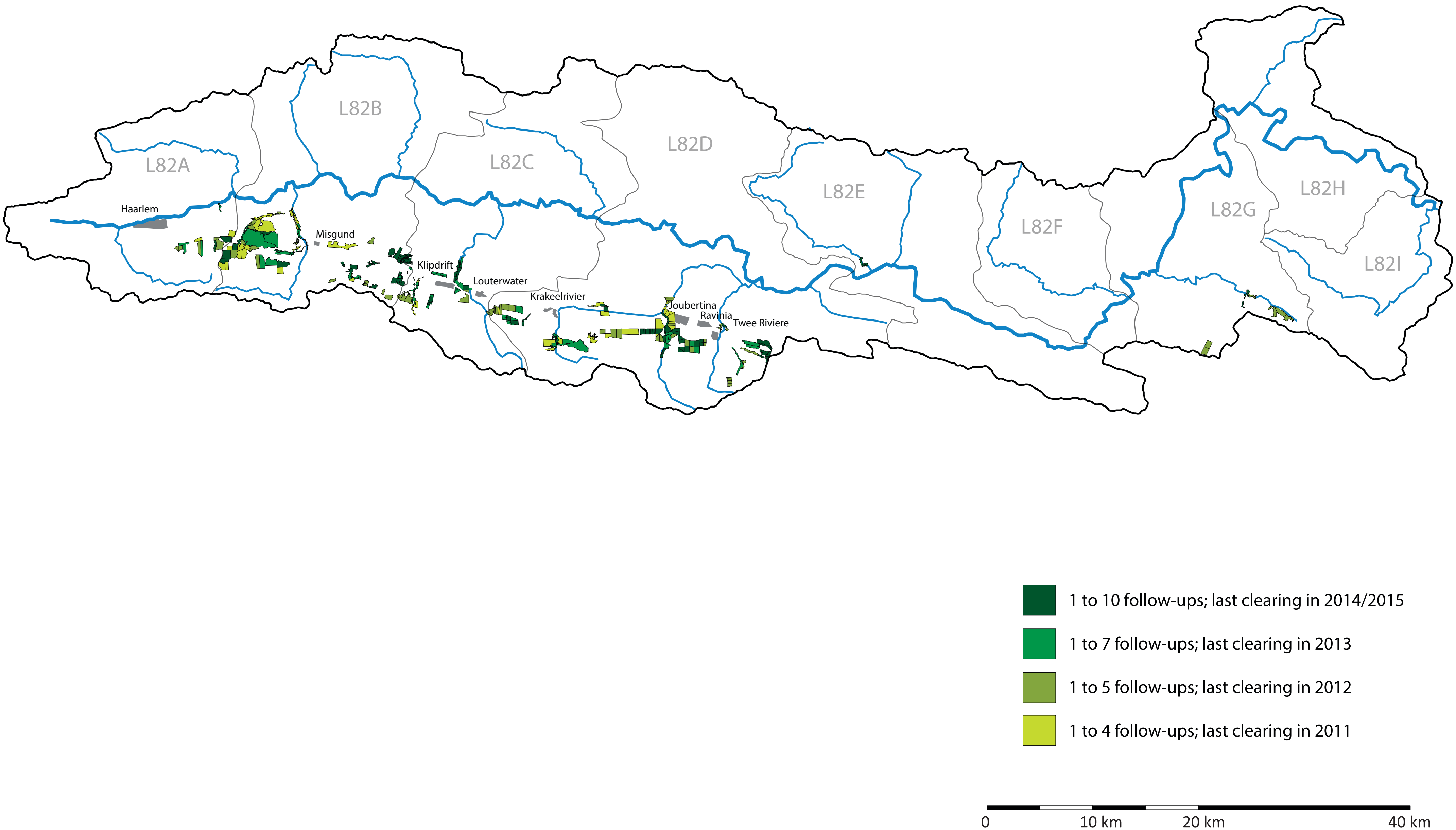
Clearing activities WfW: Acacia mearnsii (black wattle)
Most of the clearing activities of WfW are concentrated in the Langkloof. The clearings have been carried out mostly on the plain of the Langkloof and on the slopes on the south of the Langkloof. Only in subcatchment L82C a large part of the top of the subcatchment is cleared by WfW.
The clearing efforts of the last 5 years are concentrated in subcatchments L82B, C and D. Most of the clearings have been carried out along the tributaries in the Langkloof or on the slopes in the south. The top of the subcatchments has not been cleared the last 4 years.

Clearing Acacia mearnsii between 2002 and 2015

0 10 km 20 km 40 km

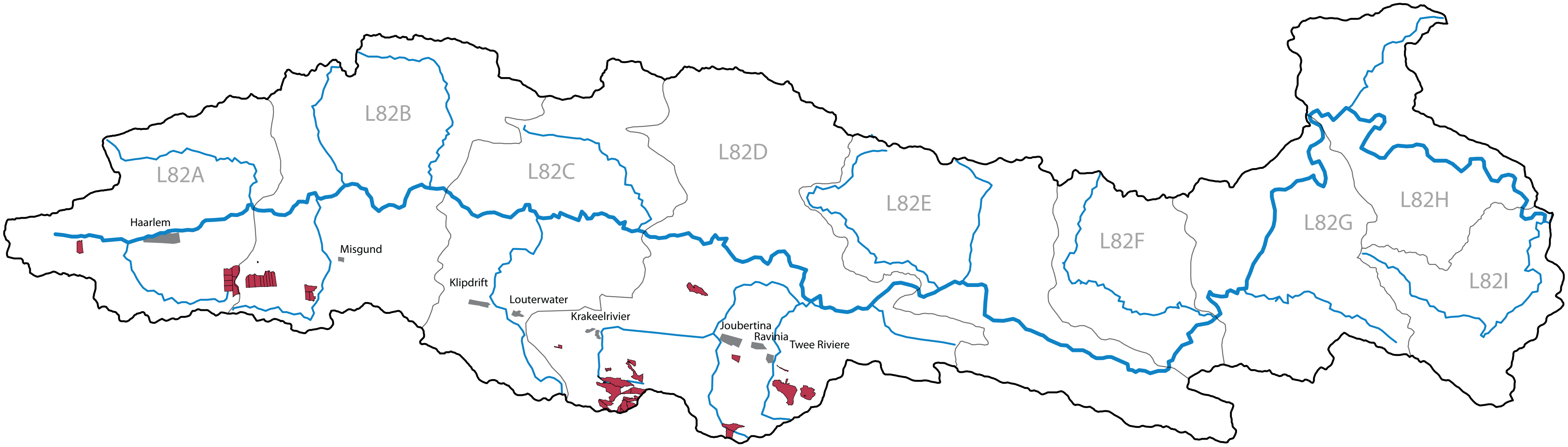
Clearing activities WfW: Acacia mearnsii (black wattle)

Last 4 years



Clearing activities WfW: Hakea sericea (silky hakea)

From 2004 until 2014



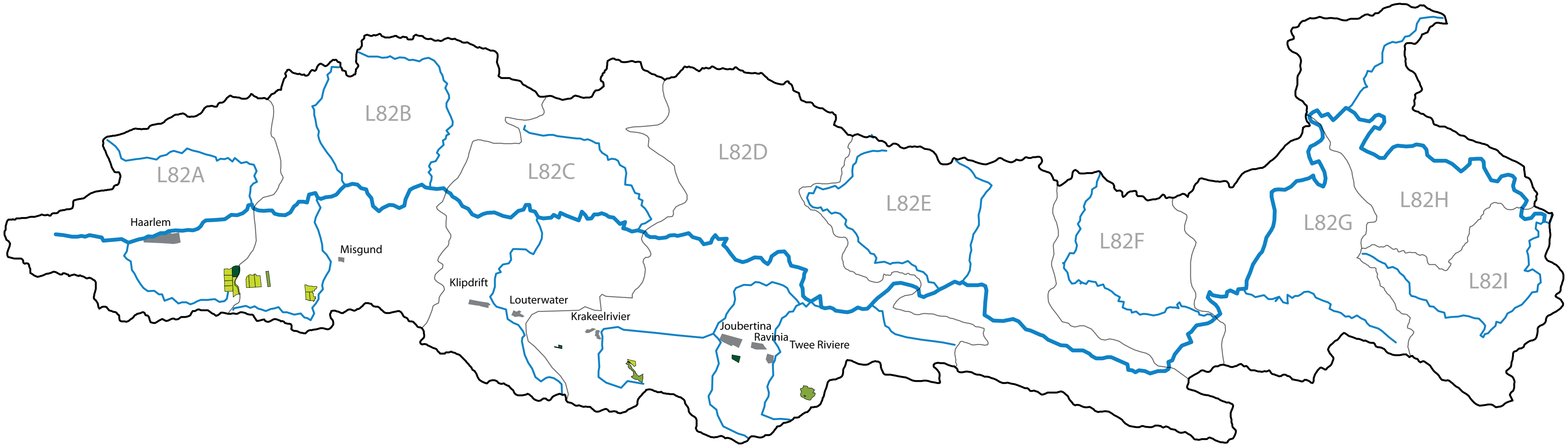
Clearing activities WfW: Hakea sericea (silky hakea)
There have been fewer clearing efforts in the Kouga catchment for silky hakea than for black wattle. Most clearings have been carried out in subcatchments L82B and D, on the slopes south of the Langkloof. The last 4 years there have not been that many clearings at all, most plots had a last follow-up in 2011.

