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Zoogeomorphological Impacts by Elephants in Private Game Reserves: Case Study of Knysna Elephant Park, South Africa

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ABSTRACT

Elephant activities have certain impacts on landscape and landscape processes. The introduction provides information about former studies conducted and their contribution to this area of study as well as to the field of zoogeomorphology. This study contributes a qualitative and quantitative assessment of the impact of these activities, and introduces a new, easy-to-repeat, method to assess impacts on game reserves. The results show that if land-use change persists as it works today, the severity of elephant impacts will be exacerbated, especially when they are subject to a limited space. The links between human geography and physical geography is bridged by zoogeomorphological approaches to landscape and landscape process change. All results are discussed and concluded by evaluating the new results in combination with other research on similar subjects. Thus, the results of this study clearly show that limited areas have more severe impacts.

Key words: *South Africa, zoogeomorphology, geography, geology, geomorphology, ecology, elephants*

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CONTENTS

1. INTRODUCTION

During the last decades, animal impacts on landscape and landscape processes have started to be systematically studied. Such studies are called zoogeomorphology and David Butler[1] and Heather Viles[2] are pioneering authors. Elephants have previously been discussed in other disciplines, such as biology, zoology as well as geology, where geomorphic processes can be shaped by the interaction with elephants.[3] However, there is a lack of studies on the geographical impacts by elephants on landscape and landscape processes, in a captive situation.

Biogeomorphology involves cooperation between ecology and geomorphology.[4] Ecology is the study of relationships between organisms and their natural environment, while geomorphology is the study of landforms and landform processes. Biogeomorphology is therefore best described as the study of the interactions between organisms and the development of landforms. There is a lack of agreement on what kind of studies can be called bio-geomorphological, although it is somewhat defined as a crossing point between ecology and geomorphology.[5] Zoogeomorphology as described by Butler[6] is “the study of the geomorphic effects of animals”[7], while by Naylor et al[8] it is presented as “reflecting the interface between animals and geomorphology”. This is a study in zoogeomorphology, more specifically a study of the geographic impact of elephants on landscape and landscape processes. Elephants are in this case the biological organisms as described by Butler and Naylor, which can also be seen as ecosystem engineers as described below.

Elephants have been named by for example Gary Haynes and David Butler as “ecosystem engineers”,[9] because of how their activities undeniably change their environment. Elephants have mostly been researched in a biological or an ecological sense[10], in their interaction with other elephants, vegetation and humans, or the interactions with human settlements.[11] Environmental impacts concerned in this study are as follows: trampling, wallowing, grazing, uprooting, digging, swimming, browsing and geophagy.[12]

Quantifying physical environmental impacts by elephants in a private game reserve with captive elephants, from a geographical standpoint, is something that has not been done before. In the following section criteria and various indicators of zoogeomorphological impacts are explained and assessed. The section begins with an explanation of background terms, followed by behavioral activities by elephants that alter landscape and landscape processes.

1 Butler, 1995
2 Viles, 1988
3 Bigwood T, 2011&Swanson et al., 1988; Phillips, 1999a; Urban, 2002 in Stallins, 2006, p. 207
4 Naylor et al, 2002
5 Ibid, p.4
6 Butler 1995, p.6
7 Ibid, p.1
8 Naylor et al 2002, p.4
9 Haynes, 2011, Butler 1995
10 Eriksson, 2011,Thomas et al., 2008 & Harrop, 2011
11 Butler, 2006
12 Butler 1995

This is done to establish observable criteria and indicators, which will act as a foundation for the methods and results development explained further below. Furthermore, the following section is of importance in order to fully understand the extent of different zoogeomorphological impacts. The section also includes important definitions of used terms, such as zoogeomorphology, and where they derive from.

This is even though authors such as Heather Viles have stated that there is an importance of quantification, as it has become “a key goal in the search for rigorous models which can be used to explain, predict and control landform development”.[13]

From a sustainable landscape perspective the question arises whether elephants can be viewed as a destructive force causing land degradation. The land degradation is induced by trampling, which creates paths with very low or no vegetation growth[14], uprooting of trees, thus removing trees that were agents keeping soils down with roots and shelter[15], and digging, actually removing soil by geophagy i.e. eating soil to get to minerals, or moving the soil from one place to another, thus changing the landscape physically.[16]

Game reserves are used for different purposes, either as a refuge for wild animals or for various kinds of tourism. The transformation of private farms into private game reserves is changing the South African landscape.[17] Tourists are attracted by wild animals, and these game reserves can provide both for photographic tourism and reserves for hunting. Deere discusses the ecological and economic impacts by these influxes of tourists. According to Deere, there are economic advantages of both kinds of tourism, although environmentally, hunting will have less of an environmental impact, since hunters “require fewer local amenities and infrastructure, therefore reducing habitat degradation”.[18]

The negative impacts on the wild animals are somewhat ignored, but most important are the continuous effects these reserves will have when enclosing animals in small fenced in habitats, sharing space with other species. Furthermore, the reserves will have impacts on further land use and the behavior of animals, as well as expanding tourism as an income for former farmers.

1.1 Aim and Objectives

The aim of this study is to provide a first assessment of the physical impacts by elephants on private game reserves in South Africa, with the case study of the Knysna Elephant Park.

This aim will be achieved through the following objectives:

- To establish observable criteria and indicators of zoogeomorphological impacts.
- To assess the spatial extent and intensity of the impacts from a geographical standpoint.
- To evaluate the consequences of the impacts of elephants on the physical environment.

13 Heather Viles, 1988, p. 4
14 Haynes, 2012, p. 100
15 Valeix et al, 2011, p. 904
16 Haynes, 2012, p.101
17 Deere, 2011
18 Ibid, 2011

2. CRITERIA AND INDICATORS OF ZOOGEOMORPHOLOGICAL IMPACTS

2.1 Important terms explained

Geography can be classed together with geomorphology, ecology, biogeomorphology and zoogeomorphology as a part of the earth sciences.[19] According to Heather Viles earth sciences are all in constant development, because of ongoing technical and theoretical innovations.[20] Moreover, all earth sciences still have an expanding realm of interest, where features that have not been studied before can be found.[21] An example is zoogeomorphological physical impacts by elephants on landscape and landscape processes in private game reserves.

2.1.1 Geography

Physical geographers have dealt with the interactions between the different disciplines for a long time.[22] These are now considered to be interlinked systems. Rogers et al writes that when conducting a study, a geographical perspective will provide the base for a vision spanning from past to present and to the future. With these links in mind scientists will also create studies that will cover a broader span between other disciplines.[23]

2.1.2 Geomorphology

Geomorphology is the study of landforms and landform processes i.e. how the landscape is structured and with what kind of sediments.[24] Landform processes can be bioturbation; the movement of soil, or weathering; the breakdown of soil, just to name a few.[25] Geomorphology, as described by David Butler, is the study of landforms and landform processes as well as explanations of their current form and shape. According to Butler, this is done by means of a description of erosion, transportation and sediment deposition.[26] Importantly, geomorphology scholars focus on the various time aspects in landform processes, keeping a thought of past, present and future in mind when conducting research and gathering evidence.[27]

Heather Viles brings forth how geomorphology was developed from geology. According to her, geomorphology was not its own subject until the end of the nineteenth century, because geologists had started to focus on other areas of study. Thus, in comparison to geography or geology, to study geomorphology became of interest rather late.[28] Interestingly, throughout studies in geography and geology, an important focus has consistently been to explain how

19 Viles, 1988, p.5
20 Ibid, p.5
21 Ibid, p. 5
22 Rogers et al, 1992, p. 3
23 Ibid, p. 4
24 Corenblit et al, 2011, p. 310
25 Engvall, 2013, p. 5
26 Butler, 1995 p.1
27 Ibid, p. 1
28 Viles, 1988, p.3

landscapes, as well as processes on the surface of the earth, form. This has constantly baffled and interested people, scholars, as well as hobbyists, throughout all the various disciplines. [29] In the academic structure used by Viles, geomorphology has joined in, as she describes it, the perceived seclusion from other scientific areas of study.[30]

2.1.3 Ecology

Ecology is a subject that focuses on the distribution of flora on the earth's surface. Ecology can be considered to be a close ally with biogeography since they both interlink with geography, geology and later zoogeomorphology.[31]

2.1.4 Biogeomorphology

Biogeomorphology describes the interactions between animals and their non-biotic or abiotic environment.[32] Biogeomorphology takes all kinds of animals, all over the world, into consideration. Viles describes a current change in geomorphology and ecology studies. She means that the studies move towards a more biogeomorphical view, where more interactions between various subjects have been of interest.[33] Butler writes that in biogeomorphology the activities of animals are sometimes described as biotic, which means direct, or abiotic, which means indirect.[34] This was already discussed by D.S.G Thomas in 1988.[35] Biotic also means that the activities alter the structure of the community in which the animals live, i.e. when mammals wallow or graze. Also, the ground cover can be reduced or totally removed, which exacerbates the erosion rate of soil.[36] Abiotic refers to all the activities where the presence of animals creates structure and intensifies landscape processes.[37] In this study, these processes are considered to be when elephants wallow, trample or drink from waterholes.[38]

The term biogeography is sometimes included in biogeomorphology, and refers to the geographic importance of biology. There is an obvious difference between the geography departments in Sweden versus South Africa; biogeography is a common topic of interest in South Africa, as is most physical geography, although in Sweden the social geographies are more sought after. The background to biogeography shares the same origin as ecology and geomorphology, therefore their methodologies intercept in many aspects. This is explained by how they originated from natural history.[39]

Heather Viles did not intend for biogeomorphology to stay as an independent area of study. She intended it to be an explanation for changes on landscape and landscape processes

29 Viles 1988, p.3
30 Ibid, p. 3
31 Ibid, p.4
32 Engvall, 2013, p.5
33 Viles, 1988, p.2
34 Butler, 1995, p. 82
35 D.S.G Thomas in Viles, 1988, p. 204-205
36 Butler, 1995, p.82
37 Ibid, p.82
38 Butler C.F Sawyer, 2006 p. 2
39 Viles, 1988, p, 5

induced by organisms and plants[40]. She identified two focus points: “first, the influence of landforms/geomorphology on the distributions and development of plants, animals and microorganisms”[41]. Second, “the influence of plants, animals and microorganisms on earth surface processes and the development of landforms.”[42]

2.1.5 Zoogeomorphology

As defined by Butler, the discipline zoogeomorphology explains, quantifies and assesses the interaction and geomorphological effects of animals on landscape[43], i.e. how activities and impacts of animals can be seen in the landscape over time. This also provides the foundation for further studies of the impacts in the future. An important detail is that human-induced changes should not be confused with the activities and impacts by animals. Conducted studies should instead be focused on animal induced changes in environments with as little influence by humans as possible, although this is knowingly difficult.[44]

Zoogeomorphology is a term not excessively used in geographical or geological establishments, which once again is evidence for the narrowness of the field in its current form. This is the case even though impacts of animal activities are significant and sometimes easy to identify. The primary difficulty is that these activities and impacts have not been thoroughly studied and thus not classified and assessed. This means that no real conclusion can be drawn yet about the importance of studying animals from a geographical viewpoint.

