EFFECTS OF LINEAR BARRIERS ON AFRICAN BUFFALO (*SYNCERUS CAFFER)* MOVEMENT IN A TRANSFRONTIER CONSERVATION AREA

by

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B.Sc., The University of British Columbia, 2015

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF

THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF SCIENCE

in

THE FACULTY OF GRADUATE AND POSTDOCTORAL STUDIES

(Resource Management and Environmental Studies)

THE UNIVERSITY OF BRITISH COLUMBIA

(Vancouver)

June 2015

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Abstract

Understanding the movement of large wildlife species is crucial for biodiversity conservation efforts. Despite a recognition of the need for landscape scale conservation efforts addressing connectivity, our understanding of the effects of linear landscape features on wildlife movement remains incomplete, particularly in developing country contexts. In this study, we used a six-year GPS collar dataset of the locations of 36 buffalo, in Namibia and surrounding countries, to investigate permeability of linear features to buffalo movement, and the effect of proximity to these linear features and human settlements on buffalo movement, including behaviour when crossing potential barriers. We found that buffalo alter their behaviour in proximity to linear barriers, increase their speed when crossing roads, and are less likely to cross roads when they are near human settlements. These findings can aid conservation planners' understanding of how large animals respond to landscape features to better manage for connectivity at the landscape scale.

Preface

The buffalo GPS data were collected by WWF-US and the Ministry of Environment and Tourism Namibia, provided to me by Dr. Robin Naidoo. The rest of my dataset was assembled by me, under the direction of Dr. Robin Naidoo. The analysis was performed by me, under the direction of Dr. Robin Naidoo with relevant input from Dr. Kai Chan. The writing was also done by me, with editing and helpful comments from Dr. Robin Naidoo and Dr. Kai Chan.

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List of Abbreviations

AICc……. Akaike's Information Criterion, finite sample size correction

CBNRM…… Community-based natural resource management

EVI……...…… Evaluated vegetation index

GPS…… Geographical Positioning Systems

KAZA…….. Kavango-Zambezi

TFCA……...…...…… Transfrontier conservation area

WWF……..... World Wildlife Fund for Nature

Acknowledgements

Thank you to my supervisors, Dr. Kai Chan and Dr. Robin Naidoo for all of your guidance and support, and help with funding. Thank you to the NSERC Canadian Graduate Scholarship (master's) program for funding this work. To my grandparents, Douglas and Eva Thompson for providing me with financial support for education. To my parents for financial and emotional support. To Ryan, Olive, and Walter for always being there for me. Thank you to the rest of my family and friends for reminding me that life is so much more than school. Thank you to my lab group for help with statistics, presentations, and insightful discussion.

Dedication

This thesis is dedicated to my family.

Chapter 1: Introduction

1.1 Ecological and biodiversity decline, and the growth of applied conservation

The field of conservation biology sprung from a growing recognition of rapid decline of biodiversity and a desire to stop or reverse this trend. It is well recognized that conservation biologists often must work with imperfect information to provide recommendations to managers and planners (Soule, 1985). Over time, both our understanding of the importance of ecosystems to human wellbeing and ecosystem function, and the breadth and depth of science supporting conservation efforts, have grown (e.g. Costanza & Folke, 1997; Armsworth et al., 2007; Naidoo et al., 2008; Visconti et al., 2011; Cardinale et al., 2012). At the same time, biodiversity loss has continued at historically unprecedented rates (Dirzo & Raven, 2003; Barnosky et al., 2011). Applied approaches to conservation have changed in response to our evolving understanding. There is still a recognized need for core conservation areas that exclude much human activity, but increasingly conservation initiatives involve whole landscapes, including human use areas, and often aim to pair biodiversity conservation with poverty alleviation (Rands et al., 2010; Turner et al., 2012). Programs such as payments for ecosystem services and community-based natural resource management are implemented at local scales and encourage local people to manage landscapes for the conservation of biodiversity, ecosystem services, and/or ecosystem function (Munthali, 2007; Naidoo et al., 2011). Transfrontier conservation areas build upon the traditional approach to conservation of national parks, by linking core conservation areas across borders in a network of protected areas, encouraging cooperation between managers to create landscape level conservation plans. All three of the aforementioned conservation approaches aim to link income generation with conservation. As these approaches involve (in part, or

completely) conservation in working landscapes, an understanding of the impacts of human development on ecological systems is necessary, as is a landscape-scale understanding of the requirements of target species. Ecological studies of target conservation species can provide information supporting the implementation and monitoring of such conservation initiatives.