Clearing Hakea sericea between 2002 and 2015

0 10 km 20 km 40 km

Clearing activities WfW: Hakea sericea (silky hakea)

Last 4 years



0 to 1 follow-up; last clearing in 2014

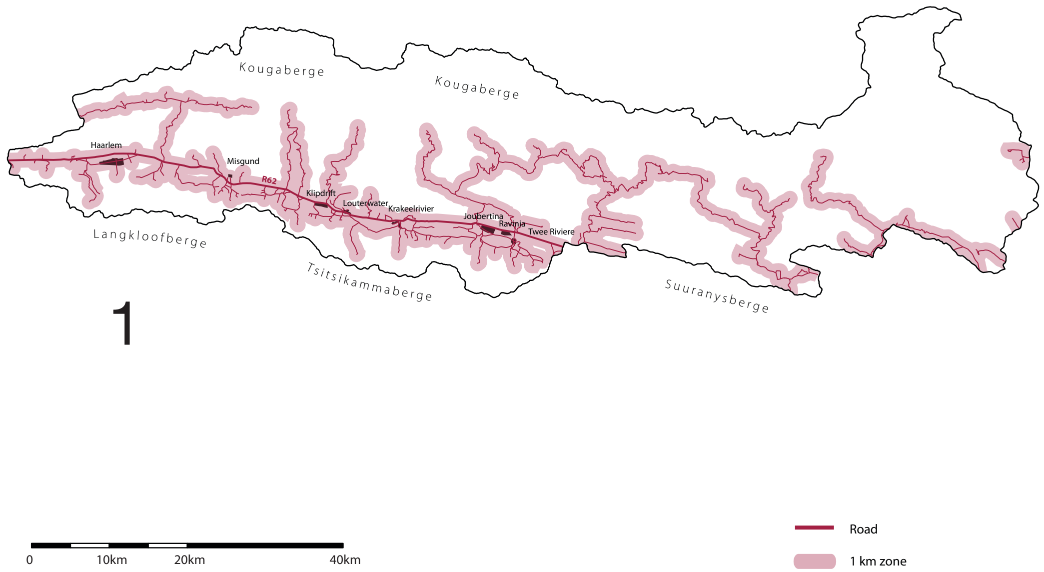
1 to 2 follow-ups; last clearing in 2012

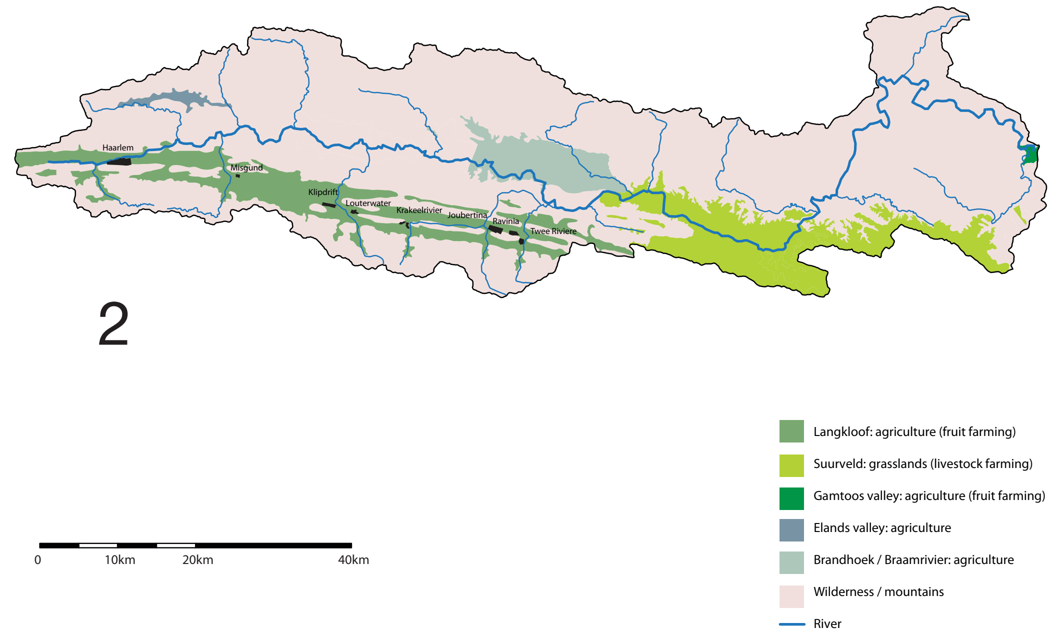
1 to 3 follow-ups; last clearing in 2011

0 10 km 20 km 40 km

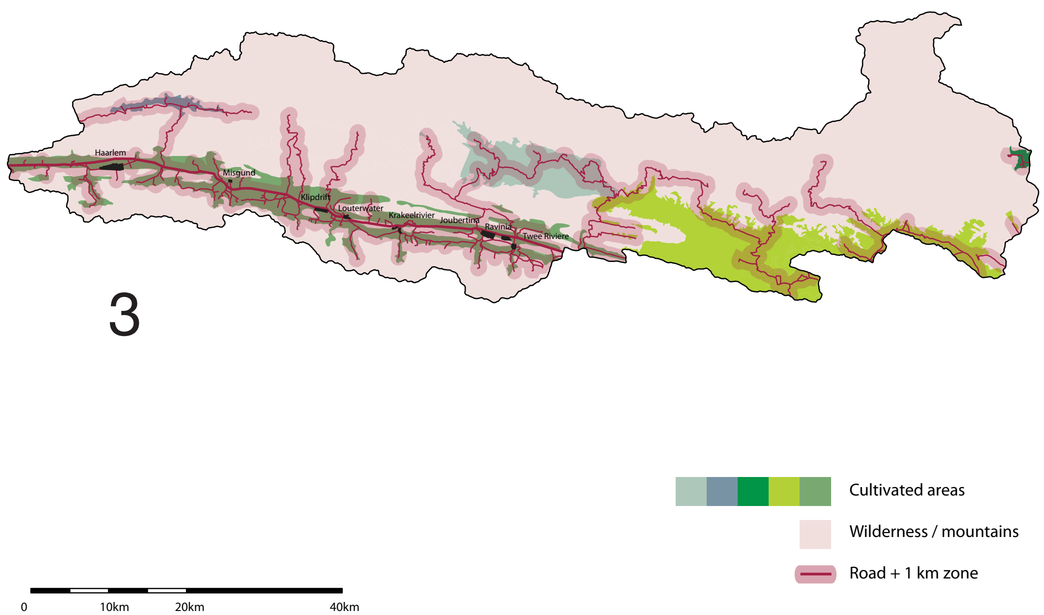
Roads + 1km zone

Wilderness - Cultivated areas

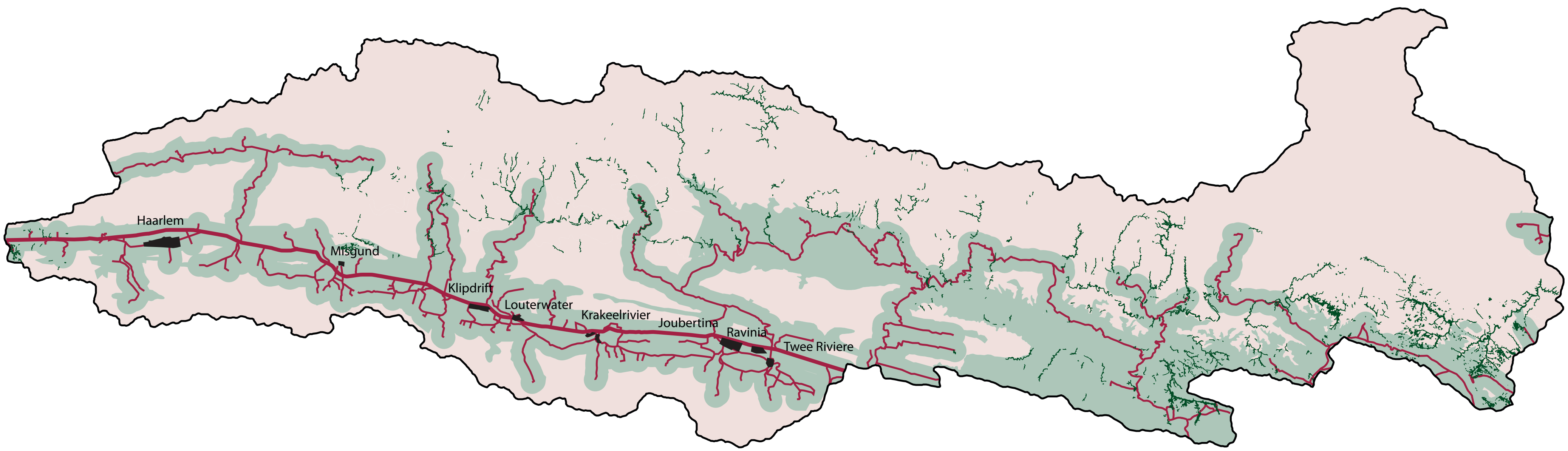




Maps 1 + 2 combined ---→ Accessible land



Accessible black wattle infestations: 1.796 ha



4.3 Zoning of the Kouga

Now that the criteria for zoning are clear, they will be combined to create one zoning map for the Kouga catchment. First the subcriteria will be combined into one map for each criterion. Then these maps will be combined into one overall zoning map.