2.2 Elephant zoogeomorphological impacts

Elephants are known to impact landscape and landscape processes in multiple ways. Although some impacts are undeniable and vast like the one in the picture by Jan Boelhouwers[45], not all impacts are as direct. A zoogeomorphological impact as severe as in the picture below was impossible at Knysna Elephant Park, because of the time the elephants had already been in the park, as well as the lack of trees on the premises.

40 Viles 1988, p.6
41 Viles, 1988, p.6
42 Ibid, p.6
43 Butler, 1995, p,6
44 Ibid, p. 6
45 J. Boelhouwers, October 2009

Figure 1. A photo illustrating elephant impact on physical landscape, Kruger Park, South Africa. While tree destruction in wooded savanna is well known, the associated soil exposure can lead to enhanced soil erosion and land degradation (photo: J. Boelhouwers, October 2009)

In Figure 1, one can see destructive elephant activities and its impact on landscape and landscape processes. The soil and root interface is called rhizosphere, and the picture above illustrates how this particular sphere is heavily altered by elephant behavior.[46]

Stallins brings forth four so-called themes in his study from 2006[47], and these are discussed in the work by Bert Eriksson (2011).[48] The themes are: multiple causality and recursivity,[49] organisms as ecosystem engineers,[50] expression of an ecological topology[51] and ecological memory.[52] For this study the focus lies with the organisms as ecosystem engineers. Ecosystem engineering is the key feature in understanding what this study is all about.

2.2.1 Trampling

Trampling is the act of walking, running, crawling and stampeding, and thus creating paths by animals on the ground. By studying trampling, moving patterns can be traced and quantified.[53] Trampling occurs in all groups of animals and it has no correlation to the size of the animal itself. Furthermore, it is also an act of trampling when an animal walks by itself, because it is the act of travelling from one location to another that trampling refers to. Depth and vegetation cover on/by the tracks shows how often the tracks are used.

Elephants are known to migrate between different areas during the year.[54] Haynes[55] explains that they migrate because of seasonal changes. Hence, when the grass dries out during summer, elephants must travel to areas with more woody vegetation to obtain twigs

46 P. B Mitchell in Heather Viles, 1988, p. 44
47 Stallins, 2006, p. 208
48 Eriksson, 2011, p. 17
49 Stallins, 2006, p.208
50 Ibid, p.210
51 Ibid, p.211
52 Ibid, p.212
53 Engvall, 2013, p. 6
54 Haynes 2011, p.101
55 Ibid, p. 101

and leaves. Impacts of trampling on landscape can be both direct and indirect, especially when it causes erosion. Trampling around the edges of water sources can directly alter landscape by damaging the edges. This could make the soil looser or making the water source, like a waterhole or a stream, larger. Indirect impacts occur when ground cover is completely rubbed off or eaten. According to Butler the impacts of trampling are visible to a greater extent because it alters bigger "patches" of landscape.[56]

2.2.2 Wallowing

Wallowing is any kind of activity when animals stay in one place, gathering in herds or by themselves. A common example of wallowing is when elephants lie down in mud holes and rub themselves in the mud. Some mammals, like elephants, use rock surfaces or wooden stubs to scratch themselves, sometimes polishing the surface completely.[57] These activities occur frequently. Examples of direct impacts from wallowing are polished surfaces of rock walls.[58] Indirect impacts occur when animals lie down in the mud and later get up, removing mud from the wallow.

2.2.3 Grazing

Grazing is when animals eat vegetation, on ground level or up in trees. When animals pick their areas for grazing, many different variables are considered. It is found by Valeix et al. that smaller herbivores choose to graze in areas which are showing impacts of elephant grazing, if the grazing by elephants has not been so intense that new shoots have been unable to grow.[59] Valeix et al. suggests that with a decrease in trees, other herbivores can feel more secure while grazing and the impacts by elephants on landscape help to increase visibility.[60] When a woody area has been under pressure from grazing by elephants it might change the whole structure[61]. Elephants can strip all branches and twigs from trees, sometimes even knocking trees over to get to the upper branches.[62]

2.2.4 Uprooting

Direct impacts of uprooting are visually impossible to miss, since larger mammals such as elephants can destroy large patches of land when uprooting trees. Indirect impacts are when the uprooting of trees in turn helps other animals.

Here, we can show that elephants can be considered ecosystem engineers because they modify food availability as well as visibility, hence lower the predation risk in the habitats of other herbivores.[63] Gary Haynes[64] uses the term "ecosystem engineers" to define elephant behavior. For example, he discusses elephants stripping bark from trees and digging in the soil

56 Butler 1995, p.83
57 Haynes 2011, p. 101
58 Haynes 2011, p. 101
59 Valeix et al, 2011, p. 910
60 Ibid, p. 910
61 Haynes 2011, p.101
62 Ibid, p. 101
63 Valeix et al 2011, p. 908
64 Haynes 2011, p.100

with their trunks. These behaviors alter the landscape and it also influences their surroundings and the animals living in the same habitat. Therefore, they are ecosystem engineers.[65] According to Jachmann and Croes[66], woodlands can be completely destroyed by browsing elephants.

2.2.5 Digging

Mammals dig for soil, roots and plants, but also to create resting spots, shade and to protect from heavy rainfall.[67] Larger mammals sometimes paw at the ground, i.e. scrape the ground to get to roots and forbs. Other smaller animals sometimes dig tunnels to get to the same food source.[68]

Digging can have both indirect and direct landscape impacts, and this is because some diggings are already existent, although the use of them changes between different species. Digging at new locations is a direct impact since new holes and burrows are created. African elephants are known to dig for various reasons: in search of water, for dust and mud to cover their bodies in in order to get relief from parasites[69]and to obtain minerals in the soil.[70]In Knysna Elephant Park, searching for African potatoes is another reoccurring reason for digging .

2.2.6 Swimming

Elephants at Knysna Elephant Park have the opportunity to swim in a dammed up river. The river is still bringing a constant supply of water, which keeps the dam full. Elephants swim in order to cool off and get relief from insects.[71] It is also a way for elephants to bond with one another, since the elephants tend to move around and play more in the water.

2.2.7 Browsing

Browsing is the occurrence of elephants eating twigs and branches from trees or branches brought out by the staff of the park. This is a specific genre because of the difference between browsing and grazing. Browsing includes eating branches of trees but also eating branches brought out by staff. Even though the elephants can graze throughout the day on grass and ground plants, branches are brought out to the field since the elephants have little or no chance of browsing on branches from trees in the vicinity of the park.[72] When browsing, the elephants choose between different branches, they also eat them differently. Elephants sometimes only eat the leaves of some trees, and only the bark of others.[73]

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65 Haynes 2011, p.101
66 Jachmann and Croes 1990, p. 22
67 Haynes 2011 p. 99
68 Hamandawana 2011, p. 2
69 Bigwood, 2011, p. 13
70 Engvall, 2013, p. 8
71”own observations”
72 ”own observations
73 “own observations”

2.2.8 Drinking

Elephants seldom drink since they can store water in their bodies for long periods of time. At Knysna Elephant Park, the elephants usually drink once a day in the morning, during the morning walkouts. Later, they will drink if the weather is dry or hot.

2.2.9 Dusting

Dusting is a vital part of the elephant's daily life. It protects from insects and usually occurs after the elephant has been wallowing or swimming. This is to encapsulate the water or mud, which functions as a kind of sunscreen.

2.2.10 Geophagy

Geophagy is when animals eat soil or rocks to ingest minerals.[74] Some animals gather at specific locations to lick stone surfaces. These spots are called saltlicks and can be seen as a natural version of the saltlicks that are given to cows. Butler defines geophagy as "earth consumption"[75] which is a perfect way to sum up what geophagy actually entails. Animals may even travel vast distances to get to specific spots where they can find a certain mineral and then keep coming back to the same location.[76]

A direct impact of geophagy is when soil or rocks are actively removed or eaten thus altering the spot where it is taken from. This creates visible hollows in the landscape and on landscape features.[77]

2.2.11 Mourning

Elephants are known to mourn their dead. These behaviors and activities are mentioned by Haynes when he describes that elephants sometimes re-arrange the bones of dead elephants when coming across death sites.[78] Elephants mourn in various ways. These behaviors are described as resembling funerals after the death of an elephant[79].

Elephants are known to touch and caress the dead body. Sometimes, they also cover the body with dust, twigs, branches or leaves. This happens not only when elephants encounter other elephants, but also when, for example, they have killed a human or another animal.[80] The activities considered as mourning always occur in the same way, not depending on individuals, indicating that it is a specific elephant behavior, not the behavior of a certain herd or cluster of individuals confined to any area.[81] I

In March of 2013 one of the elephants in the park unfortunately gave birth to a stillborn calf. The mother stood outside in the rain for hours, throughout the night, until she joined the herd in the morning. Refusing to leave the body of her calf, there was no way the personnel working at the park could do anything but let her stay with the body until she decided to

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74 Engvall, 2013, p. 7
75 Butler 1995, p. 43
76 Ibid, p. 84
77 Engvall, 2013, p. 7
78 Haynes 2011, p. 102
79 Meredith, 2001, p. 183
80 Meredith, 2001, p. 183
81 Ibid, p.183-185

leave. Since mourning is an activity that have an effect on landscape, it is important to mention for coming studies and research on elephants. Throughout this study no signs of mourning activity could be recorded. Facts about the mourning scenario that occurred were provided orally by staff at KEP and AERU.