1.2 Movement ecology applied to conservation

The impacts of changes on species, such as human development, or conservation programs, can be difficult to evaluate, as population-level indicators can take years, or even decades, to manifest. The field of movement ecology contributes to conservation planning and monitoring by striving to understand the proximate and ultimate drivers of animal movement (Bucholz, 2007; Nathan, 2008). Alteration in movement patterns in response to a conservation intervention, human development, or changes in climate can provide clues for the long term effect of such changes on the wellbeing of wildlife species (Doerr et al., 2011).

Biotelemetry, the use of remote sensing tools to study movement ecology, is a fast evolving suite of technology and accompanying techniques, which has contributed to conservation efforts by allowing researchers to track wildlife to places where humans cannot easily access or sample (Cooke et al., 2004). The use of remote sensing technology in wildlife studies has grown from a focus on the use of aerial photography to the inclusion of radio collars and GPS satellite collars that can track wildlife at ever increasing temporal and spatial resolution (Cagnacci et al., 2010). The tools of movement ecology have also expanded to include the use of complementary technology to monitor wildlife, such as camera traps (McCarthy et al., 2010; Pettorelli et al., 2010) and biological sensors (e.g. collars on cattle that record head movements

to identify grazing behaviour, see Augustine & Derner, 2013), and the pairing of GPS technologies with additional sensors to add extra dimensions to the understanding of wildlife movement.

The relative proliferation of GPS and associated technology and its rapid improvement has led to the publication of numerous research papers documenting and analyzing the movement paths of wildlife species ranging from very small (insects, e.g. Kissling et al., 2014) to very large (elephants, whales, e.g. Mate et al., 2011; Mashintonio et al., 2014), including aquatic and avian species (e.g. Pérez-García et al., 2012; Villegas-Ríos et al., 2013). As a result, a wide variety of models have been built to accommodate such a range of study species and different types of movement, from random walks to movement models that incorporate multiple behavioural strategies, such memory-based movement, area restricted search, directed travel, and others (e.g. Dalziel et al., 2008; Fryxell et al., 2008; Johnson et al., 2008; Fagan et al., 2013). The increasing sophistication of these models has improved the scientific understanding of the patterns underlying movement. With a broad set of tools for modeling movement, a focus has developed on producing results that can be applied to conservation management.

Movement ecology offers many contributions to applied conservation, including identifying space use patterns as well as understanding interactions between wildlife and their environment. The ability to identify species home ranges and their seasonal and inter-annual changes provides an overview of the spatial needs of wildlife from the daily scale up to the multi-year scale (Chadwick et al., 2010; Getz et al., 2007; Naidoo et al., 2012; Ryan et al., 2006, Williams et al., 2011). Pairing GPS datasets with indigenous or local knowledge has helped researchers to provide a more complete picture of species needs, adding layers of detail that may not be easily quantified (e.g. Service et al., 2014). Researchers have used complementary spatial

data to understand how animal behaviour is influenced by the environment (Augustine & Derner, 2013; Morales et al., 2004), which can lead to identifying the outcomes of conservation interventions (such as artificial water holes) (Loarie et al., 2009), and understanding the multiple scales at which resources influence movement (Frair et al., 2005; Fryxell et al., 2008). Spatially explicit data has also been paired with GPS tracking data to examine how a wide range of species respond to anthropogenic development including roads, fences, settlements, and other features (including underwater man-made structures) (e.g. Russel et al., 2014; Leblond et al., 2013, Frair et al., 2014), and the conditions under which linear features on the landscape can become barriers (Matawa et al., 2012; Cozzi et al., 2013; Beyer et al., 2014; Elliot et al., 2014). The results of these studies then can be further applied to build "resistance" surfaces (maps that are coded based on varying levels of resistance to wildlife movement across the landscape) to help planners identify potentially suitable movement corridors (Richard & Armstrong, 2010; Zeller et al., 2012; Squires et al., 2013; Zeller et al., 2014; Elliot et al., 2014). Researchers have gained insight into drivers of human-wildlife conflict (e.g. Gunn et al., 2013), enabling better conflict mitigation strategies. With the growth of movement ecology studies, an understanding of animal space use at multiple temporal and spatial scales, and how individuals respond to their environment and changes in it, managers can better understand species needs and apply that understanding to conserving habitat.

1.3 KAZA and CBNRM programs in Namibia

In southern Africa, innovative programs have been developed to address conservation and human development needs simultaneously, recognizing that wildlife and human lives are directly intertwined. Namibia, a country in southern Africa, is taking part in two such programs –

a transfrontier conservation area (TFCA) initiative, and a community-based natural resource management program (CBNRM). TFCAs consist of a network of different land-use areas, from core conservation to human use, spanning international borders, and aim to balance the needs of local people living within the TFCA with the biodiversity conservation goals. The direct sources of economic benefits that people derive from TFCAs include nature-based tourism, hunting, and plant-based products, among others (Thomson et al., 2013). Namibia's CBNRM program is also aimed at conserving biodiversity while promoting economic development, by transferring the rights to manage natural resources local groups (conservancies), allowing them to manage, and profit from, the resources within their conservancies (NACSO, 2014).