Accessibility

The maps *Roads + 1km zone* and *Wilderness - Cultivated areas* are combined into one map: *Accessible land*. As the title of the map already explains, shows this map the area within easy reach for carrying out the clearings. The total amount of accessible land is 124.808 ha.

The map *Accessible black wattle infestations* shows how many hecaters of infestations fall within these accessible areas: approximately 1.796 ha. [Mapping black wattle incomplete: to be continued]

According to Mugido et al. (2014) is the available biomass from invasive stands of black wattle 31,73 tonnes/ha (harvested) at 100% canopy cover. The mapped infestations in this project have a cover density of 50% or more. So the available biomass of 31,73 tonnes/ha is a maximum possible yield. This would mean that in the Kouga catchment a maximum of 56.987 tonnes of wood could be sourced and used for compost making or other value adding processes.

Road

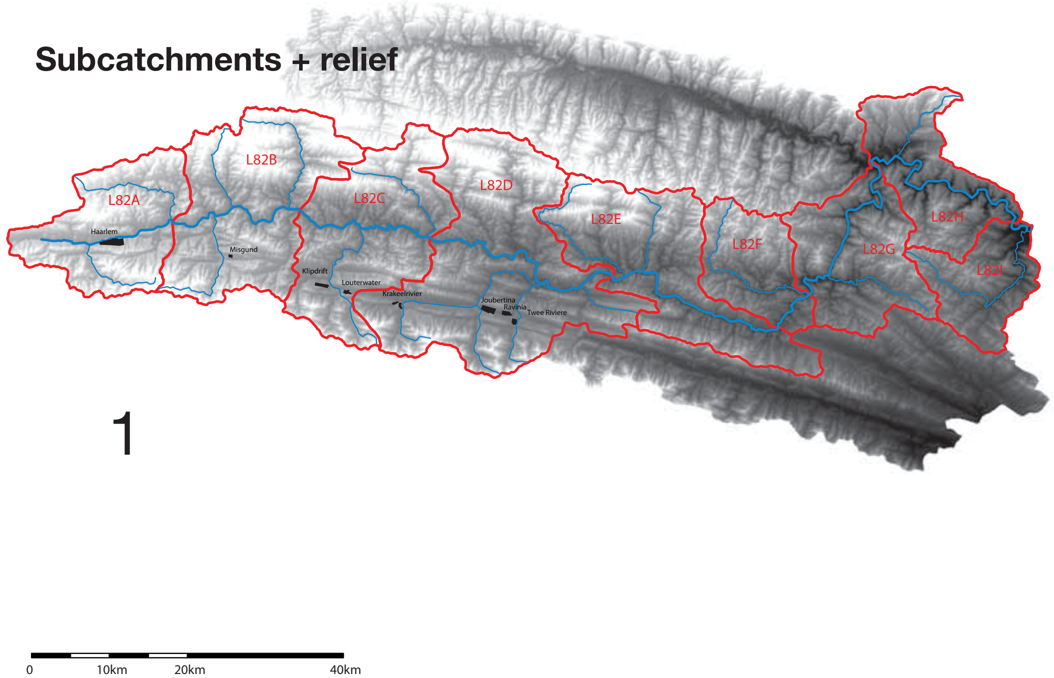
Accessible land: 124.808 ha

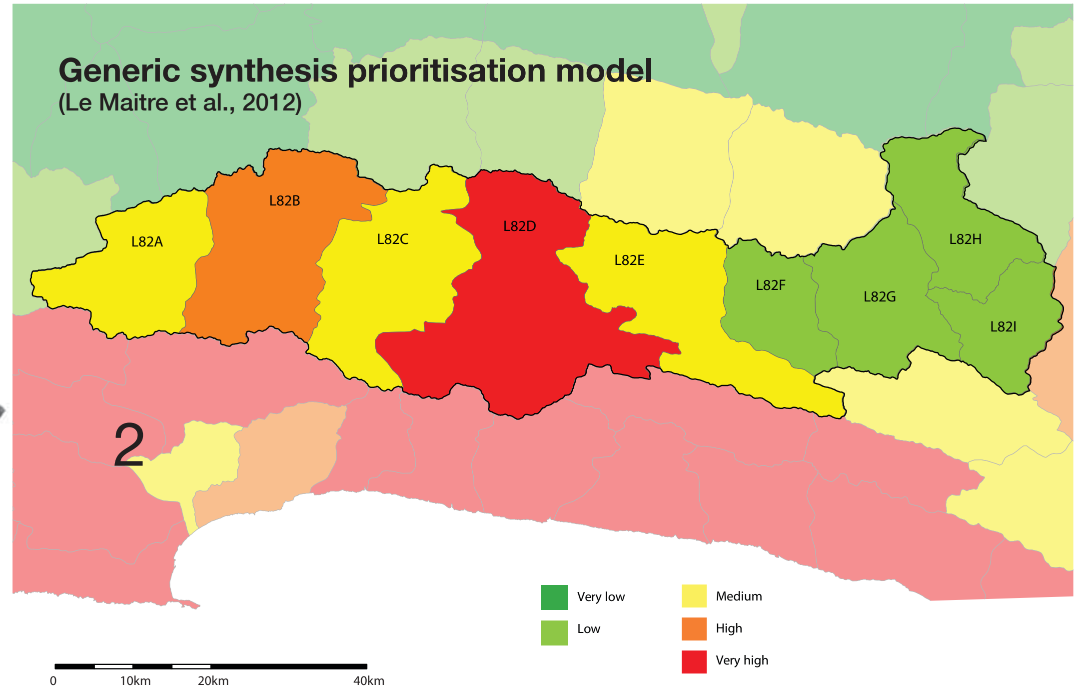
Wilderness / mountains

Infestations Black Wattle

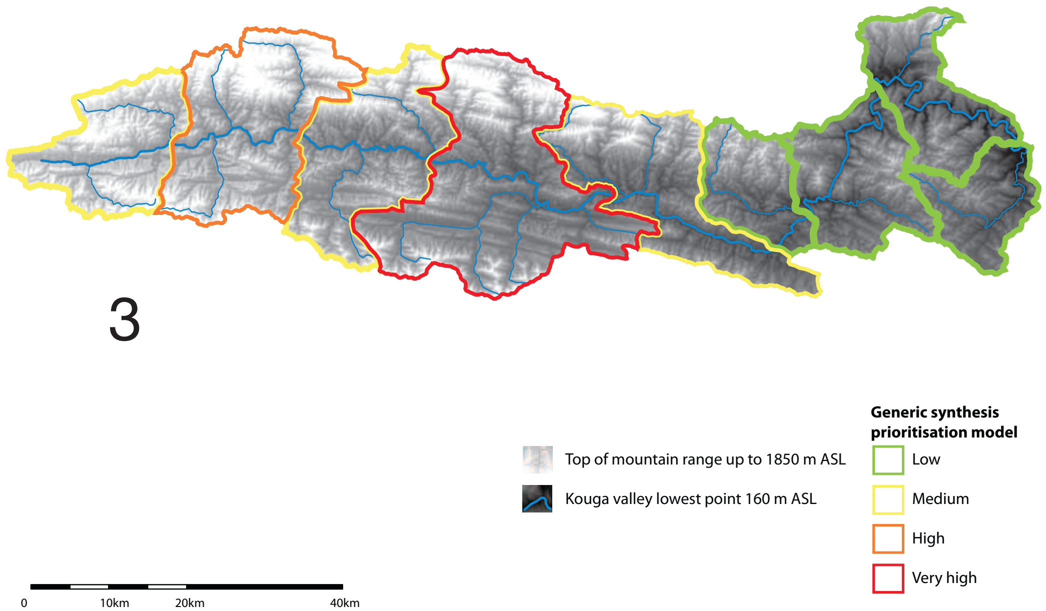
Infestations Black Wattle on accessible land: 1.796 ha