2.2.12 Bioturbation

Bioturbation can be defined as the mixing and movement of sediment by organisms.[82]This is caused by, for example, uprooting, digging and geophagy, but also at some extent by all animal activity. Throughout history the study of bioturbation has been overlooked as an important geomorphological factor. As Gabet et al explains, there has been a lack of appreciation for the importance of bioturbation in geomorphological studies.[83] Moreover, the evidence for the importance of bioturbation is seen in the consequences of bioturbation when considering landscape processes in various ecosystems. Animals in this case mix the soil with their normal activities, thus impacting on the landscape and landscape processes.[84]

When elephants for example uproot trees, it may break up the bedrock itself[85] and cause an increase in soil creep and change the density of the soil. When mammals manure it may also cover the ground, thus changing the infiltration rates of water in to the ground.[86] The term bioturbation is of importance in order to further understand animal impacts on landscape, throughout this study as well as in future studies.

2.3 Study Area: Knysna Elephant Park

Figure 2. Location of KEP in South Africa, www.google.se/#q=south+africa+maps [2014-04-08]

According to WWF, forests are southern Africa's smallest biome[87]. A biome is an area with similar construction, such as a desert or a forest. Biomes have the same kind of flora and

82 Bates & Jackson & Gabet et al 2003, p. 250
83 Gabet et al 2003, p. 250
84 Ibid, p.269
85 Ibid, p. 249
86 Bowerman & Redente 1998 in Gabet et al 2003, p. 269
87 http://worldwildlife.org/ecoregions/at0115 (2013-03-07 11:06)

fauna, also known as an ecosystem.[88] According to Midgley et al (1997)[89] , the Knysna forest covers approximately 568 km2 and is situated between 22°E and 25° E and 34°S, at the southern Cape coastline of South Africa.[90] Geldenhuys (1989) defines the predominant geology to be made up of quartzite, shale, schist, conglomerate and dune sand.[91] In the 1860's there were only 500 elephants left in the Knysna forest, in 1920 they were 12, and in 1990 only four.

In the introduction of the park, as can be read on the Knysna Elephant Park website[92], there are signs of geographical changes due to elephant impacts. One of these changes occurred when a great grandfather of the founder had built roads along elephant trampling trails.[93]

The staff who specifically work with the elephants are called handlers. They work on a rolling schedule, seven days on and 2 days off. Some of them live in the township and they get picked up there in the morning and are taken back when they finish their shifts.

The day starts at 06:30 when the elephants are let out of the boma. They are kept in there for safety reasons, both protecting the elephants as well as the people living around the park. At 6:30, the elephants are either ridden by visitors or they get to go out to their first grazing spot.

From 9:00 to 17:30 visitors are taken out to the elephants. What follows is the same every time new visitors arrive: as soon as the elephants can hear the tractor that brings the tourists out in the park, they gather at the feeding grounds behind a steel barrier. They have constant placements, so the elephants always stand at the same spots. The placements are not regulated by the handlers, but solely by the elephants. They are fed fruit by the tourists, who then get to touch them, as well as take photos with them. The tourists can arrive and leave every half hour. The amount of tourists varies between none and around 60.

At 18:30 the elephants are brought back to the boma for the night. When they come in they get fresh branches and twigs as well as a container of mixed fruit and pellets. At 20:30 it is time for browse, which is when they get fresh new twigs and perhaps a snack, consisting of fruit and pellets.

2.3.1. The elephants at the park

The Latin name for the African elephant is *Loxodonta Africana*. It has two subspecies: *Loxodonta africana africana*, also known as the savanna or bush-elephant, and *Loxodonta africana cyclotis*, the forest elephant.[94]

All elephants at Knysna Elephant Park are savanna elephants. The elephants are not bought; they are often taken in to care after some kind of trauma. Some elephants are former

88 ”own observations”
89 http://worldwildlife.org/ecoregions/at0115 (2013-03-07 11:08)
90 http://worldwildlife.org/ecoregions/at0115 (2013-03-07 11:09)
91 http://worldwildlife.org/ecoregions/at0115 (2013-03-07 11:11)
92 http://www.knysnaelephantpark.co.za/ (2013-04-07)
93 http://www.knysnaelephantpark.co.za/ (2013-04-07)
94 Meredith 2001, p.136

circus elephants or have survived culling. Culling is the act of removing elephants from herds in overpopulated areas.[95] This involves actually killing elephants in some cases.

Sally: Female. Born 1989, arrived at the park in 1994.
Nandi: Female. Born 1993, arrived at the park in 2002.
Thandi: Female. Born 2003, she was the first to be born in the park. (Daughter of Nandi).
Keisha: Female. Born in 2003, arrived at the park 2004.
Thato: Female. Born in 2007, arrived at the park in 2008.
Shungu: Male. Born in 2007. (The son of Harry and Thembelie)
Mushudu: Male. Born in 2007, arrived at the park in 2008.
Shaka: Male. Born in 2001, arrived at the park in 2004.
Clyde: Male. Arrived from a circus in 2009, estimated at the same age as Shaka.
Fiela: Female. Born 5th of March 2013, the daughter of Thandi. Thandi rejected Fiela when she was born, so she has been hand raised by AERU staff, students and volunteers. An introduction to the herd started on the 8th of April.

2.4 Land use

Converting farmland for other use is a current discussion topic in South Africa. This, in combination with current discussions about dropping fences, takes up a large portion of the South African land use debate, which was evident when conducting research at an animal park.[96] Knysna Elephant Park has been used for livestock, but since 1994 it has been used for elephants. A recent contribution to the land use debate was presented after a conference with 26 international land-use experts from various disciplines.[97] In land use debates the term rangeland is often used, which refers to patches of land defined by a cover of grass or trees, which is used for grazing or browsing. [98] As of now, most rangelands are driven by two forces; human and biophysical, which means human alterations of landscape processes as well as animal impact on the same land. [99]

During this conference the difficulty to distinguish directional change was debated. Directional change is, for example, loss of biodiversity or soil degradation,[100] although, elephants are often blamed to be the cause for both. This is, because it is seen as difficult to actually determine what a natural fluctuation is and what immediate impact by humans or animals is. Therefore, interpretations must be cautiously formed.[101]

Important for this study in particular was the conclusion the researchers made that grazing does not have to be inherently destructive, but instead it can be a necessity in order to maintain an area.[102] Elephants and their activities aid biodiversity by spreading manure, grazing, browsing and uprooting, as well as creating puddles where water can accumulate.

95 van Aarde et al, 2006, p. 385
96 ”own observations”
97 Lambin et al, 2001, p. 262
98 Ibid, p.263
99 Solbrig, 1993; Sneath 1998 in Lambin et al 2001, p264
100 Lambin et al 2001, 264
101 Sandfam 1983 & Puigfabregas 1998 in Lambin et al 2001, p. 264
102 Oba et al 2000, in Lambin et al 2001, p.264

When land becomes a scarcity, it might lead to an increase in land use for higher value products, which in turn leads markets to trigger commodification.[103] This is evident in South African land use today. As mentioned before, landowners are beginning to expand their use of wild game to attract more sustainable incomes from tourism etc. This increased regional land use change is often related to an incorporation of the said region into an international economy.[104] When animals are introduced, or reintroduced, to an area, it is a so-called biophysical event, and this can exacerbate inevitable changes.[105] All ecosystem engineering species have requirements on what area to occupy. [106] In natural environments these requirements limit choices made by the animals. In conclusion, introducing animals to a private game reserve will amplify changes, and these need to be studied further.

2.5 Limitations

Considering the vastness of a subject like this, there are areas that will not be considered. When observing a specific study area, the area itself comes with opportunities as well as limitations. The limitations, in this specific case, include that the areas are fenced in, therefore the areas that elephants reach do not change. Whatever ecosystem engineering that occurs will have an effect on landscape and landscape processes. Later on, the same kind of ecosystem engineering will have an effect on the already altered landscape. Wallows will increase, uprooted trees will not grow back and trampled trails will consistently be more visible.[107] Moreover, because of the structure of the park in combination with the park practices, some things were difficult to accomplish, such as measurements of elephant trails. Instead, that part was done using GIS. Measuring features in the park proved unnecessarily difficult to arrange. The aim of the study and the objectives have been successfully studied and assessed through field work, 102.3 hours of observations, note taking, photographs, satellite imagery, GPS tracking and ArcGIS. The ethical part of this study was considered, and it is important for the reader to know that it is acknowledged that this study includes animals. Although they are not considered as specific animals, they are considered as features that impact landscape and landscape processes. This is not a behavioral study; behavior includes other aspects that are not connected to this study in particular. This study focuses on activities regardless of the behavioral features.

3. METHOD

Based on a previous study called “A first classification of zoogeomorphological impacts by elephants in private game reserves”[108], known zoogeomorphological activities and impacts of large mammals have been described and classified. In said study, a classification was developed and tested by means of web camera observations and Google Earth imagery. The

103 Lambin et al, 2001, p.265
104 Ibid, p.266
105 Ibid, 266
106 Jones 2012, p.76
107 ”own observations”
108 Engvall, 2013

method used in the previous study as well as the method for the study behind the current results are both created, assessed and proven by myself.

In this current study, more detailed descriptions were made to qualitatively and quantitatively describe the observed impacts. This included emphasizing trampling routes through the park, showing the variations of tracks, using photos and ArcGIS maps, showing vegetation cover and composition through ArcGIS mapping and changes in bare or trampled ground and their spatial distribution.

Zoogeomorphological impacts of elephants were related to observable behaviors and activities, where these occur, and when/how often, and their duration. These steps in the project were done by observations of the elephants in their normal routines, and observations of different activities that relate to impacts. During this study information was gathered that is only attainable while present in the natural environment of the elephants, such as time frames for different behaviors that impact on the physical environment, as well as mapping where this occurs. The elephants were located by following them at a safe distance to determine where they are on the map provided by AERU that was used.

It was possible to record all information needed by note taking, pictures and noting of the exact movement of elephants by GPS that later helped in creating the final maps over Knysna Elephant Park.

3.1 To establish observable criteria

In order to establish various observable criteria, literature was consulted. Literature was compared to evidence already existing at the location. This part of the study was finished at Rhodes University, Grahamstown, Eastern Cape in South Africa, between 1st of March 2013 and 13th of March 2013. Former literature was consulted and with already existing knowledge, observable criteria were defined and later used, when to create the method for fieldwork.

In order to establish what was to be observed in the park, such as the size and features like dams and patches of bare ground, maps needed to be collected. Maps and aerial photos were provided by the Geography Department at Rhodes University. Aerial photos in the Result section show the area of the park since the 1960’s. It was possible to see changes in land use and how the park has expanded and changed.