The Kavango-Zambezi (KAZA) TFCA is a new TFCA in southern Africa that includes parts of Angola, Botswana, Namibia, Zambia, and Zimbabwe, that will be approximately 500,000 km^2 when complete, roughly the size of France (Russell Taylor Pers. Comm.; KAZA TFCA, 2013). Key issues for TFCAs include identifying areas for conservation zoning and those for economic development, fostering cooperation among land use managers across borders, and ensuring connectivity for wildlife throughout the TFCA to maintain healthy animal populations (Munthali, 2007). Connectivity is especially important in KAZA as in addition to natural barriers and human infrastructure, veterinary fences have been erected to prevent the spread of disease from wild buffalo (*Syncerus caffer*) to cattle. Buffalo are among many large wildlife species in the region, which require large tracts of habitat to maintain healthy populations (Naidoo et al., 2014; Naidoo et al., 2014a).

The CBNRM program in Namibia has contributed to the recovery of many of the country's large wildlife species (NACSO, 2014). Wildlife are an important source of benefits for conservancies, as benefits from trophy hunting and photographic safaris currently provide the

greatest income to communities registered in the CBNRM program (Naidoo et al., 2011a). Additional research has found that biodiversity is correlated to conservancy income in Namibia, and the more wildlife species (especially 'Big 5' iconic species) a conservancy has, the more income the conservancy derives (Naidoo et al., 2011b). Communities also benefit from wildlife because they own the meat from animals that are killed in the trophy hunt, which provides an important source of protein. The meat from certain species is also used in traditional feasts, and has a cultural importance for local people. The benefits from wildlife-based endeavors are clear, but a potential downside is human-wildlife conflict as habitats overlap and wildlife may raid crops and livestock for food, transmit diseases to wildlife, and cause direct human harm (Mulonga et al., 2003). Understanding the drivers of wildlife movement is important in the context of CBNRM as understanding movement patterns can help managers plan for conservation and the reduction of mitigating human-wildlife conflict (Gunn et al., 2013).

Namibia's Kavango and Zambezi regions (formerly the Caprivi Strip) lie at the heart of KAZA TFCA and include 17 conservancies in the CBNRM program. It is an ideal study area for wildlife movement as the benefits (and costs) of wildlife to local people are transparent, but there are clear threats to the health of wildlife populations. Connectivity is a major concern in the TFCA context as KAZA spans 5 partner countries with major migratory routes through the area and the challenge of coordinating management throughout the system. At the CBNRM level, connectivity is an important issue as conservancies continue to grow, attracting more people to the region and building infrastructure, both of which can be deterrents to wildlife movement.

1.4 The African buffalo

The African buffalo (*Syncerus caffer)* is an important species in the KAZA TFCA and Namibia's CBNRM program, both ecologically and for socio-economic reasons. Buffalo are large herbivores whose diet ranges from approximately 75-100% grass (Cerling et al., 2003; Codron et al., 2007; Tshabalala et al., 2009). As large grazers, buffalo can change plant communities directly through their grazing patterns, and indirectly by influencing the distribution of other smaller grazing species (McNaughton, 1985; Bar-David et al., 2009). Buffalo are also an important prey species for lions, top predators in the ecosystem, and along with lions, they are a member of the "Big 5" most dangerous species to hunt, and therefore a top target for trophy hunting and photographic safaris, which benefits local people (Naidoo et al., 2010). In addition playing a part in tourism benefits, buffalo are a regionally important species as they are a target of subsistence hunting and are used for meat in traditional feasts (Naidoo et al., 2011). At the opposite end of the spectrum, buffalo can also have a negative impact on human wellbeing. Human-wildlife conflict also arises because buffalo occasionally consume or degrade crops. Buffalo can also carry foot-and-mouth disease and bovine tuberculosis (Vosloo et al., 2001; Miguel et al., 2013). The transfer of Bovine tuberculosis and foot-and-mouth disease to cattle can have devastating effects, as the disease can cause lameness, and in severe cases, mortality. Accordingly, regions with foot-and-mouth disease in cattle have very limited access to export markets for beef (Thomson et al., 2013).

Buffalo are large animals (weighing 500-900kg on average) and require varying sizes of intact habitat to survive. Historically, buffalo range selection was constrained by the availability of surface water and grazing, and the only linear features restricting movement were large, impassable rivers. In the current day, many more potential barriers to movement exist, due to

human development, such as roads, fences, and settlements. Along with nutritional and water needs, anthropogenic and natural linear features on the landscape play a factor in determining buffalo range selection and movement, from daily movement decisions up to inter-annual migration and dispersal patterns (Naidoo et al., 2012).