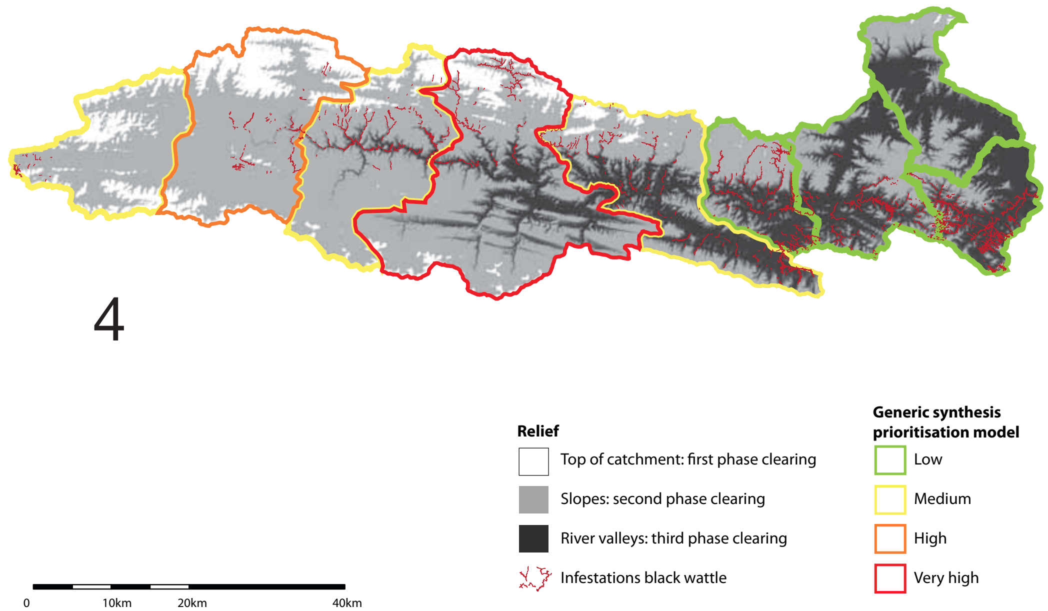
0 10 km 20 km 40 km



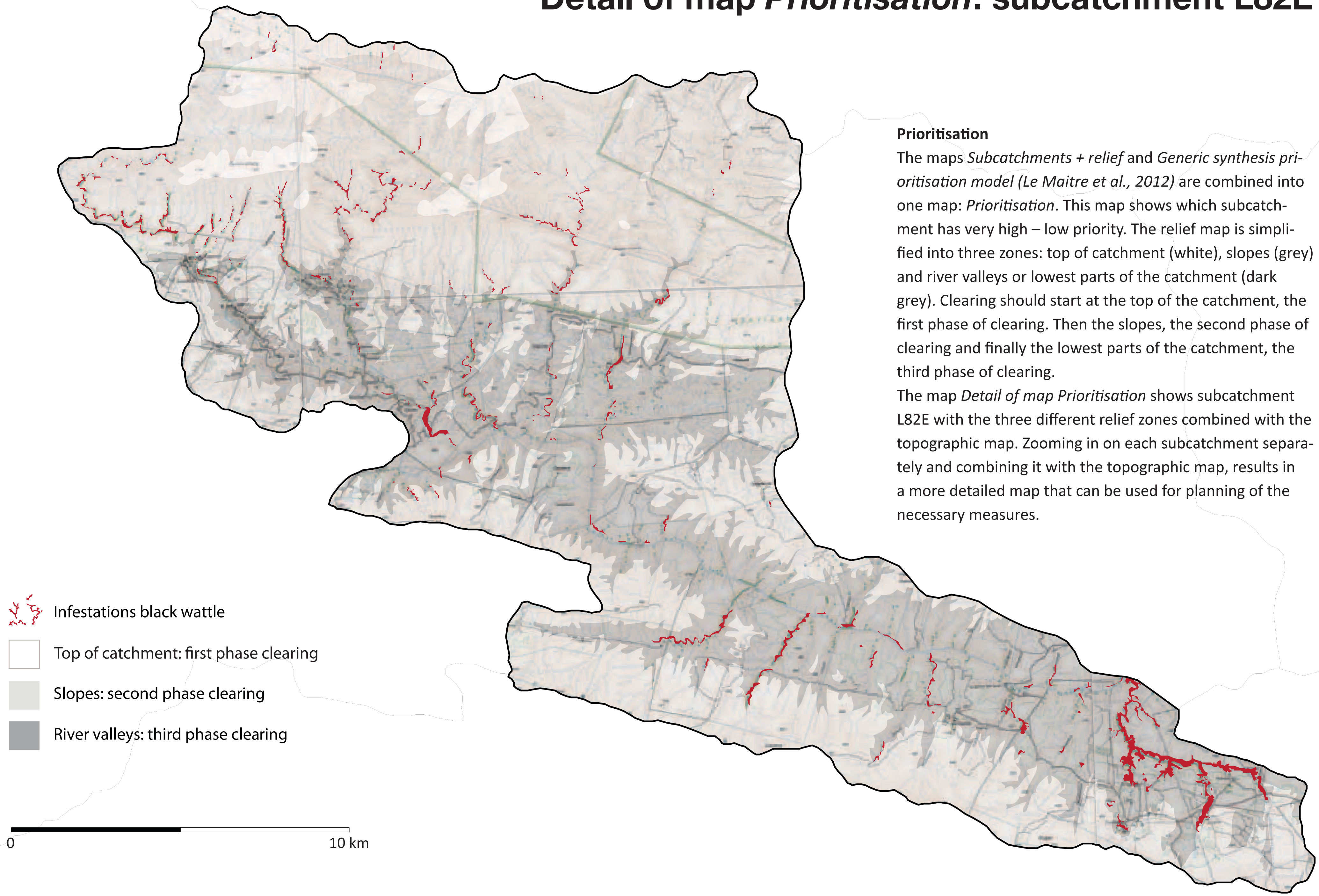


Maps 1 + 2 combined ------→ Prioritisation



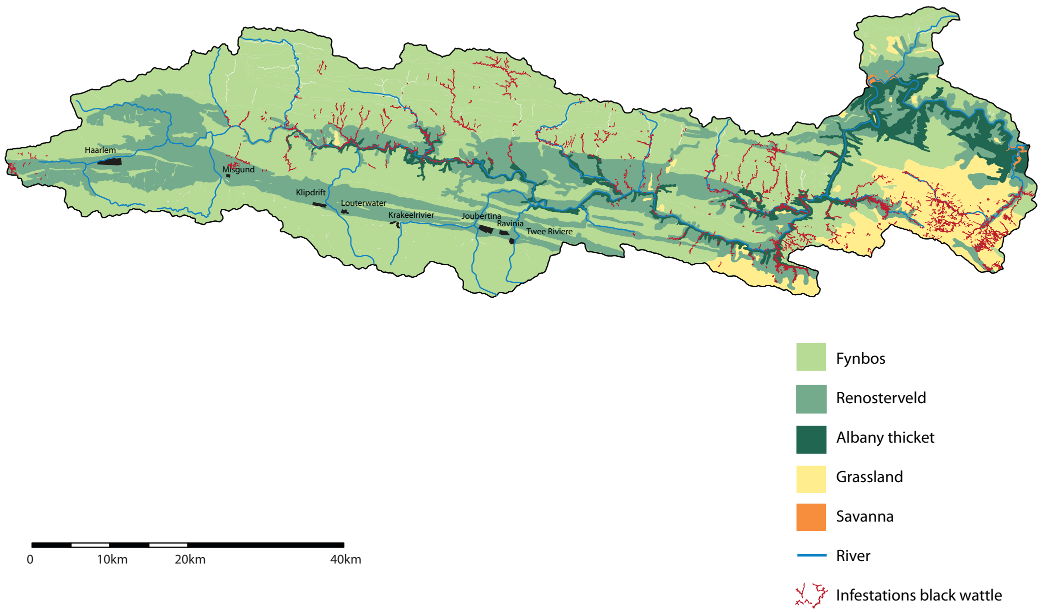


Detail of map *Prioritisation*: subcatchment L82E

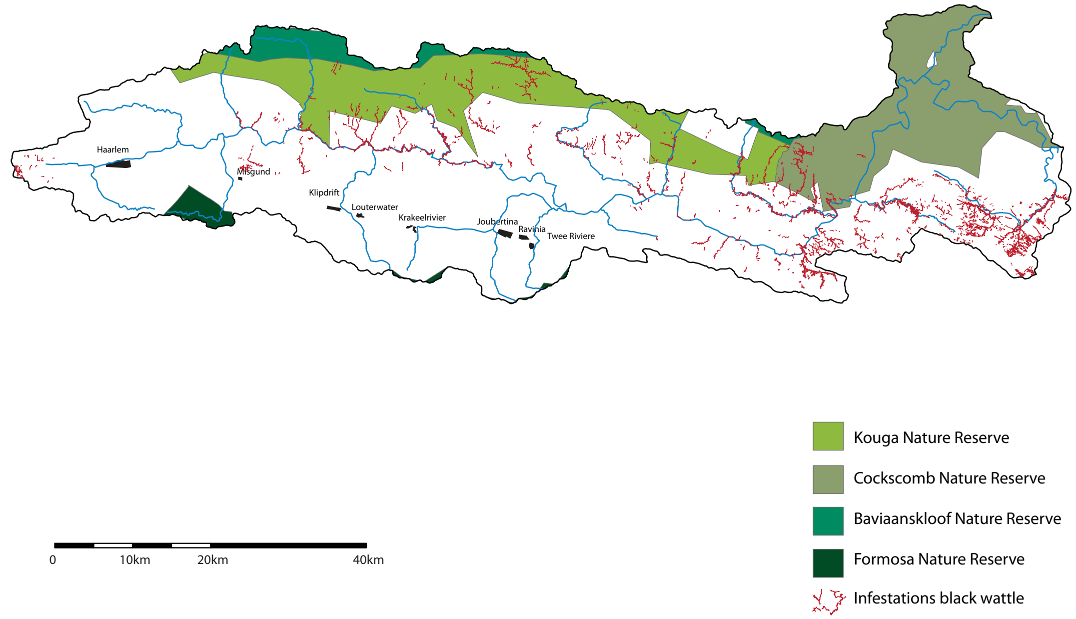


Prioritisation
The maps *Subcatchments + relief* and *Generic synthesis prioritisation model (Le Maitre et al., 2012)* are combined into one map: *Prioritisation*. This map shows which subcatchment has very high – low priority. The relief map is simplified into three zones: top of catchment (white), slopes (grey) and river valleys or lowest parts of the catchment (dark grey). Clearing should start at the top of the catchment, the first phase of clearing. Then the slopes, the second phase of clearing and finally the lowest parts of the catchment, the third phase of clearing.
The map *Detail of map Prioritisation* shows subcatchment L82E with the three different relief zones combined with the topographic map. Zooming in on each subcatchment separately and combining it with the topographic map, results in a more detailed map that can be used for planning of the necessary measures.

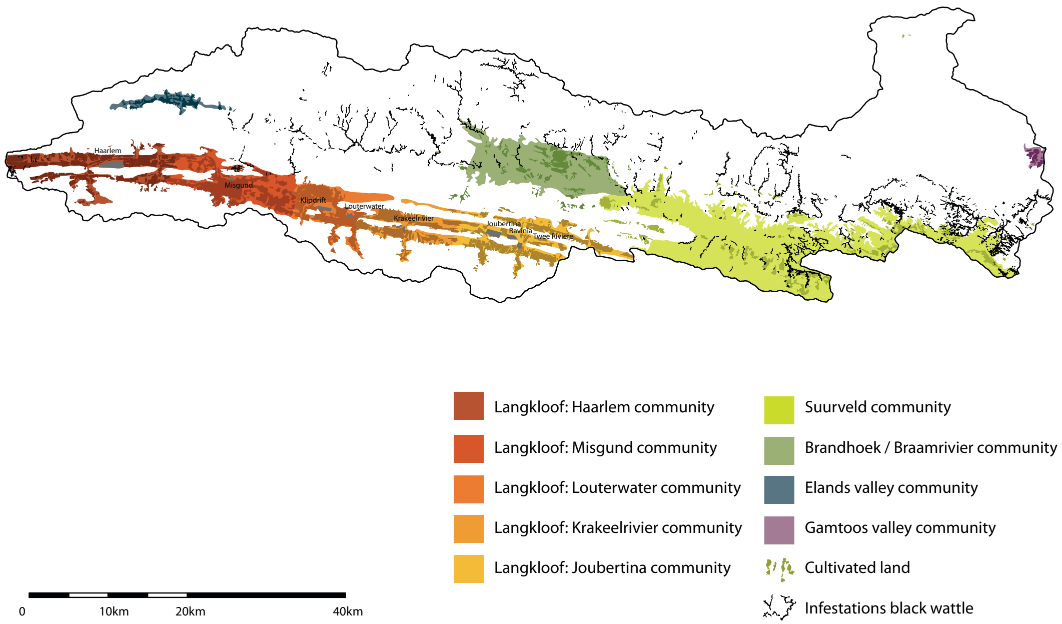