To determine the length of the roads at KEP, Google Earth was used. The same was done for the trampling paths at the park. With Google Earth it is possible to get closer to ground level and still retain a qualitative image as well as trampling paths that had been noted in field work, but which was invisible at the rectified photos used for GIS.

3.2 Assessment of spatial extent and intensity of the impacts from a geographical standpoint

In the following text the fieldwork method is described. This is, to show how the spatial extent and intensity of impact are studied. An explanation for the method is given and the method itself is also explained in detail for further studies. The method used in this study was created for this study in particular. A main goal was to create a study that can be used on other areas with the same specific qualities. The method was structured in a way that would allow the results to be displayed in a way that can be understood and used by people from the realms of zoogeomorphology, but also by geographers, geologists, conservationists and landowners. To have this spread in audience is a difficult starting point, but it leads to the project being influential when assessing spatial extent and intensity of elephant impacts.

3.2.1 Fieldwork

The fieldwork took place in Knysna Elephant Park, which is a private game reserve located between Plettenberg Bay and Knysna, Eastern Cape, South Africa (Figure 2). It spanned from 13 March 2013 until the 19^{th} of April 2013. Data was collected at the park during 100 field hours when elephants were followed at a safe distance, with assistance by handlers. During fieldwork a work sheet was used to identify what kind of activities as well as impacts the elephants had on the park. It also shows when these activities take place, see Table 1.

The work sheet also includes if these activities occur because of handler interference or tourism, or if it is a natural activity. Date is recorded at the start of the day. Time is recorded at every major change in activities, as well as what kind of activity. These are defined as (UNA), unnatural activities, i.e. handler interfered activities, when they tell elephants to stop or wait or move on. (UNA) also includes all interference from tourists, as when tourists take photos with elephants, or when the elephants are made to stay or lie down, or when the elephants are fed fruit and pellets. NA i.e. natural activities are the ones described above: Grazing (Gr), Trampling (Tr), Browsing (Br), Wallowing (Wa), Swimming (Sw), Drinking (Dr), Dusting (Du), Digging (Di) and Geophagy (Ge). When elephants are down in the valley it is impossible to follow them, thus, when that occurred it is stated as OoS – Out of Sight. These are written under Physical Impacts, PI. For most activities there are comments. These are for example how many tourists there were, what kind of current change in activities and how many of the elephants were taking part of the current activity.

Date	Time	L/N	(UNA)	NA	PI	Comments (!)
1						
2						
3						
4						
5						

Table 1. Field work worksheet Engvall 2013

Table 2 shows how it was used out in the field. This was created because it gives a variety of information but it is still very easy to work with and replicate. It is also usable when the weather is difficult, as in hard winds and large quantities of rain, in which a voice recorder should be used instead. If a voice recorder is used, the date, time, place, and the physical impact codes are recorded and later entered in a paper or computer work sheet.

25/3 2013	Time	L/N	(UNA)	NA	PI	Comments (!)
1	06:30	E-F/5	X	X	(HI) Tr	Morning walkout, training session where elephants are ridden and the handlers decide where they go.
2	07:15	K/4		X	Gr, Dr, Tr	During grazing the elephants socialize by sparring etc. 9 elephants are out.
3	07:40	J/4		X	Gr, Tr	
4	07:45	H-I/4	X	X	(HI) Tr, Gr	Elephants move towards the All Weather Barrier, gets diverted by handlers
5	07:55	H-I/2-3	X	X	(HI) Tr, Gr	When elephants stop or try to divert they get herded towards the dead trees

Table 2. Created work sheet for Field Work at KEP, Engvall 2013

The work sheet above thus includes all valuable activities and their impacts. It includes where the activities occur, when they occur, what kind of activities they are and if there are any important aspects and comments about the occurring activity. How the area was defined is explained in the next paragraph.

A map was provided by the African Elephant Research Unit, AERU, combined with a grid dividing the park into squares (Figure 3). This made it possible to easily define where the elephants roam, and it was used in this study so it would be compatible with other works that are conducted by AERU. The area where the elephants are contained is 150 hectares, combined; the park itself is 250 hectares. Studies conducted in other areas are advised to use the same method, where the area is divided in to squares to easily define where activities occur. According to this map activities by the big *Pine Tree*, would be noted at area J6. Activities by the *All Weather Barrier* would be noted at H4.

Figure 3. Map of the park provided by African Elephant Research Unit (AERU) at Knysna Elephant Park

This map provided information valuable for the study. It was possible to easily define where the elephant activities occurred since most of the park's prominent features are marked on the map. During fieldwork in the park, more detailed observations on observable impacts were mapped that are not visible from aerial photos.

3.3 Evaluation of consequences following elephant zoogeomorphological impacts on the physical environment

At Rhodes University all data was gathered and later mapped. To determine what should be mapped out in ArcGIS, created tables were used. They clearly accentuate areas which had the most activity and what type of activity (we may never know their reasons for doing so). These tables, in combination with created activity maps, will give a broad spectrum analysis of Knysna Elephant Park as a game reserve. It makes it possible to qualitatively determine what activities are most frequently natural or unnatural. It is also possible to quantify where natural and unnatural activities occur and why.

In the table below, it is emphasized where activities occur by following the grid on the map used. J/6 has a grey color, which means that the numbers of activities are in a span that has a frequency between 61 and 70, the exact number (66) is written in the J6 box. All activities that have been mentioned have their own box as on the grid on the map. These first four tables cohere to describe the spatial distribution of the four major activities, i.e. the activities that occurred the most, indifferent to why (unnatural or natural). These are grazing, wallowing, trampling and browsing.

Grazing							Wallowing						
A1	A2	A3	A4	A5	A6	A7	A1	A2	A3	A4	A5	A6	A7
B1	B2	B3	B4	B5	B6	B7	B1	B2	B3	B4	B5	B6	B7
C1	C2	C3	C4	C5	C6	C7	C1	C2	C3	C4	C5	C6	C7
D1	D2	D3	D4	D5 1	D6 6	D7	D1	D2	D3	D4	D5	D6	D7
E1	E2 3	E3	E4	E5 4	E6 9	E7 5	E1	E2	E3	E4	E5	E6 7	E7 2
F1 3	F2 4	F3 2	F4	F5	F6 11	F7 7	F1	F2	F3	F4	F5	F6 11	F7 8
G1 13	G2 13	G3	G4 1	G5	G6 1	G7 7	G1 2	G2	G3	G4	G5	G6	G7 2
H1 7	H2 6	H3 3	H4 17	H5 3	H6 14	H7 3	H1	H2 1	H3	H4	H5	H6 8	H7 1
I1	I2 1	I3 2	I4	I5	I6 5	I7 3	I1	I2	I3	I4	I5	I6	I7 4
J1	J2 2	J3 2	J4 1	J5 2	J6 66	J7 1	J1	J2	J3	J4 1	J5	J6 8	J7 1
K1 3	K2	K3 10	K4 7	K5	K6	K7	K1	K2	K3 4	K4	K5	K6	K7
L1	L2	L3	L4	L5	L6	L7	L1	L2	L3	L4	L5	L6	L7

Trampling							Browsing						
A1	A2	A3	A4	A5	A6	A7	A1	A2	A3	A4	A5	A6	A7
B1	B2	B3	B4	B5	B6	B7	B1	B2	B3	B4	B5	B6	B7
C1	C2	C3	C4	C5	C6	C7	C1	C2	C3	C4	C5	C6	C7
D1	D2	D3 3	D4	D5	D6 3	D7	D1	D2	D3	D4	D5 1	D6	D7
E1	E2 3	E3	E4	E5 5	E6 9	E7 2	E1	E2 4	E3	E4	E5 1	E6	E7
F1 1	F2 4	F3 4	F4	F5	F6 9	F7 3	F1 1	F2 3	F3	F4	F5	F6	F7
G1 9	G2 22	G3	G4 1	G5	G6 1	G7 5	G1 7	G2 3	G3	G4	G5	G6	G7
H1 4	H2 7	H3 3	H4 16	H5 1	H6 16	H7 2	H1 4	H2 4	H3	H4 3	H5	H6 2	H7
I1 2	I2 2	I3 2	I4	I5	I6	I7 1	I1	I2	I3 1	I4	I5	I6 1	I7
J1 1	J2 3	J3 1	J4	J5 2	J6 60	J7 1	J1	J2 1	J3	J4	J5	J6 17	J7
K1 3	K2	K3 7	K4 5	K5	K6	K7	K1 2	K2	K3 1	K4	K5	K6	K7
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Figure 4 . Major activities at KEP, Engvall 2013

Above the major activities are displayed, multiple colors are used to make eventual patterns clear.

The following figure shows all other recorded activities and their numbers in the exact same way as the table above. These activities are swimming, geophagy, dusting, drinking, digging and uprooting. It is evident that these activities occur less than the four activities above, therefore, they are regarded as minor activities. These tables where created in Office-Excel close to the original data. Data used in the tables are extracted from the raw data collected at the park. No excessive calculations were made to limit eventual calculation problems, instead the human factor had to be accounted for, and therefore the data was checked, not altered, at different times, before finalizing the last version.

The major and minor activities all impact landscape and landscape processes and they are all a sign of ecosystem engineering. During fieldwork, the tables that were created ensured easy data collection that would display results that anyone could understand. The work sheets made it possible to collect all data that was later transformed into the already mentioned figures.