For buffalo in the Kavango-Zambezi region of Namibia, home range size has been shown to range from as small as 0.60 km^2 up to 448 km^2 (Naidoo et al., 2012). Buffalo in this region have exhibited a range of behaviour from long distance migration (up to 100km one-way) and dispersal (greater than 200km), to non-migrant behaviour where the home range stays constant year round (Naidoo et al., 2012; Naidoo et al., 2014). Although buffalo populations appear to be growing in Namibia under the CBNRM program, a recent study found that populations are less genetically related than historically, indicating restricted gene flow and possibly impediments to connectivity (Epps et al., 2013). Elsewhere in KAZA, buffalo have been found to have lower heterozygosity than in the past, which increases their susceptibility to population loss from stochastic events (Smitz et al., 2014). These changes have been attributed in part to fragmentation from human development and increasing distance between buffalo herds (Epps et al., 2013, Smitz et al., 2014)

1.5 Linear barrier impacts on wildlife

In light of a growing understanding of the space needs of large herbivore species and the potential effects of human infrastructure on conservation efforts, researchers have begun to use movement ecology techniques to study the impacts of linear barriers on wildlife movement. The effect of roads on wildlife has been well studied on a both herbivores and carnivores, large and small (Forman & Alexander, 1998; Spellerberg, 2007; Forman, 2010). The impact of fences,

pipelines, and other potential barriers on wildlife movement has also been studied (Dyer et al., 2002; Sheldon, 2005; Gates et al., 2012; Semeniuk et al., 2012; Beyer et al., 2014). Many of these linear barrier studies have taken place in North America (Dyer et al., 2001; Sheldon, 2005; Waller & Servheen, 2005; Northrup et al., 2012; Roever et al., 2010; Lendrum, 2013; Seidler & Long, 2014). The southern hemisphere has had less research on the impact of barriers, although this field is growing. Researchers in southern Africa have begun to study the impact of barriers on movement in the context of TFCAs as well as other conservation areas, many of which are completely fenced in in this part of the world (Loarie et al., 2009; Mbaiwa & Mbaiwa, 2006; Vanak et al., 2010a; Gates et al., 2012). In KAZA, the effect of roads has been studied on lions, as well as a predator guild (Cozzi et al., 2013; Elliot et al., 2014). It has also been established in KAZA that human land use, such as small agriculture, near natural linear barriers, rivers, can lead to an increase in human-wildlife conflict with large herbivore species (Matawa et al., 2012). Growing programs supporting conservation and livelihood goals are excellent case studies to understand the impact of current linear barriers on wildlife movement, and gain an understanding that can be used to predict the impact of future linear structures on movement.

1.6 Research objectives and questions

The objective of this thesis was to gain an understanding of the current state of connectivity in the Kavango and Zambezi regions of Namibia, as perceived by a large herbivore species, the African buffalo. This is important in the context of both the KAZA TFCA and the CBNRM program. For the KAZA TFCA to function as intended, wildlife must be able to move between core conservation areas through the surrounding landscape. We aim contribute to an understanding of whether the TFCA is functioning as a connected network of protected areas, or

as a collection of isolated patches. As a part of the CBNRM program, buffalo are an important species and their long-term conservation is tied in to the success of the program. The Kavango and Zambezi regions of Namibia are undergoing human population growth, and this baseline assessment will establish the current state of connectivity for buffalo, and allow managers to anticipate future connectivity changes as human density in the region increases.

To assess connectivity in the study area, we specifically studied the impact of linear barriers on the movement of wildlife. We asked the research questions: which features in the study area constitute linear barriers, and are these barriers impermeable or semi-permeable to buffalo movement? Do buffalo alter their behaviour in proximity to linear barriers on the landscape, such as rivers, roads, or fences? Do buffalo alter their movement when crossing semi-permeable linear barriers (e.g. roads), and do factors such as human settlement affect crossing behaviour?

The thesis is comprised of one main chapter containing the study, and a closing chapter with a broader discussion and general conclusions.

Chapter 2: Effects of Linear Barriers on African buffalo (*Syncerus caffer)* Movement in a Transfrontier Conservation Area

2.1 Introduction

Understanding large-scale wildlife movement patterns is critical for biodiversity conservation. Broad scale movement processes such as migration and dispersal enable species to optimize nutritional requirements, find mates, avoid predation, adapt to changing environmental conditions, and maintain genetic flow between populations (Zeller et al., 2012). These processes require connectivity between habitats and are threatened by human-induced landscape change (Trakhtenbrot et al., 2005; Kokko & López-Sepulchre, 2006). Loss of connectivity can lead to population collapse and local extinction (Saunders et al., 1992; Bolger et al., 2008). There is a recognized need for landscape-scale conservation approaches to manage for connectivity, and in cases where landscapes span multiple countries; one of the approaches taken is the creation of transfrontier conservation areas (Rands et al., 2010).