Vegetation



Nature reserves

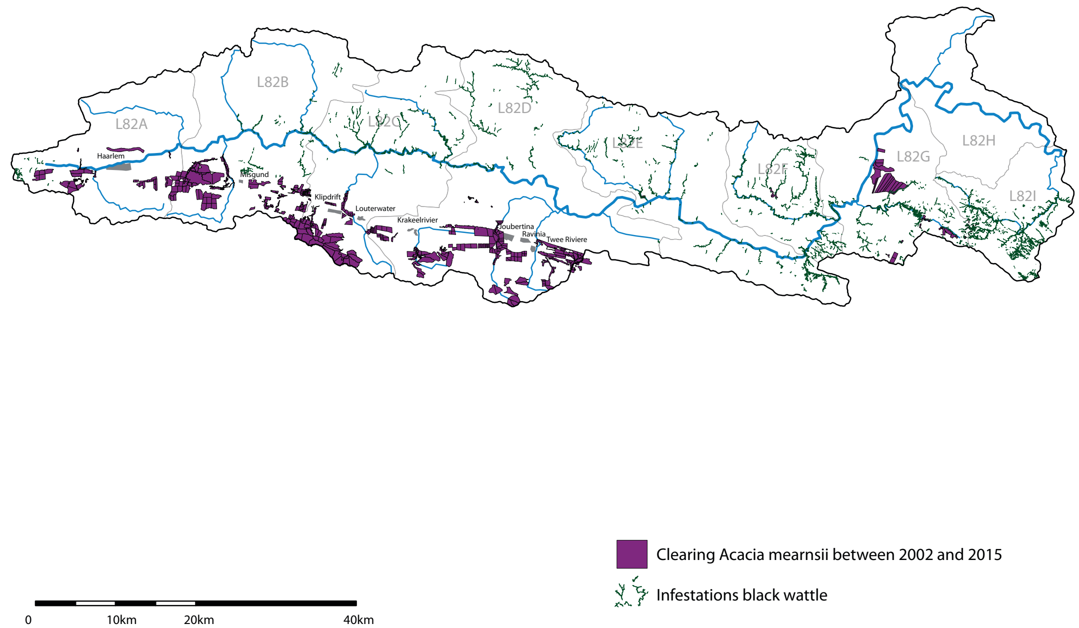


Communities



Clearing activities WfW: Acacia mearnsii (black wattle)

From 2002 until 2015



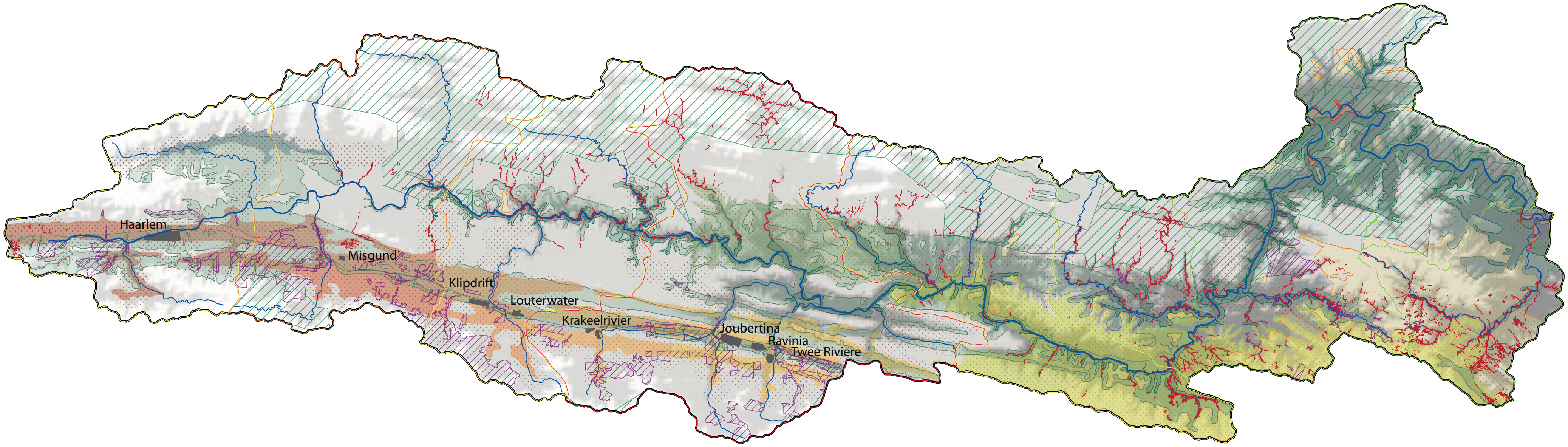
Natural values
The map *Vegetation* is combined with the infestations of black wattle and shows which vegetation types are most heavily infested. The type of vegetation that is infested, might have consequences for the measures to be applied. A lot of small river valleys and dry water courses in the fynbos area are heavily infested. Also the albany thicket, that grows in the valleys of the tributaries and the Kouga river, is heavily infested. However, the northeast of the catchment, where most of the albany thicket grows, is free from infestations. The grassland in the southeast of the catchment is also heavily infested, mostly in the river valleys and dry water courses. [Mapping black wattle incomplete: to be continued]

The map *Nature reserves* is also combined with the infestations of black wattle. This gives insight in what part of the infestations falls within a nature reserve. If the infestations fall within a nature reserve, it will have consequences for the measures to be applied.