Swimming							Geophagy						
A1	A2	A3	A4	A5	A6	A7	A1	A2	A3	A4	A5	A6	A7
B1	B2	B3	B4	B5	B6	B7	B1	B2	B3	B4	B5	B6	B7
C1	C2	C3	C4	C5	C6	C7	C1	C2	C3	C4	C5	C6	C7
D1	D2	D3	D4	D5	D6	D7	D1	D2	D3	D4	D5	D6	D7
E1	E2	E3	E4	E5	E6 5	E7 1	E1	E2	E3	E4	E5	E6	E7 1
F1	F2	F3	F4	F5	F6 11	F7 9	F1 1	F2	F3	F4	F5	F6 1	F7
G1	G2	G3	G4	G5	G6	G7	G1 1	G2	G3	G4	G5	G6	G7
H1	H2	H3	H4	H5	H6	H7	H1	H2	H3	H4	H5	H6 1	H7
I1	I2	I3	I4	I5	I6	I7	I1	I2	I3	I4	I5	I6	I7
J1	J2	J3	J4	J5	J6	J7	J1	J2	J3	J4	J5	J6 1	J7
K1	K2	K3	K4	K5	K6	K7	K1	K2	K3	K4	K5	K6	K7
L1	L2	L3	L4	L5	L6	L7	L1	L2	L3	L4	L5	L6	L7

Dusting							Drinking						
A1	A2	A3	A4	A5	A6	A7	A1	A2	A3	A4	A5	A6	A7
B1	B2	B3	B4	B5	B6	B7	B1	B2	B3	B4	B5	B6	B7
C1	C2	C3	C4	C5	C6	C7	C1	C2	C3	C4	C5	C6	C7
D1	D2	D3	D4	D5	D6 4	D7	D1	D2	D3	D4	D5 2	D6	D7
E1	E2	E3	E4	E5 1	E6 1	E7 3	E1	E2	E3	E4	E5	E6	E7
F1	F2	F3	F4	F5	F6 1	F7	F1	F2 1	F3 3	F4	F5	F6 1	F7 3
G1 6	G2 3	G3	G4	G5	G6	G7 3	G1	G2	G3	G4 1	G5	G6	G7
H1	H2	H3	H4 5	H5 1	H6 1	H7 1	H1	H2	H3	H4 1	H5	H6 5	H7
I1	I2	I3	I4	I5	I6 1	I7	I1	I2	I3	I4	I5	I6	I7
J1	J2	J3	J4	J5	J6 15	J7	J1	J2	J3	J4	J5	J6 4	J7 1
K1	K2	K3 3	K4	K5	K6	K7	K1	K2	K3 5	K4 2	K5	K6	K7
L1	L2	L3	L4	L5	L6	L7	L1	L2	L3	L4	L5	L6	L7

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Digging							Uprooting						
A1	A2	A3	A4	A5	A6	A7	A1	A2	A3	A4	A5	A6	A7
B1	B2	B3	B4	B5	B6	B7	B1	B2	B3	B4	B5	B6	B7
C1	C2	C3	C4	C5	C6	C7	C1	C2	C3	C4	C5	C6	C7
D1	D2	D3	D4	D5	D6 2	D7	D1	D2	D3	D4	D5	D6	D7
E1	E2	E3	E4	E5 2	E6 3	E7	E1	E2	E3	E4	E5	E6	E7
F1	F2	F3	F4	F5	F6 3	F7 4	F1	F2	F3	F4	F5	F6	F7
G1 2	G2 1	G3	G4	G5	G6	G7 1	G1	G2	G3	G4	G5	G6	G7
H1	H2	H3	H4	H5 1	H6 1	H7	H1 1	H2	H3	H4	H5	H6	H7
I1	I2 1	I3	I4	I5	I6	I7	I1	I2	I3	I4	I5	I6	I7
J1	J2	J3	J4 2	J5 1	J6 3	J7	J1	J2	J3	J4	J5	J6	J7
K1	K2	K3 1	K4 2	K5	K6	K7	K1	K2	K3	K4	K5	K6	K7
L1	L2	L3	L4	L5	L6	L7	L1	L2	L3	L4	L5	L6	L7

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Figure 5. Minor activities at KEP, Engvall 2013

Above, all minor activities are displayed. It is of importance to mention that the word minor is used only because they occur less often. Later in this study, it is explained how the least frequent activities, in the case of elephants, are sometimes the ones with the most impacts on landscape and landscape processes.

At Rhodes University in Grahamstown, South Africa, the results were compiled and mapped in ArcGIS. GIS is an acronym for Geographical Information Systems, which is a frequently used tool in map creation by geographers and geologists. The map used in ArcGIS is the newest rectified map from 2010. Using said map as the base, features were determined and entered on to the map.

Figure 6. Knysna Elephant Park and its placement next to the N2, map: 3423AB_01_2010_324_RGB_RECT, Engvall 2013

The map above is the one used for all mapping in ArcGIS. Knysna Elephant Park is located in the area enclosed in red. Even from this view certain features are evident, such as the roads in the park. The waterholes and some of the buildings are also visible. Through GIS it is possible to zoom in on an area, different layers of the map are created and each layer can display a certain feature.

The grid makes it possible to enter features such as GPS points on the map. It also allows certain features to be created. Every layer can contain various so-called shape files. The shape files are, for example, trees. Single trees are marked on a map with a point. If vegetation were mapped out, one would use a polygon, which captures areas instead of points. When mapping roads one would use polylines. Below, such a map is displayed, where features have been mapped out, to clearly illustrate how a layer on the map can be created.

Figure 7. GIS-map of Knysna Elephant Park showing elephant reach and roads, Engvall 2013

In Figure 7, the roads through the park have been marked in white and the area the elephants can reach are highlighted in dark grey. In this map the features have purposely been created as opposites to show the intentions of GIS-mapping.

4. RESULTS

In this section, the results of this study are presented. It is planned in a way that follows the structure of the rest of this paper. Considering the objectives, the questions connected to the objectives are answered here. Results and evidence for zoogeomorphic impacts by elephants on landscape and landscape processes are visible through photos. This is divided between the already explained impacts and photos clearly showing the impacts accounted for. All photographs, unless otherwise cited, are taken during fieldwork at Knysna Elephant Park with the consent of AERU.

The photos are accompanied by a more detailed description of the mentioned major and minor activities. This is to increase the quality as well as quantity of the results gathered. The results are numerous, so when assessing them, multiple variations of the imagery were chosen. The photos give the data another aspect that would have been lost if they were only to be explained in text.

4.1 Established observable criteria and indicators of zoogeomorphological impacts

The results of the literature review contributed to the layout of the fieldwork and the analysis. Former literature about ecosystem engineering, sustainable conservation practices, land use, elephant behavior and zoogeomorphology etc. proved to be of great importance in planning the fieldwork. In the literature, the impacts by elephants on landscape and landscape processes are evident and discussed. To see landscape change before elephant impacts would prove to be useful for this study. Below are four aerial photos of the park and surrounding areas.

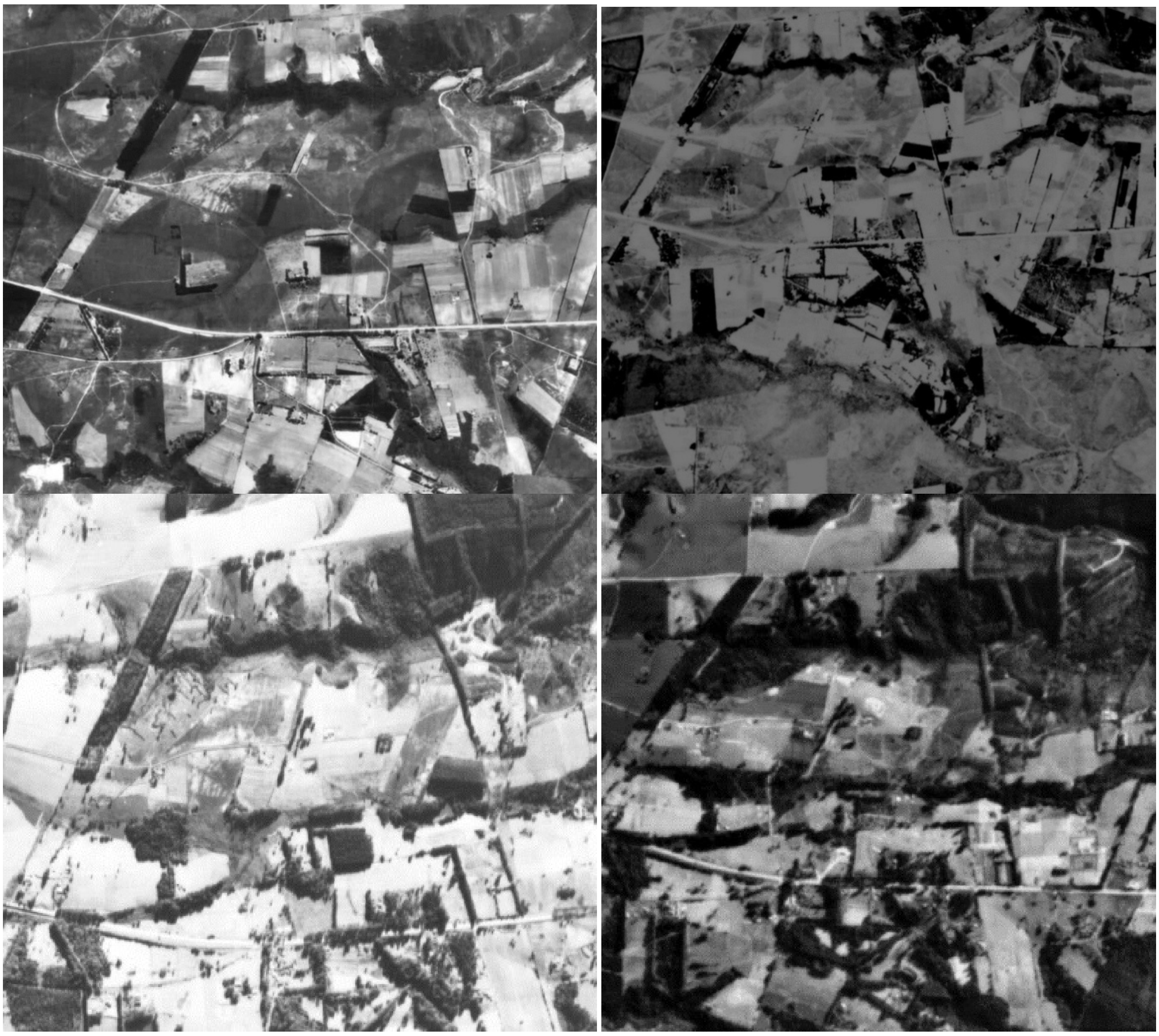

Figure 8. Aerial photos: left top corner 1960, right top corner 1972, left bottom corner 1990 and right bottom corner 1998

The aerial photos where used to illustrate land use change, but also the expansion of the park area in particular. It was also interesting to evaluate eventual changes at the park itself, after it opened in 1994. Some very important features consistent topographic objects in these photos are the fire gate on the left, the bend in the N2 Highway, the two valleys on either side of the park, the old river and the v-shaped pasture on the right. Using the N2 Highway as a constant, the park is located just before the bend in the N2, just above the riverbed in the middle of the two valleys. The two valleys imply that the park is located on a rather flat surface, which is entirely true. Now, most of the park is on high ground and it is rather flat. However, it does end in one valley on the top of the park, and slopes down towards the river and the waterhole at the bottom. The waterhole at the bottom is man-made; it was decided to dam the river to create a waterhole, which is why it is not visible on older images.