Transfrontier conservation areas (TFCAs) are one critical tool in the effort to maintain large-scale wildlife movement. As networks of protected areas that span national borders and incorporate multiple land use types, the goal of TFCAs is to conserve biodiversity while encouraging sustainable economic development for the people living within the TFCA (Munthali, 2007). Theoretically, by fostering cooperation among park managers and also local people in their attitudes toward wildlife, TFCAs can manage wildlife at the landscape scale, conserving habitat connectivity (Munthali, 2007). Despite this vision, on the ground there are many factors that may compromise the ability of managers to achieve conservation success.

Anthropogenic and natural linear features on the landscape may hinder the ability of wildlife to migrate and disperse (Dyer et al., 2002; Dussault et al., 2007; Loarie et al., 2009; Sawyer et al., 2013a; Beyer et al., 2014). TFCA managers must work within the bounds of the previously existing human infrastructure as well as plan for anticipated future growth. A crucial component of TFCAs is managing the effects of linear features already present on the landscape, including roads, pipelines, rivers, and fences.

Linear features on the landscape can have a multitude of effects of on wildlife movement. The physical structures themselves can vary in their permeability (Dyer et al., 2002; Sheldon, 2005; Seidler & Long, 2014). Different types of physical structures affect animal movement in different ways, such as fences of different heights and materials, underground versus above ground pipelines, and gravel versus paved roads (Spellerberg et al., 2007; Ferguson & Hanks, 2010). In addition to potentially impeding movement, linear features can create edge habitat surrounding them, which can influence the species assemblages that will use such habitat (Forman, 2010; Vanak et al., 2010; Beyer et al., 2014; Frair et al., 2014). Other indirect effects of linear features can also influence animal movement, such as the use of man-made linear corridors by wolves in northern Canada to hunt prey, causing learned avoidance of linear features by caribou (Dyer et al., 2001). There are important questions about the effect of linear features on animal movement that have implications for landscape scale connectivity and biodiversity conservation.

The field of movement ecology provides the tools necessary to answer the above questions. Movement ecology has been rapidly growing as GPS and other tracking technology decreases in size and prize, and increases in battery life (Cagnacci et al., 2010). This technology has allowed researchers to study animal movement at the micro scale (such as tagging insects, or recording

animal movement every few seconds), in environments humans cannot easily access (underwater, in dense jungle), and up to the macro scale (recording full migrations over hundreds of kilometres) (Kissling et al., 2014; Naidoo et al., 2014a; Naidoo et al. 2014b). The types of studies using GPS or radio collar technology have grown from exploring spatiotemporal patterns within the movement trajectory (e.g. Morales et al., 2004; Horne et al., 2007; Smouse et al., 2010), to studying the connection between the external environment and movement patterns (e.g. Frair et al., 2005; Roever et al., 2010; Johnson et al., 2011).

The growth of both movement ecology studies and accompanying analytic methods has also allowed researchers to examine how linear features (both natural and anthropogenic) affect the movement of species of conservation concern. There has been a concentration of studies in North America as the rapid development of the natural gas and oil industries have caused declining populations of large mammals (e.g. Dyer et al., 2001; Sheldon 2005; Morellet et al., 2011). In the southern hemisphere, researchers have examined the impact of roads, water sources, and fences on the movement of large wildlife species (e.g. Graham & Douglas-Hamilton, 2009; Loarie et al., 2009; Elliot et al., 2014). With the development of multiple TFCAs in southern Africa (Ramutsindela, 2007), and the focus on connectivity throughout these cross-border parks, there has been a more recent effort to quantify connectivity in the region for large predators (Cozzi et al., 2013; Elliot et al., 2014). In southern Africa, there is the opportunity to mitigate against the potential impacts of human population growth on connectivity by planning for transboundary movement. Understanding the impacts of linear features, both natural (e.g. rivers), and man-made (e.g. roads) on species of conservation concern is crucial for large scale planning for healthy wildlife populations.

Here we use the case of the African buffalo (*Syncerus caffer)* in the Kavango-Zambezi TFCA to pose and answer a set of research questions about the movement of wildlife in relation to linear barriers. Research questions include: which features in the study area constitute linear barriers, and are these barriers impermeable or semi-permeable to buffalo movement? Do buffalo alter their behaviour in proximity to linear barriers on the landscape, such as settlements, roads, or fences? Do buffalo alter their movement when crossing semi-permeable linear barriers (e.g. roads)?