Society
The map *Communities* is combined with the infestations of black wattle. This gives insight in which communities are most infested. [Mapping black wattle incomplete: to be continued]

WfW clearing activities
For the zoning map of the Kouga catchment all clearing activities from 2002 onwards are included. This gives a complete overview of past clearing efforts of WfW on catchment scale. In a more detailed map for implementation, a more precise clearing history can be indicated per plot. [Mapping black wattle incomplete: to be continued]

Zoning Kouga catchment



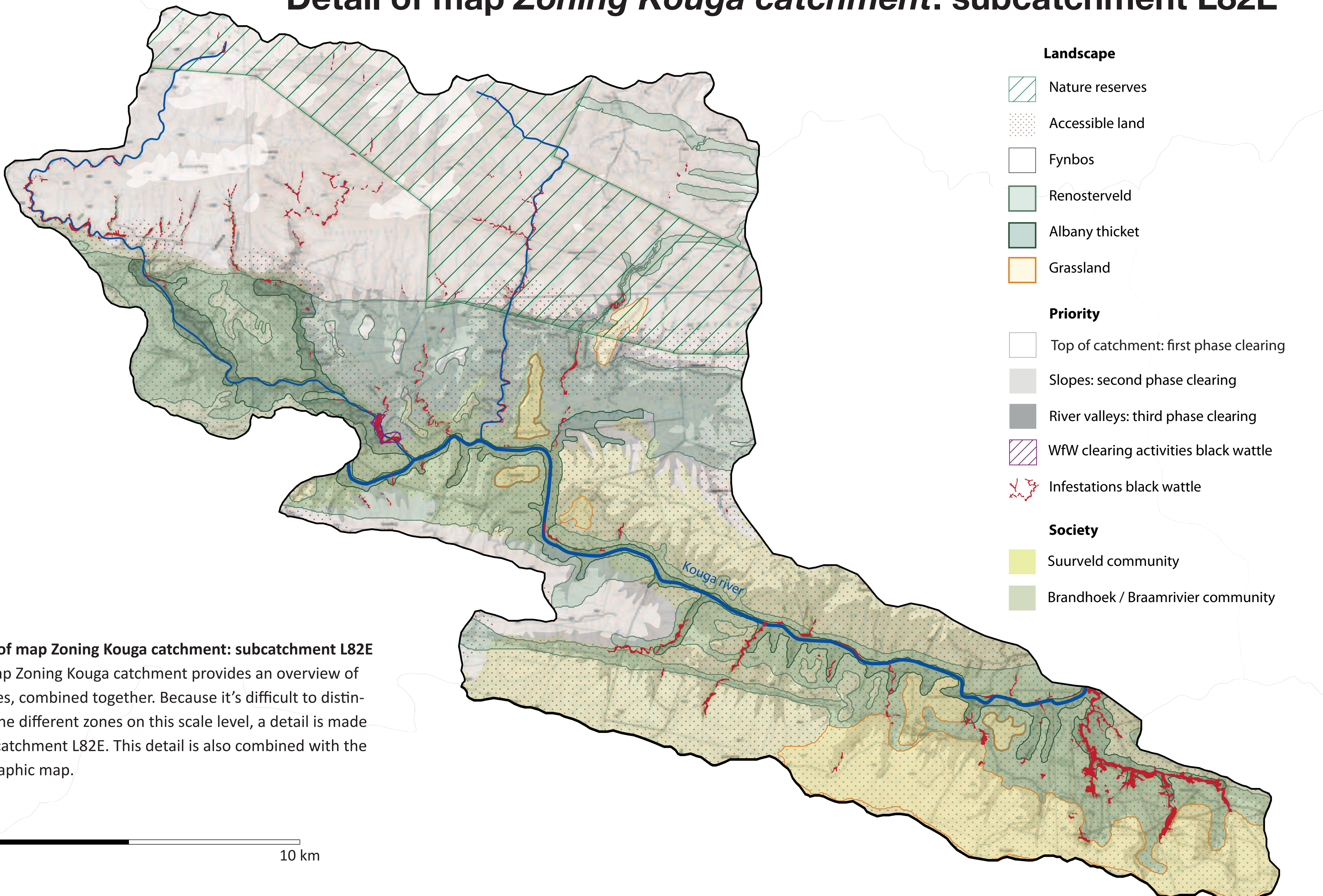
Zoning Kouga catchment
All previous zoning maps are here combined into one map: *Zoning Kouga catchment*. The map provides guidelines on three different aspects:

1. Priority: phasing of the clearing
The Kouga catchment is a very large area and can best be subdivided in different subcatchments. The generic prioritisation model of Le Maitre et al. (2012) can help with prioritizing the subcatchments.
Most logical would be to start clearing in the western part of the catchment because this part is higher and these subcatchments also have a higher clearing priority. Within the subcatchments the tops of the Kougaberge, Langkloofberge and Tsitsikammaberge should be cleared first, after which the slopes and lower areas can be cleared.
If possible, the clearing efforts of WfW should be incorporated in the clearing strategy. When a more detailed clearing plan is prepared, then the exact clearing history of each plot should be taken into account.

2. Landscape: type of measures
The landscape characteristics provide guidelines for the type of measures to apply. A large part of the top of the catchment, north of the Kouga river, falls within nature reserves. This means that restrictions will apply for the type of control used in these areas. Biocontrol will be the most important measure here, because this is harmless for the environment and relatively easy to apply in inaccessible areas. If an area is difficult to access, then more or less the same restrictions will apply as for nature reserves. The type of vegetation can also be of influence for the type of measures to be applied.

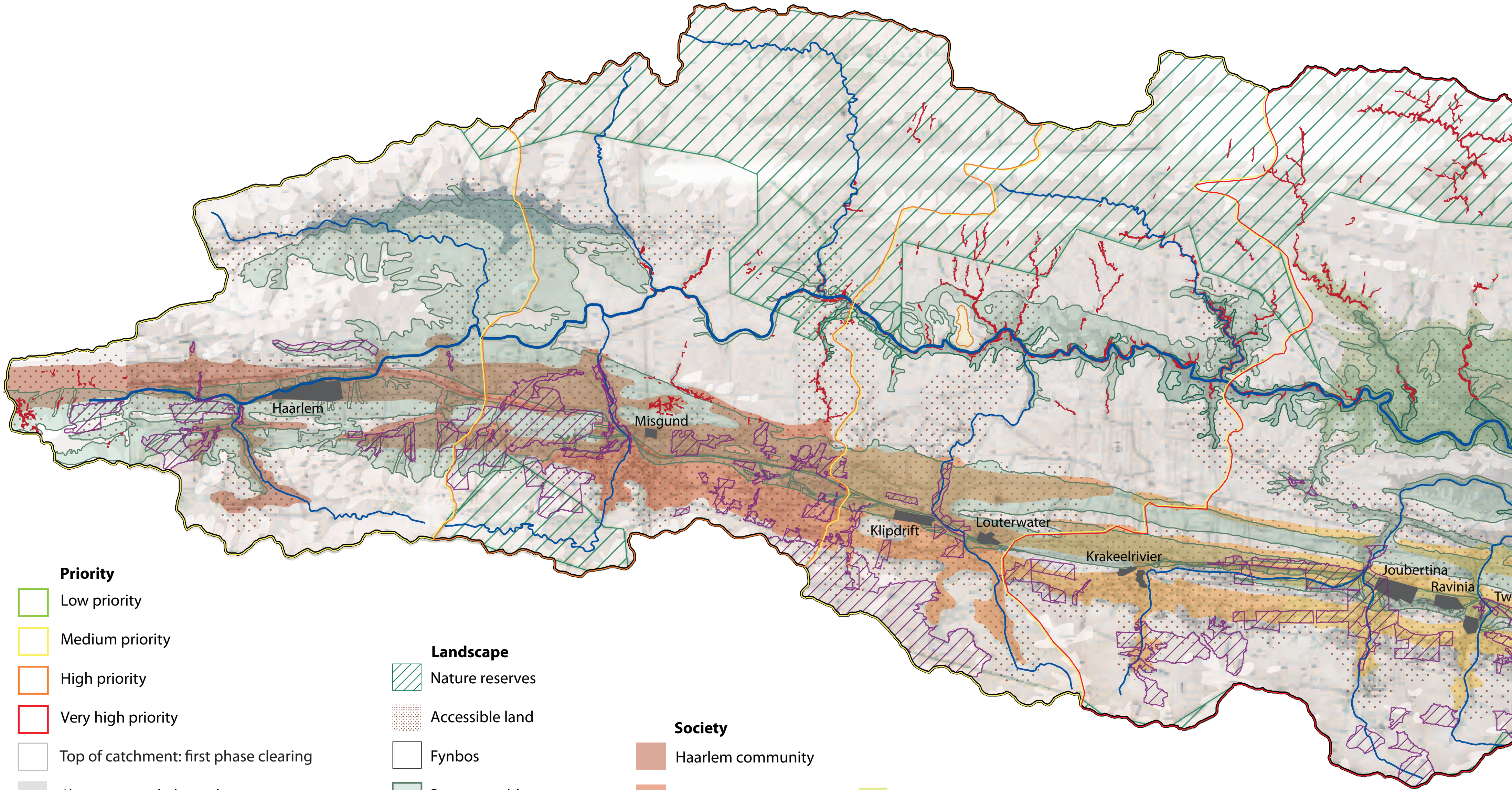
3. Society: who to mobilize where
The communities indicated on the map, show the local groups of people that can be mobilized in the different parts of the Kouga catchment for implementing the clearing strategy. The land properties (map *Farms*) are not included in the zoning map. This information is more relevant in the next step when a more detailed plan for clearing is developed for implementation.