The changes in the area are multiple, and some conclusions can be made. From the 1960's the area has been used for cattle and it has since the 60's had scarce tree cover, although the tree cover has diminished over the years. Tree cover in the area during the years between 1960 and 1990 is similar. In the picture from 1998, the changes are evident: tree cover is reduced, and there is an increase in bare ground. Road and trampling impacts have started to show. In the picture from 1998 the patches of bare ground are connected to each other. This is a result of reoccurring use by vehicles or elephants. The conclusion drawn from the picture is that since the elephants arrived at the park in 1994, there has been an increase in impacts at certain areas. These results can be expected in other areas where elephants have been introduced. There is an exacerbated impact in this area because the elephants are fenced in, limiting activities that would occur in the wild or less limited confined areas.

4.2 Assessment of spatial extent and intensity of impacts from a geographical standpoint

In the following section the various zoogeomorphological impacts are accounted for through photo imagery and close-ups on accounts of activity. This is to qualify and quantify the results that were found during the fieldwork. In the method section, this part of the fieldwork was described.

4.2.1 Field Work

Following are the results of the fieldwork at Knysna Elephant Park. All results are emphasized with photos and spatial activity tables.

4.2.1.1 Trampling

Below, three images display three variations of trails that are made by elephants. The depth and vegetation cover show the intensity of usage. This means that the trails trampled most often are the ones with the least vegetation cover. Trails hardly recognized because of vegetation are those that are less used.

Figure 9. Trampling of various intensity, AERU at KEP, Engvall 2013

Trampling is an activity that is evident since it leaves obvious traces in the landscape. Therefore, areas in any game park where trampling is accumulated will have more visible features connected to trampling. Those features include an increase of bare ground, because vegetation is worn down in the paths. This is evident in the pictures above.

Trampling						
A1	A2	A3	A4	A5	A6	A7
B1	B2	B3	B4	B5	B6	B7
C1	C2	C3	C4	C5	C6	C7
D1	D2	D3 3	D4	D5	D6 3	D7
E1	E2 3	E3	E4	E5 5	E6 9	E7 2
F1 1	F2 4	F3 4	F4	F5	F6 9	F7 3
G1 9	G2 22	G3	G4 1	G5	G6 1	G7 5
H1 4	H2 7	H3 3	H4 16	H5 1	H6 16	H7 2
I1 2	I2 2	I3 2	I4	I5	I6	I7 1
J1 1	J2 3	J3 1	J4	J5 2	J6 60	J7 1
K1 3	K2	K3 7	K4 5	K5	K6	K7
L1	L2	L3	L4	L5	L6	L7

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51-60
61-70
71-80
81-90
91-100
100+

Figure 10. Trampling occurrences at KEP, Field Work Engvall 2013

In Figure 10 one can see that G2 has an increase in trampling. This is the area the elephants walk through to get out to the field in the morning and walk in from the field at night. This area is therefore under more pressure from the elephant activity. This is apparent in the maps created in ArcGIS further down in this text.

Figure 11. Google Earth imagery with marked trampling paths

Google Earth was used to determine road lengths throughout the park. The lengths of the roads were estimated at 2602 m and are marked as the white thicker lines on this map. For another view, another map created in GIS is presented further down in the result section. The longest trampling path is the one used for tourist rides. That specific trail is 20976.62 m long and it circles the upper part of the park and then turns back through the lower part of the park. Combined all trampling trails reached 5623.18 m and they are spread out over the park, although they consistently lead from waterhole to a wallow, or to barriers.

4.2.1.2 Wallowing

One of the key features when it comes to wallowing is the occurrence of water. Wallowing is static and always adjacent to a source of moisture, whereas dry spots are used for dusting. Wallowing often occurs at the same places because of the influx of water from the dam, when there is a dry period with less or no rainfall.

Figure12. Wallows, AERU at KEP Engvall 2013

When elephants wallow at the park they have preferred areas. All are close to some kind of water. Elephants wallow multiple times every day to get rid of annoying parasites, but also to get shelter from the sun. The mud functions as a kind sun lotion or sun block. Wallowing is often followed by dusting. This is to encapsulate the moisture of the mud.

0.	Wallowing						
1-5.	A1	A2	A3	A4	A5	A6	A7
6-10.	B1	B2	B3	B4	B5	B6	B7
11-15.	C1	C2	C3	C4	C5	C6	C7
16-20.	D1	D2	D3	D4	D5	D6	D7
21-25.	E1	E2	E3	E4	E5	E6 7	E7 2
26-30.	F1	F2	F3	F4	F5	F6 11	F7 8
31-25.	G1 2	G2	G3	G4	G5	G6	G7 2
36-40.	H1	H2 1	H3	H4	H5	H6 8	H7 1
41-45.	I1	I2	I3	I4	I5	I6	I7 4
46-50.	J1	J2	J3	J4 1	J5	J6 8	J7 1
51-60	K1	K2	K3 4	K4	K5	K6	K7
61-70	L1	L2	L3	L4	L5	L6	L7
71-80							
81-90							
91-100							
100+							

Figure 13. Wallowing occurrences, Field Work KEP, Engvall 2013

4.2.1.3 Grazing

Elephants spend 16-18 hours a day feeding[109], thus, a major part of the elephant's time out in the field is spent grazing. This activity is a natural activity and easy to identify. The trunk is

109 "own observations"

the elephants most important feature since it is the tool used for all kinds of feeding. When the grass is tough to rip of the ground, the elephant will grip the straws with its trunk and tear it of the ground pushing the trunk with one of its feet, thus cutting the grass with a scythe motion.

Figure 14. Elephants grazing, AERU at KEP, Engvall 2013

Grazing occurs consistently throughout the park. This is, because the park is covered mostly by grass, but also because of the limited space. Although elephants spend 16 to 18 hours of their day eating, grazing does not accumulate as other activities do. The grazing pattern seen in the figure below shows the spread of this activity.

Grazing						
A1	A2	A3	A4	A5	A6	A7
B1	B2	B3	B4	B5	B6	B7
C1	C2	C3	C4	C5	C6	C7
D1	D2	D3	D4	D5 1	D6 6	D7
E1	E2 3	E3	E4	E5 4	E6 9	E7 5
F1 3	F2 4	F3 2	F4	F5	F6 11	F7 7
G1 13	G2 13	G3	G4 1	G5	G6 1	G7 7
H1 7	H2 6	H3 3	H4 17	H5 3	H6 14	H7 3
I1	I2 1	I3 2	I4	I5	I6 5	I7 3
J1	J2 2	J3 2	J4 1	J5 2	J6 66	J7 1
K1 3	K2	K3 10	K4 7	K5	K6	K7
L1	L2	L3	L4	L5	L6	L7

0.
1-5.
6-10.
11-15.
16-20.
21-25.
26-30.
31-25.
36-40.
41-45.
46-50.
51-60
61-70
71-80
81-90
91-100
100+

Figure15. Grazing occurrences at KEP, Field Work, Engvall 2013

4.2.1.4 Uprooting

There is evidence at the park that uprooting has come about multiple times. This is evident by looking at time laps photography where one can clearly see that the tree cover has diminished in the park. Nevertheless, it was not possible for photographs to be taken of the activity as it occurred. There was only one instance where uprooting was observed. This happened while the elephants where browsing. One small bush was then dragged out of the ground and tossed away by one of the young males.

Uprooting						
A1	A2	A3	A4	A5	A6	A7
B1	B2	B3	B4	B5	B6	B7
C1	C2	C3	C4	C5	C6	C7
D1	D2	D3	D4	D5	D6	D7
E1	E2	E3	E4	E5	E6	E7
F1	F2	F3	F4	F5	F6	F7
G1	G2	G3	G4	G5	G6	G7
H1 1	H2	H3	H4	H5	H6	H7
I1	I2	I3	I4	I5	I6	I7
J1	J2	J3	J4	J5	J6	J7
K1	K2	K3	K4	K5	K6	K7
L1	L2	L3	L4	L5	L6	L7

0.
1-5.
6-10.
11-15.
16-20.
21-25.
26-30.
31-25.
36-40.
41-45.
46-50.
51-60
61-70
71-80
81-90
91-100
100+

Figure 16. Uprooting occurrences, Field Work at KEP, Engvall 2013

Because uprooting is regarded as one of the most destructive activities, its zoogeomorphological impact on landscape and landscape processes cannot be ignored. In previous and future research it needs to be considered and evaluated. If it is not occurring at the specific time when the research is concluded, previous research or aerial photos should be consulted. This is what was done for this particular study. Remnants of uprooting were apparent at the park, so there is evidence for uprooting and this was used in assessing landscape and landscape process impacts. The assessment that followed was that uprooting in fact is a destructive activity when done in a closed off area such as game reserves. Trees cannot re-grow in a pace that allows heavy impacts by elephants. Therefore tree cover diminishes until there are no more trees.

4.2.1.5 Digging

Figure 17. Impacts of digging, here one can see that the soil is completely dry, AERU at KEP, Engvall 2013

In Knysna Elephant Park another reoccurring reason for digging is in search of African potatoes. The elephants in the park do this by scratching the ground with their feet and then using their tusks to loosen up the spoil. This is a kind of bioturbation. When the elephants dig, the soil is loosened and displaced.

Figure18 . Thandi digging for African Potatoes, AERU at KEP, Engvall 2013

The elephant above is called Thandi, and she is digging for African potatoes. Since her tusks are small, she firstly scrapes the ground with her feet, and when she locates a potato she gets down on her knees and digs with her tusks. After she has loosened the **soil**, she uses her trunk to dig up the potato. She then rolls the potato in her trunk and rubs it against her chest or chin to get rid of excessive dirt before eating it.

Digging						
A1	A2	A3	A4	A5	A6	A7
B1	B2	B3	B4	B5	B6	B7
C1	C2	C3	C4	C5	C6	C7
D1	D2	D3	D4	D5	D6 2	D7
E1	E2	E3	E4	E5 2	E6 3	E7
F1	F2	F3	F4	F5	F6 3	F7 4
G1 2	G2 1	G3	G4	G5	G6	G7 1
H1	H2	H3	H4	H5 1	H6 1	H7
I1	I2 1	I3	I4	I5	I6	I7
J1	J2	J3	J4 2	J5 1	J6 3	J7
K1	K2	K3 1	K4 2	K5	K6	K7
L1	L2	L3	L4	L5	L6	L7

0.
1-5.
6-10.
11-15.
16-20.
21-25.
26-30.
31-25.
36-40.
41-45.
46-50.
51-60
61-70
71-80
81-90
91-100
100+

Figure 19. Digging occurrences at KEP, Field Work, Engvall 2013

4.2.1.6 Swimming

Swimming is an important activity for the elephants. They are more active when in the water than any other time, and this is because the cold water cools the elephants, which in turn energizes them.[110] When swimming, the elephants often play with one another. There are different variations of play: wrestling, spraying water, standing on each other etc. This ripples the water, making it turbulent. The wave motion brings water to hit the edges of the waterhole. This loosens the soil and expands the parts of the waterhole where swimming and wallowing can occur.