2.2 Study area

The study area is comprised of the Kavango and Zambezi regions of Namibia (formerly known as the Caprivi Strip), with a buffer of approximately 50km to the north and south. The Kavango and Zambezi regions are in northeast Namibia, taking the form of a narrow arm jutting out of the northeast corner of the country (Figure 2.1). The study area lies at the heart of the Kavango Zambezi TFCA, a new TFCA in southern Africa that includes parts of Angola, Botswana, Namibia, Zambia, and Zimbabwe and will be approximately 500 000 km^2 when complete, roughly the size of France (Russell Taylor Pers. Comm., KAZA TFCA, 2013).

The Kavanzo and Zambezi regions combined are approximately 450km long (east-west) and is 30km at the narrowest point. The study area is relatively flat topographically (~930-1100 m above sea level) and experiences seasonal rainfall, as the majority of annual precipitation (~650 mm per year) falls between November and April (Naidoo et al., 2012). Major geographical features include the Chobe river flowing along the southeastern border section, the Zambezi river on the northeast border, and the Okavango and Kwando rivers which intersect the study area flowing north-south (Figure 2.1). The study area contains a variety of habitat types, including a

mixture of floodplains, grasslands, shrub savannas, tree savannas, and woodland. There are 5 core conservation areas in the study area surrounded by a matrix of human-use and natural landscape (Figure 2.1). Compared to the rest of Namibia, the Kavango and Zambezi regions have a relatively dense human population, at 6.1 persons per square kilometre (the national average is 2.1 persons per square kilometre) (Namibia Statistics Agency, 2011).

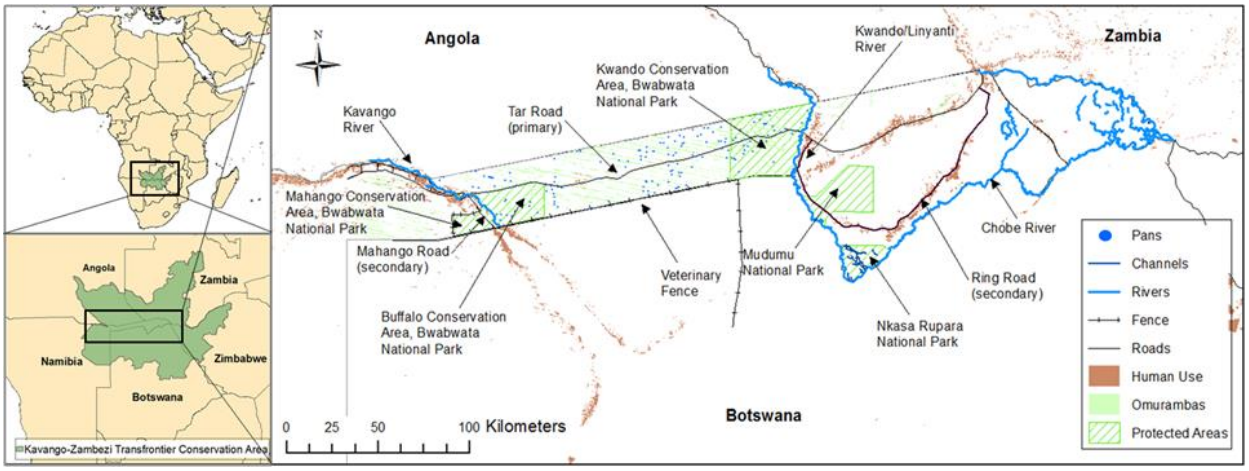

Figure 2.1 Map of the study area including the Kavango and Zambezi regions of Namibia and surrounding area. Potential barriers to buffalo movement and protected areas are also identified.

The study area contains linear features, both man-made and natural, posing as potential barriers to buffalo movement. The human-made barriers include a veterinary fence running east-west along most of the southern border between Namibia and Botswana, covering the western two-thirds of the study area, a north-south veterinary fence in northern Botswana connecting with the border fence, a fence surrounding Mahango Conservation area, and a small section of fence north of Mahango (Figure 1). There are also roads through this region, including a major highway (the Tar Road), and two secondary roads (the Mahango road and the Ring road) (Figure 2.1). The aforementioned rivers comprise potential natural barriers to buffalo movement.