Detail of map *Zoning Kouga catchment*: subcatchment L82E



Detail of map Zoning Kouga catchment: subcatchment L82E
The map Zoning Kouga catchment provides an overview of all zones, combined together. Because it's difficult to distinguish the different zones on this scale level, a detail is made of subcatchment L82E. This detail is also combined with the topographic map.

Zoning Kouga catchment



Priority

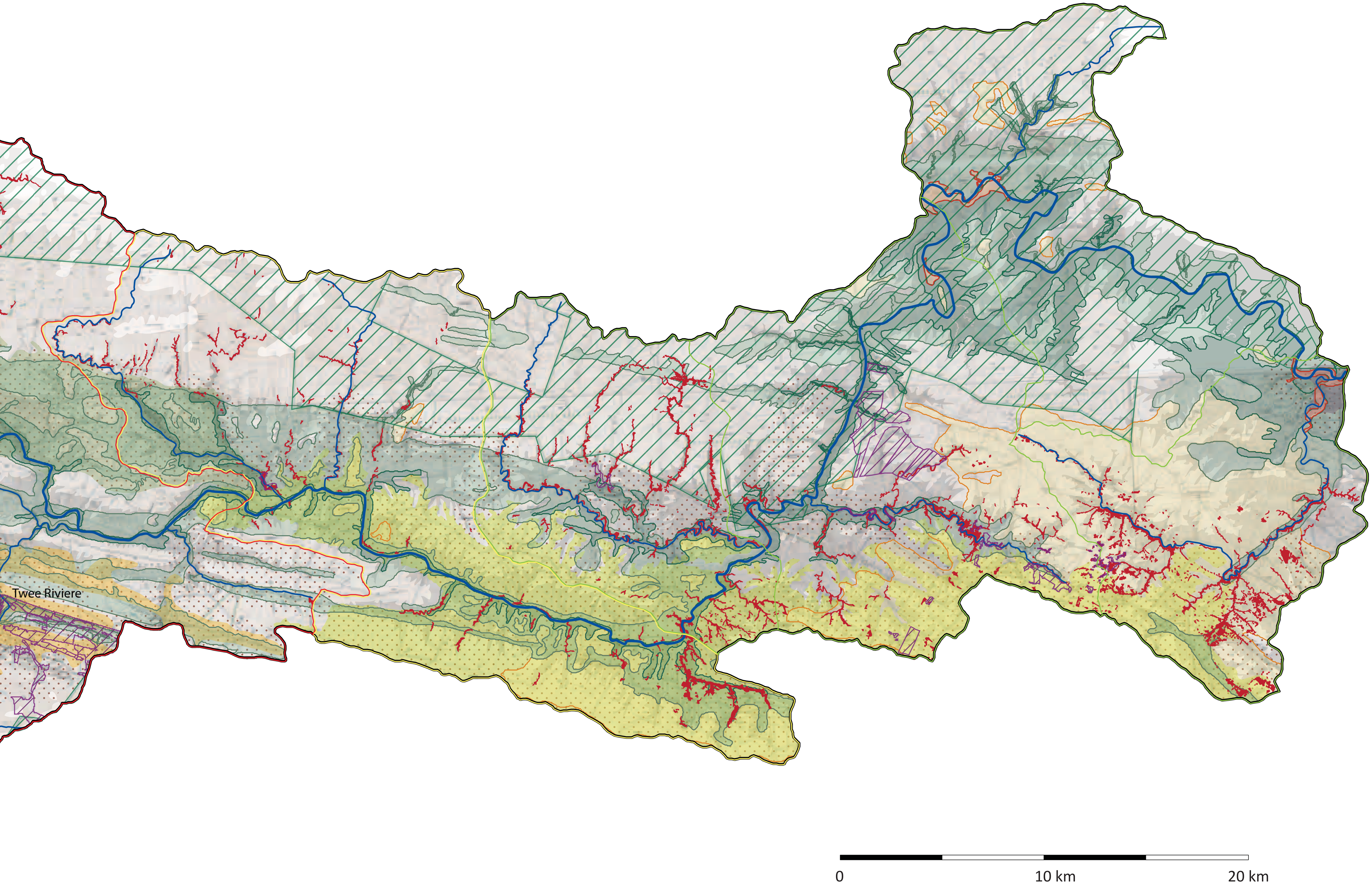
- Low priority
- Medium priority
- High priority
- Very high priority
- Top of catchment: first phase clearing
- Slopes: second phase clearing
- River valleys: third phase clearing
- WfW clearing activities black wattle
- Infestations black wattle

Landscape

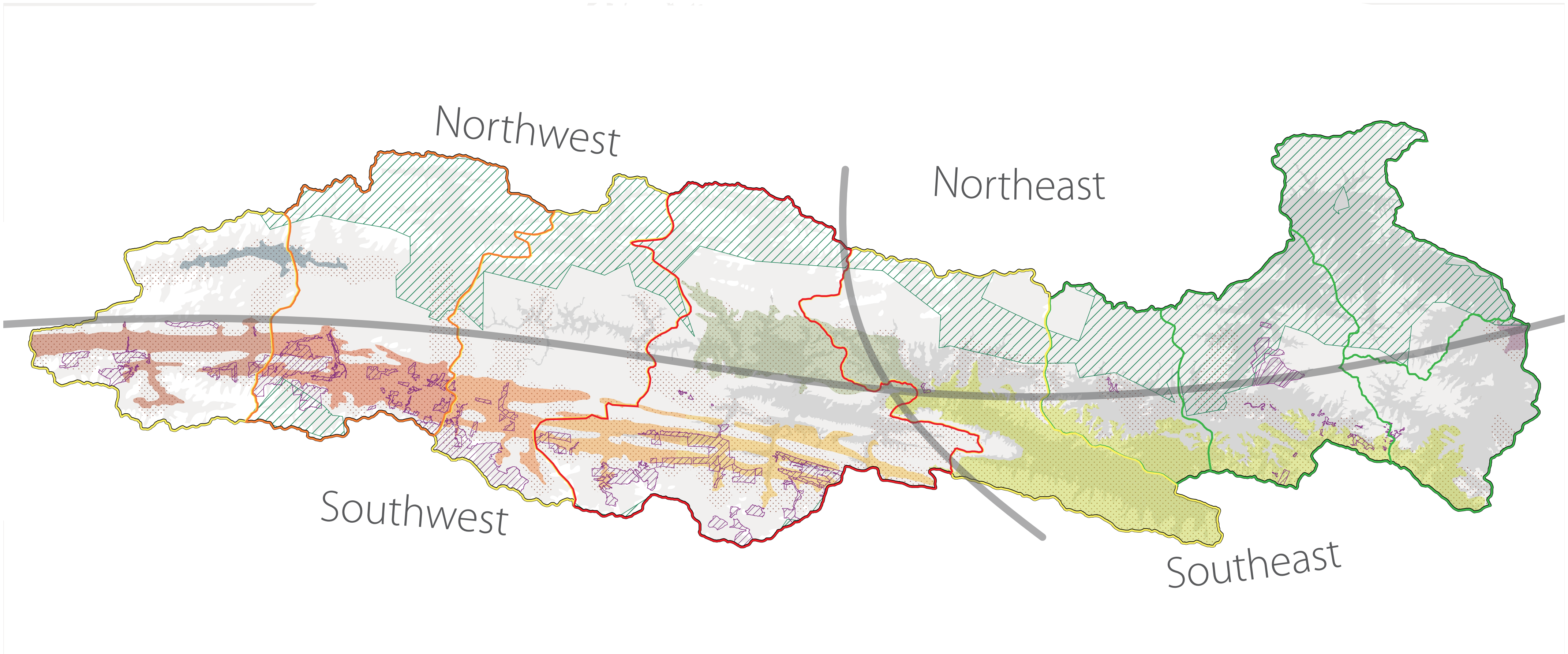
- Nature reserves
- Accessible land
- Fynbos
- Renosterveld
- Albany thicket
- Grassland
- Savanna