Figure 20. Swimming is an important activity for elephants and an important aspect of zoogeomorphological impacts, AERU at KEP, Engvall 2013

110 ”own observations”

Swimming only occurs at the waterhole in the bottom part of the park. The other waterhole is used for drinking by the elephants. The herd did not use the second waterhole for swimming once during the observations. Observations show that the reason for this is handler interference. If the elephants do not instigate walking towards the lower waterhole, the handlers will ensure they do by vocal commands or by leading the elephants. Therefore, this is sometimes classed as an unnatural activity when it is instigated by handlers and not the herd.

Swimming						
A1	A2	A3	A4	A5	A6	A7
B1	B2	B3	B4	B5	B6	B7
C1	C2	C3	C4	C5	C6	C7
D1	D2	D3	D4	D5	D6	D7
E1	E2	E3	E4	E5	E6 5	E7 1
F1	F2	F3	F4	F5	F6 11	F7 9
G1	G2	G3	G4	G5	G6	G7
H1	H2	H3	H4	H5	H6	H7
I1	I2	I3	I4	I5	I6	I7
J1	J2	J3	J4	J5	J6	J7
K1	K2	K3	K4	K5	K6	K7
L1	L2	L3	L4	L5	L6	L7

0.
1-5.
6-10.
11-15.
16-20.
21-25.
26-30.
31-25.
36-40.
41-45.
46-50.
51-60
61-70
71-80
81-90
91-100
100+

Figure 21. Swimming occurrences at KEP, Field Work, Engvall 2013

Swimming as an activity is always a natural activity. Weather has no influence on whether elephants choose to swim or not, although it is more frequent in dry weather.

4.2.1.7 Browsing

Browsing reoccurs in the valleys where the vegetation is comprised of bushes and shrubs. Browsing also occur at browsing spots where staff at the park place branches once a day. The branches are put out in the park since the elephants have no chance of getting browsing material by themselves.

Figure 22. The first photo pictures a browsing pile brought out by KEP staff, the second is of the herd browsing in the valley, AERU at KEP, Engvall 2013

Browsing						
A1	A2	A3	A4	A5	A6	A7
B1	B2	B3	B4	B5	B6	B7
C1	C2	C3	C4	C5	C6	C7
D1	D2	D3	D4	D5 1	D6	D7
E1	E2 4	E3	E4	E5 1	E6	E7
F1 1	F2 3	F3	F4	F5	F6	F7
G1 7	G2 3	G3	G4	G5	G6	G7
H1 4	H2 4	H3	H4 3	H5	H6 2	H7
I1	I2	I3 1	I4	I5	I6 1	I7 2
J1	J2 1	J3	J4	J5	J6 17	J7
K1 2	K2	K3 1	K4	K5	K6	K7
L1	L2	L3	L4	L5	L6	L7

0.
1-5.
6-10.
11-15.
16-20.
21-25.
26-30.
31-25.
36-40.
41-45.
46-50.
51-60
61-70
71-80
81-90
91-100
100+

Figure 23. Browsing occurrences at KEP, Field Work, Engvall 2013

4.2.1.8 Drinking

Drinking occurs in the morning, during the morning walkout, where the elephants walk towards the second waterhole. They usually drink once a day at the exact same place, increasing trampling impacts on one side of the waterhole. During hot or windy days they also travel down to the major waterhole at the bottom part of the park to drink. Drinking also occurs when swimming. There are some occurrences of drinking at other spots if they are to stay in one place for a longer time during hot and windy days, but most often drinking occurs at the waterholes.

Drinking						
A1	A2	A3	A4	A5	A6	A7
B1	B2	B3	B4	B5	B6	B7
C1	C2	C3	C4	C5	C6	C7
D1	D2	D3	D4	D5 2	D6	D7
E1	E2	E3	E4	E5	E6	E7
F1	F2 1	F3 3	F4	F5	F6 1	F7 3
G1	G2	G3	G4 1	G5	G6	G7
H1	H2	H3	H4 1	H5	H6 5	H7
I1	I2	I3	I4	I5	I6	I7
J1	J2	J3	J4	J5	J6 4	J7 1
K1	K2	K3 5	K4 2	K5	K6	K7
L1	L2	L3	L4	L5	L6	L7

0.
1-5.
6-10.
11-15.
16-20.
21-25.
26-30.
31-25.
36-40.
41-45.
46-50.
51-60
61-70
71-80
81-90
91-100
100+

Figure 24. Drinking occurrences at KEP, Field Work, Engvall 2013

When drinking occurs at other areas than adjacent to waterholes, it is mostly when the weather has been wet and water has accumulated in puddles where it cannot soak up through the ground.

4.2.1.9 Dusting

This section of the park is located at a slope so it increases surface water runoff, therefore enhancing the dryness of the soil. This area proves to be a preferred dusting spot. That is also evident in maps created, which are displayed further down in this text. The soil displayed in a photo below shows that this area in particular, is one of the areas frequently used by elephants. Again, the ground is heavily impacted by trampling, but the bioturbation from dusting has made the soil looser. The loose dirt can be seen as ripples on the ground.

Figure 25. Two elephants dusting themselves, second picture features a dry area often used by elephants when dusting, AERU at KEP, Engvall 2013

Dusting also follows a pattern, and like the other activities it occurs more often at areas connected to tourism and handler interference. This particular activity is spread out towards the lower right section of the park. This is for three reasons; the first being that it is located on higher ground. Secondly, it is situated between the two most used barriers at the park. And third, it is close to the waterhole and the most frequently used wallows. As mentioned before, wallowing, as well as swimming, is often followed by dusting to keep the skin moist and cool.

Dusting						
A1	A2	A3	A4	A5	A6	A7
B1	B2	B3	B4	B5	B6	B7
C1	C2	C3	C4	C5	C6	C7
D1	D2	D3	D4	D5	D6 4	D7
E1	E2	E3	E4	E5 1	E6 1	E7 3
F1	F2	F3	F4	F5	F6 1	F7
G1 6	G2 3	G3	G4	G5	G6	G7 3
H1	H2	H3	H4 5	H5 1	H6 1	H7 1
I1	I2	I3	I4	I5	I6 1	I7
J1	J2	J3	J4	J5	J6 15	J7
K1	K2	K3 3	K4	K5	K6	K7
L1	L2	L3	L4	L5	L6	L7

0.
1-5.
6-10.
11-15.
16-20.
21-25.
26-30.
31-25.
36-40.
41-45.
46-50.
51-60
61-70
71-80
81-90
91-100
100+

Figure 26. Dusting occurrences at KEP, Field Work, Engvall 2013

4.2.1.10 Geophagy

Geophagy is when animals eat soil. They do so because they have certain mineral deficits. Elephants frequently eat soil, sometimes rocks, but also dirt and mud. At Knysna Elephant Park, the elephants tend to eat soil in the vicinity of wallows and waterholes. The reason for this is that it is easier for the elephants to eat wet soil; dry soil tends to be harder to swallow. Dry rocks are sometimes picked up, sucked on and later dropped.

Geophagy						
A1	A2	A3	A4	A5	A6	A7
B1	B2	B3	B4	B5	B6	B7
C1	C2	C3	C4	C5	C6	C7
D1	D2	D3	D4	D5	D6	D7
E1	E2	E3	E4	E5	E6	E7 1
F1 1	F2	F3	F4	F5	F6 1	F7
G1 1	G2	G3	G4	G5	G6	G7
H1	H2	H3	H4	H5	H6 1	H7
I1	I2	I3	I4	I5	I6	I7
J1	J2	J3	J4	J5	J6 1	J7
K1	K2	K3	K4	K5	K6	K7
L1	L2	L3	L4	L5	L6	L7

0.
1-5.
6-10.
11-15.
16-20.
21-25.
26-30.
31-25.
36-40.
41-45.
46-50.
51-60
61-70
71-80
81-90
91-100
100+

Figure 27. Occurrences of geophagy at KEP, Field Work, Engvall 2013

4.3 Evaluation of impact consequences by elephants on the physical environment.

The following figures, 28, 29 and 30, with adjacent map, show the total number of activities noted during the fieldwork. It also shows what number of activities could be directly linked to handler interference and tourism. These are important aspects of activities at a private game reserve. In this particular case study of Knysna Elephant Park, the handler interference and tourism aspect are of vital importance. These figures reinforce what has already been described in the previous sections; handler interference and tourism has a big impact on elephant activities and where it occurs.

A1	A2	A3	A4	A5	A6	A7
B1	B2	B3	B4	B5	B6	B7
C1	C2	C3	C4	C5	C6	C7
D1	D2	D3	D4	D5 21	D6 9	D7
E1	E2 5	E3 1	E4	E5 5	E6 14	E7 5
F1 3	F2 6	F3 4	F4	F5 1	F6 31	F7 12
G1 17	G2 15	G3	G4 1	G5	G6 2	G7 11
H1 7	H2 12	H3 3	H4 20	H5 4	H6 31	H7 3
I1	I2 1	I3 1	I4 3	I5 1	I6 4	I7 4
J1	J2 3	J3 3	J4 3	J5 2	J6 106	J7 1
K1 3	K2	K3 18	K4 8	K5	K6	K7
L1	L2	L3	L4	L5	L6	L7

0.
1-5.
6-10.
11-15.
16-20.
21-25.
26-30.
31-25.
36-40.
41-45.
46-50.
51-60
61-70
71-80
81-90
91-100
100+

Figure 28. Number of activities at certain areas, clearly showing where most activities occur, Engvall 2013

In Figure 28, the areas where most activities occur are H/6, J/6, F/6 and D/5. H/6 and J/6 are close to shelter. At H/6 the barrier is close to the *All Weather Barrier*, which provides shelter for handlers, volunteers and tourists in bad weather. J/6's barrier is located next to the *Big Pine Tree* where there also is shelter from bad weather. A conclusion can be directly drawn to the fact that elephants are kept close to shelter because of human decision. A second figure was created to determine if observed conclusions were correct.