2.3 Methods

2.3.1 The study dataset

The study dataset comprised of 36 African buffalo (*Syncerus caffer)* that were fitted with GPS collars in the study area from 2007-2012 (Table 2.1, Figure 2.2). Animals were darted and anesthetized from helicopters, and then collars were attached. The GPS collars were either Sirtrack or Africa Wildlife Tracking brands, programmed to record the animal's location every 5 hours. The time interval of 5 hours was chosen as a compromise between frequency of observation and collar life (due to battery life constraints), and also to obtain locations of buffalo covering every hour of the day over the collar's lifespan. The temporal span of the entire dataset of GPS locations was September 22, 2007 to May 7, 2013. Of the buffalo collared, 5 were male and 31 were female. Three male buffalo were excluded from the analysis due to insufficient data points. More female buffalo were collared than males due to relative ease on collars – males are harder on collars, often destroying them – and the fact that females aggregate in breeding herds of between 50-500 individuals, so the GPS recordings would represent herd movement patterns. The animals were collared in 7 sites across the study area, which are used to define their spatial groupings in the statistical analysis: Mahango, Buffalo Core, Horseshoe, Susuwe (all part of Bwabwata Park), Mudumu, Nkasa Rupara, and the Eastern Floodplains (Figure 2.2).

Table 2.1 Buffalo collars, their collar sites, and migration types.

Collar ID	Sex	Collar site	Migratory behaviour*	Number of data points
101108	F	Horseshoe	Migrant	1568
101109	F	Susuwe	n/a	855
77259	F	Buffalo Core	Expansionist	1332
77259new	F	Mudumu	Expansionist	1631
77259new2	F	Susuwe	n/a	841
77260	F	Susuwe	Migrant	2132

Collar ID	Sex	Collar site	Migratory behaviour*	Number of data points
77260new	F	Mudumu	Non-migrant	3350
77261	F	Susuwe	Migrant	303**
77261new	F	Buffalo Core	Migrant	3584
77262	F	Buffalo Core	Expansionist	2240
77263	F	Susuwe	Migrant	1289
77263new	F	Susuwe	Migrant	1901
77264	F	Nkasa Rupara	Non-migrant	1797
77264new	F	Nkasa Rupara	Non-migrant	3719
77265	F	Mudumu	Expansionist	2793
77265new	F	Buffalo Core	Expansionist	1148
77266	F	Nkasa Rupara	Non-migrant	3331
77266new	F	Nkasa Rupara	Non-migrant	2615
94041	F	Susuwe	Migrant	3114
94042	F	Susuwe	Migrant	1817
94043	F	Horseshoe	Migrant	2502
AG269	F	Susuwe	Migrant	3081
AG270	M	Susuwe	Migrant	241**
AG271	M	Eastern Floodplains	n/a	69**
AG273	M	Eastern Floodplains	Disperser	756
AG274	M	Horseshoe	n/a	63**
AG275	F	Horseshoe	Migrant	1235
AG276	F	Eastern Floodplains	Non-migrant	1038
AG277	F	Eastern Floodplains	Non-migrant	3881
AG278	F	Mudumu	Expansionist	4239
AG279	F	Mudumu	Non-migrant	702
AG280	M	Nkasa Rupara	n/a	22**
AM290	F	Nkasa Rupara	Non-migrant	3431
AM291	F	Mahango	Migrant	2138
SAT508	F	Buffalo Core	n/a	948
SAT509	F	Buffalo Core	n/a	940

*** migratory type identified by Naidoo et al. (2012), ** not enough data points to model this collar**

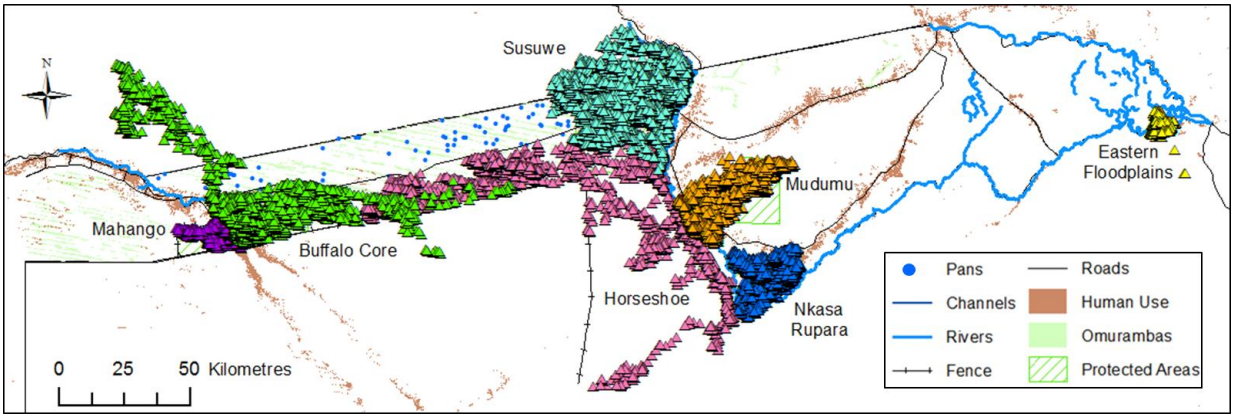

Figure 2.2 Buffalo GPS fixes and their collaring sites. GPS fixes are the coloured circles; different coloured triangles represent different sites. Purple is Mahango, green is Buffalo Core, pink is Horseshoe, teal is Susuwe, orange is Mudumu, blue is Nkasa Rupara, and yellow is the Eastern Floodplains. GPS locations were recorded every 5 hours from September 2007 – May 2013.