Society

- Haarlem community
- Misgund community
- Louterwater community
- Krakeelrivier community
- Joubertina community
- Suurveld community
- Brandhoek / Braamrivier community
- Elands valley community
- Gamtoos valley community


Twee Riviere
0
10 km
20 km

Kouga catchment: 4 parts



Priority
- Low priority
- Medium priority
- High priority
- Very high priority

- Top of catchment: first phase clearing
- Slopes: second phase clearing
- River valleys: third phase clearing
- WfW clearing activities black wattle

Landscape
- Nature reserves
- Accessible land

Society
- Haarlem community
- Misgund community
- Louterwater community
- Krakeelrivier community
- Joubertina community
- Suurveld community
- Brandhoek / Braamrivier community
- Elands valley community
- Gamtoos valley community

5 Conclusions

5.1 Conclusions

This report explores which criteria are important for zoning of the Kouga catchment. The result is a zoning map that provides guidelines for a clearing strategy on three different aspects:

1. Priority: phasing of the clearing;
2. Landscape: type of measures;
3. Society: who to mobilize where.

Combining the zones

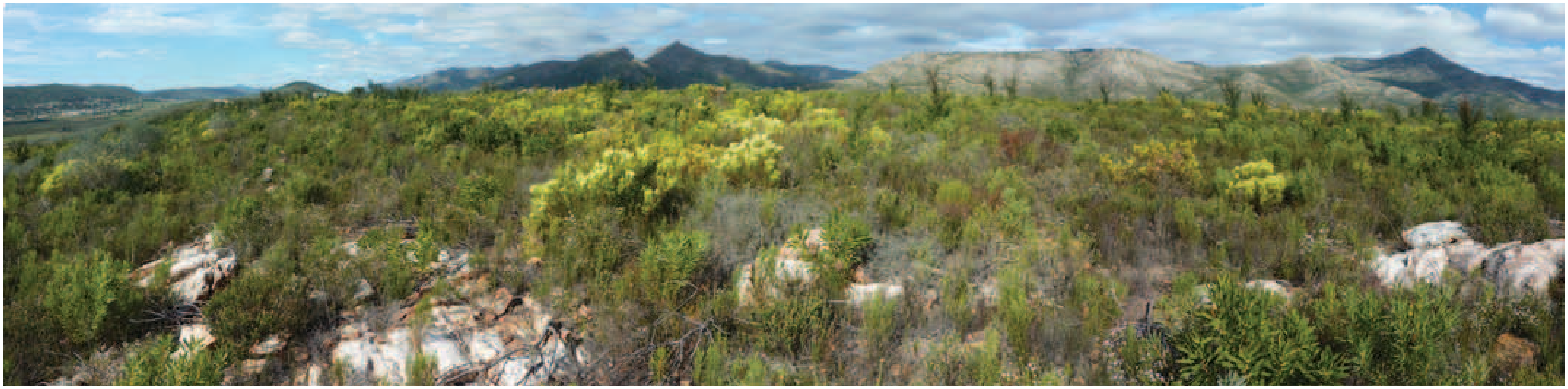
Combining the criteria/zones for the Kouga catchment layer by layer, leads to the following observations:

- The catchment can be divided in a northern and a southern part. The northern part of the catchment is the most inaccessible: most of the highest tops (first phase clearing) of the catchment are located here and the whole northern part is covered by nature reserves. There are hardly any roads/accessible areas in the northern part.
- The catchment can be divided in an eastern and a western part. The western part of the catchment is higer, has the highest clearing priority and is cut through by the Langkloof (community). The eastern part is lower, has a lower clearing priority and is covered by the Suurveld (community).
- The vegetation types that covers most of the accessible areas are Fynbos and Renosterveld. Fynbos is the vegetation type that covers most of the inaccessible areas.
- The WfW clearing activities were focused in the southwestern part of the catchment, mainly in and around the Langkloof.

From the foregoing it follows that the Kouga catchment can be divided in four different parts: southwest, northwest, southeast and northeast. The southwest has a high clearing priority, is easily accessible and the Langkloof community can be mobilized for implementing the clearing strategy. Most of the clearing activities of WfW took place in this area.
The northwest is partly accessible: Elands valley and Brandhoek/Braamrivier are located in the southern part of the northwest. The northern part of the northwest consists of nature reserves and high mountain tops and is mostly inaccessible. The northwest has a high clearing priority.
The southeast has a lower clearing priority, is relatively easily accessible and the Suurveld community can be mobilized for implementing the clearing strategy.
The northeast has a lower clearing priority, is almost completely covered by nature reserves and is mostly inaccessible.

Next step towards a clearing strategy

A clearing strategy consists of a zoning map + combination of clearing methods tailored to each zone. This report provides a zoning map and reviews the possibilities for biocontrol. A detail of each subcatchment on a lower scale level, will provide a more usable zoning map. In this report a detail is already given for subcatchment L82E. Now that the zones are identified, the type of measures and combination of measures that will match each zone can be examined.



Left: view on the Langkloof near Joubertina; Right: Fynbos vegetation infested with Hakeas

View on the Langkloof near Joubertina with Fynbos vegetation on the foreground

5.2 Recommendations

Mapping infestations

- Further refinement of mapping is needed. Now the black wattle is mapped in only one category: canopy cover of ≥50%. Different densities of infestations should be included as well, because it's important to get an overview of all the infestations, also the lower densities.
- Other types of IAPs like silky hakea and pines could also be included in the mapping.
- The mapping that is done for this project should be checked by 'ground-truthing': check on the ground if the mapped infested areas are correct. Also low densities of black wattle, which are not visible on aerial photo's, can be best mapped on the ground.

Clearing strategy

- There is no information available yet about the planned clearing activities of WfW for the near future. The clearing strategy should incorporate these planned clearing activities of WfW as well.
- According to Fourie (2012) restoration of vegetation of alien invaded ecosystems should be an integral part of any clearing strategy. Research on how to restore the indigenous vegetation should be done simultaneously with further development of the clearing strategy.
- It takes a long time before control methods for IAPs have proved themselves. After years of experimenting there are now several biocontrol agents that seem to be successful. There are more control methods which have not proven themselves yet, but may be promising as well. The clearing strategy could also function as a tool for testing and further developing promising control methods. In this way the clearing strategy could also contribute to the research on controlling methods of IAPs. A few examples of promising control methods and experiences of local people that could be further researched:
  - ◊ A couple of mature black wattles could be left in the river valleys, while all the seedlings are cleared. The big trees will prevent new black wattles from growing, because the mature trees provide a lot of shade and take all the water. The mature trees can hold the riverbanks and provide shade along the rivers to decrease evaporation. But there should be a solution for how to prevent the mature trees to spread their seeds (Peter Norris, pers. comm. 2015).
  - ◊ In the Baviaanskloof there is already an experiment with goats: all black wattle is cut and the new sprouts are eaten by goats (Maura Talbot, pers. comm. 2015).
  - ◊ Kweekgras prevents other plants, like black wattle, from growing. Kweekgras is drought tolerable. During winter kweekgras dies, then you can burn the kweekgras and the seedbank of the black wattle. The first few years you use kweekgras to remove the seedbank of black wattle. When the seedbank is removed, the indigenous vegetation can be restored. Kweekgras can also be used to hold the riverbanks (William Johnston, pers. comm. 2015).
- There are a couple of criteria that could be further detailed:
  - ◊ Map *Roads + 1km zone*: there are many more tracks and hiking trails that lead further into the mountains. These tracks are often accessible by car. So this would expand the area that is accessible considerably. Within the scope of this project only the asphalt roads are taken into account.
  - ◊ Map *Farms*: detailed information about land properties becomes important in a further stage of the clearing strategy. Within the scope of this project only the amount and spread of different properties is indicated.
  - ◊ Map *Clearing activities WfW*: specific information about initial clearing and follow-ups for each plot becomes relevant when the clearing strategy is further detailed. Within the scope of this project only general information about location of the clearing activities of WfW and a limited overview of clearing activities of the past 4 years is indicated.

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