A1	A2	A3	A4	A5	A6	A7
B1	B2	B3	B4	B5	B6	B7
C1	C2	C3	C4	C5	C6	C7
D1	D2	D3	D4	D5 13	D6 3	D7
E1	E2 2	E3 1	E4	E5 3	E6	E7 8
F1 2	F2	F3 3	F4	F5	F6 23	F7 4
G1 4	G2 7	G3	G4	G5	G6	G7 4
H1 2	H2 6	H3 3	H4 14	H5 4	H6 24	H7
I1	I2 1	I3	I4	I5	I6 2	I7 3
J1	J2 1	J3 1	J4 1	J5 1	J6 81	J7
K1 1	K2	K3 12	K4 2	K5	K6	K7
L1	L2	L3	L4	L5	L6	L7

0.
1-5.
6-10.
11-15.
16-20.
21-25.
26-30.
31-25.
36-40.
41-45.
46-50.
51-60
61-70
71-80
81-90
91-100
100+

Figure 29. Handler Interference at different areas at KEP, Engvall 2013

Figure 29 above proves the previous conclusion. It is visible that recorded handler interference occurs at the same areas as determined in figure 28. J/6, H/6 and F/6 are still heavily impacted areas, and impacts can be directly related to handler interference. When observing, an elephant might start to walk off towards another area. It would then be stopped by force or voice command to stay in a certain area. If the elephant were to then turn or start digging, this activity was enforced by unnatural influence.

A1	A2	A3	A4	A5	A6	A7
B1	B2	B3	B4	B5	B6	B7
C1	C2	C3	C4	C5	C6	C7
D1	D2	D3	D4	D5 10	D6 2	D7
E1	E2	E3 1	E4	E5 2	E6 7	E7
F1 1	F2 2	F3 2	F4	F5	F6 22	F7 3
G1 4	G2 5	G3	G4	G5	G6	G7 3
H1 1	H2 2	H3 3	H4 10	H5 4	H6 22	H7
I1	I2 1	I3	I4	I5	I6 1	I7 3
J1	J2 1	J3 1	J4 1	J5 1	J6 68	J7
K1 1	K2	K3 10	K4 2	K5	K6	K7
L1	L2	L3	L4	L5	L6	L7

0.
1-5.
6-10.
11-15.
16-20.
21-25.
26-30.
31-25.
36-40.
41-45.
46-50.
51-60
61-70
71-80
81-90
91-100
100+

Figure 30. Tourist interactions at different areas at KEP, Engvall 2013

Tourist interactions are shown in figure 30. Tourism is one of the park's primary incomes and is therefore a vital part of the elephants' daily routines. Tourism also occurs more frequently at the already mentioned areas. Once again it is clear that the influenced areas are F/6, H/6 and J/6.

Figure 31. Areas with excessive Handler and Tourism impacts, Engvall 2013

Figure 31 shows the areas with excessive handler and tourism interactions. These are also the areas with most elephant impact. This proves a strong correlation between handlers and tourism and landscape change, through zoogeomorphological impacts.

4.3.1 Vegetation

In the following sections, impacted areas are presented that are directly connected to the map provided by AERU at the park. This is to show the spatial extent and intensity of the assessed impacts. The following images clearly show where there are a higher number of impacts, why the impacts occur where they are, especially if they are influenced by handler interference or tourism, which are unnatural activities.

Figure 32. Vegetation map over KEP, Engvall 2013

The map above shows the elephants’ reach in the park where they can walk without being stopped by fences. The area where elephants are free to roam is highlighted with a light shade of green. The blue features are water; two large waterholes and numerous other water features are in the reach of the elephants when enough rain falls. The yellow highlighted areas are ground with no grass cover. Darker green areas that are also labeled with dark green spots are areas with shrubbery or bushes. They follow the valleys in the park. The green triangles represent trees.

4.3.2 Areas with excessive elephant impact

Figure 33. Barriers and Elephant Impact areas, Engvall 2013

In the map above, areas with heavy zoogeomorphological impacts are highlighted with green. These impacts occur for natural and unnatural reasons. Note that all barriers are marked by severe impacts. Other areas are the waterholes and wallowing sites, as well as dusting spots. A big area is highlighted at the top of the map. This is an area with lawn grass where elephants graze in the mornings. The elephants prefer that kind of grass because it is more moist and easier to graze in comparison with the tough grass that covers most of the park.

Figure 34. An area covered with lawn grass where elephants have grazed and ripped the grass from the ground, AERU at KEP, Engvall 2013

Other impacts in comparison to the impacts of grazing that is visible in the photo above, are where trampling is accumulated because of tourism. When elephants gather at the barriers for the tourists to feed them the impacts at the barriers becomes more severe. This leads to reduced grass cover and an increase in bare ground. This is shown in the picture below.

Figure 35. Heavy trampling impacts at J/6 Pine Tree, AERU at KEP, Engvall 2013

Reduced grass cover leads to multiple changes in the landscape. The packed soil increases surface water accumulation, thus creating large puddles of water that cannot penetrate the surface layer of the ground. Moreover, the reduced grass cover obviously leads to less grazing opportunities for the elephants at the park. This might lead to a need to increase browsing material. An important factor is the tourism that supports the park financially; it is tourism that drives elephants to gather at the barriers, thus, tourism leads to reduced grass cover throughout the park.

In the previous photo it is clear that the grass cover is reduced around the barriers, one can even see elephant footsteps. Another impact directly related to elephant trampling is that the ground is packed. This is because the elephants feet are designed to flatten the ground under them. The foot expands when it touches the ground, thus reducing the pressure by spreading it on a bigger surface. This is also why elephants are jokingly regarded as sneaky, considering the fact that such a big animal is almost completely silent when it walks across the ground surface.

To continue with the impacts of trampling from previous sections, below the roads and trampling paths are mapped out. We can also see the accumulation of trampling impact in area G/6, where the trampling paths meet. It is here the elephants walk when they are going to the boma at night, or out to the field in the morning. The paths form a kind of arrow towards the boma and the rest of the houses at the park.

Figure 35. Roads (white) and Trampling (yellow) Impacts, Engvall 2013

The results of the GIS mapping of the parks trampling paths were also marked using Google Earth, which was to provide a more recent map.

Figure 36. Google Earth image with trampling paths marked in red [2011-08-20]

Google Earth imagery provided an overview that showed trampling trails invisible on other photos.

5. DISCUSSION

The aim of this paper was to provide a first assessment of the physical impacts by elephants on private game reserves in South Africa. This was done as a case study of Knysna Elephant Park. Knysna Elephant Park provides enough information to clearly see changes in landscape and landscape processes, before and after elephants were introduced. It proves beneficial to conduct studies like this because of increasing numbers of private game reserves. The method created for this study can be replicated in other areas by people from various disciplines.

To achieve creating this first assessment, three objectives were determined. These were determined because they were found to both target a broad spectrum assessment as well as an in-depth analysis. The first objective was to establish observable criteria and indicators of zoogeomorphological impacts. This was done by consulting previous literature about zoogeomorphology and elephants as well as looking at maps over the area. This provided a basic understanding of what was possible to research during fieldwork and it also presented limitations. The literature offered information about zoogeomorphological impacts by animals on landscape and landscape processes. This created a foundation for what could be anticipated during observations. The limitations were obvious and they were all linked to tourism. Tourists will affect animal activities, although the severity of tourism interactions could not be anticipated. The elephants were supposed to be completely free roaming, although the study proved that tourism actually affects the activity impacts to a great extent. Considering the expected outcome of this study, the results did benefit from the tourism interactions. The tourists made elephant impact increase in specific areas, which made it easier to evaluate how certain activities will impact landscape and landscape processes.

The second objective aims to assess spatial extent and intensity of impacts from a geographical standpoint. Here, fieldwork was the main feature; during field work the first objective was tested. Some information found in the literature was reinforced and could be studied, others proved more difficult. The difficulties rouse from management. Even though the elephants are captive they are still wild animals, therefore, safety was always a first priority. This meant that the fieldwork was regulated by tourists and handlers. Many tourists meant that the handlers were busy and no one had time to accompany me when following the elephants more closely. Elephants have proven to be less limited as study objects because they can be studied from further away than other animals.

The third objective aims to evaluate the consequences of the impacts by elephants on the physical environment. Hence, this is the section where the consequences are actually evaluated. Impacts have been proven and the reasons for the impacts have been proven, so lastly an evaluation is needed in order to finalize the results. The zoogeomorphological impacts discussed, assessed and determined in this study are definite. They express what can be expected in the future at private game reserves like Knysna Elephant Park.

Because of the birth of Fiela, the staff and volunteers at the park was under a lot of pressure. Tending to Fiela required two people around the clock, so students were asked to help when they did not have fieldwork. This, in fact, proved to aid fieldwork. Elephant activities were understood more in-depth, because whatever Fiela did, like dusting, gave a new perspective to the same activity in the herd. It also increased the understanding of elephant behavior. It was possible to tell when elephants were playing or when they were annoyed since their behavior was the same as Fiela's.

The ultimate goal for this study is to highlight the importance of species that are ecosystem engineers. Since the chance came to truly experience elephants, one of the conclusions made is that elephants are like fire; when they stay at an area they will indeed be destructive to that place. Nevertheless, fires as well as elephants are valuable. When the elephants move from area to area, other processes start that is positive for the whole ecosystem. Different plants now have chance to grow because of increase in sunlight. Elephant dropping infuse nutrients to the soil and the droppings are filled with seeds, therefore bringing seeds to other areas which aid ecosystem development and biodiversity. Therefore elephants are truly sustainable ecosystem engineers.

6. CONCLUSION

When encroaching on habitat, creating habitat loss or when species are relocated to an area, there will be specific impacts by that species. Elephant activities have been proven, by this study and others, to have certain impacts on landscape and landscape processes. This study in particular has contributed with a qualitative and quantitative assessment of these activity impacts, as well as a new method, easily repeated, that can assess impacts on game reserves. If land use change persists as it works today, all results of this study can reinforce the severity of elephant impact when they are subject to a limited space.

Moreover, this study defines zoogeomorphology as a discipline worthy of more recognition. Animal impacts irrevocably change the course of human and physical environments. Therefore, the need for further studies is evident. The results proven in this study clearly show that limited areas have more severe impacts. The links between human geography and physical geography is bridged by zoogeomorphological approaches to landscape and landscape process change.

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