2.3.2 Environmental variables

We compiled a set of environmental variables that we expected to affect buffalo movement behaviour when near or crossing linear barriers. Environmental variables were selected by performing a literature review of buffalo ecology and behaviour, and a literature review of the environmental variables selected in similar movement studies of large ungulates (Sinclair 1977; Prins, 1996; Dyer et al., 2002; Winnie et al., 2008, Loarie et al., 2009; Leblond et al., 2012; Matawa et al.; 2012; Naidoo et al., 2012; Elliot et al., 2014; Naidoo et al., 2014a).

Satellite images were obtained detailing vegetation, fire, and rainfall. These variables directly impact resource distribution, which can alter buffalo movement, as buffalo rely heavily on both water and fresh graze (Sinclair, 1977). Processed satellite data containing 'enhanced vegetation index' was obtained from the NASA Reverb server covering the course of the study period (EVI – MOD13Q1, NASA LP DAAC, 2001), 16 day composite). EVI is a proxy for vegetation quality; studies have shown that buffalo select for vegetation quality when not restricted by water (Sinclair, 1972; Traill & Bigalke, 2007; Tshabalala et al., 2009; Ryan et al.,

2012). Daily estimates of fires on the landscape (fire index), were also obtained from NASA Reverb server for the course of the study period (MOD14A1 daily, NASA LP DAAC, 2001b). Fire was included in the study because vegetation growth rates are highest within 3 months of a fire, providing quality forage that may be an attractant for buffalo (Vijver et al., 1999). Daily estimated rainfall data, in the form of satellite images, was obtained from the Tropical Rainfall Monitoring Mission via a NASA server, over the course of the study period (TRMM 3B42 daily v7, TRMM 2013). In savannas, migratory animals follow rainfall gradients; during the growing season they are able to choose high quality vegetation, and during the dry season they select higher rainfall areas (Bauer et al., 2011). Satellite imagery was processed to extract EVI, fire (which was calculated as days since last fire), and rainfall measurements for individual observations throughout the study period. The rainfall data were highly skewed with many more zero than non-zero values at buffalo GPS locations, so this variable was transformed to a binary variable with 0 representing no rain, and anything greater than 0 representing rainfall on that day at the buffalo's location. Fire index was also transformed to a binary variable, fire, where 1 represented there having been a fire within the past 90 days, and 0 represented no fire within 90 days.

Spatially explicit vector layers were obtained detailing rivers, channels (smaller waterways), and pans (ephemeral water sources), settlements, and omurambas (narrow linear depressions in the landscape) in the study area, from the Ministry of Environment and Tourism, Namibia and WWF in Namibia. Buffalo must remain close to permanent water sources such as rivers and channels during the dry season, which limits their movements (Stark, 1986; Traill & Bigalke, 2007). Pans are depressions that contain water holes that fill in the wet season, and buffalo use these resources to expand their access to fresh graze. Our pans layer was derived

from a traditional knowledge study surveying land users in the western part of the study area about pans that they use (Taylor et al., 2006). Vector-based maps for roads and the veterinary fence were also used. The settlement data were derived from a land use map of the study area (World Wildlife Fund, 2005). Omurambas are narrow linear depressions across the landscape occurring at lower elevation than the surrounding landscape. They are preferred habitat for buffalo as they often contain ephemeral water during the wet season as well as grass for foraging. The omuramba layer was derived from a map of vegetation type (Mendelsohn & Roberts, 1997).

The vector features were linked to buffalo location data in ArcMap 10 (ESRI, 2011). Distance to road, river, fence, and settlement was calculated for every buffalo location. For road, river, and fence, distance to feature was converted to a binary variable indicating whether a GPS location was within a certain distance to the feature or outside. For river, the threshold was the river's floodplain; for roads and fences a threshold of 2km was chosen based on a study examining linear anthropogenic features affecting the movement of large ungulates, where it was an intermediate threshold level of potential disturbance (Leblond et al., 2012). For omurambas, the binary variable indicated whether each location was in an omuramba or not.

Each GPS location was classified temporally by whether it was recorded during day or night, and wet or dry season. Information on daily sunrise and sunset times were used to differentiate day/night observations, and movement patterns were examined in conjunction with rainfall patterns to determine season change dates for each year of the study. The temporal initiation of zebra migrations in the study area has been found to coincide with large episodic rainfall events and buffalo net squared displacement (an indicator of migration) is correlated with rainfall (Naidoo et al., 2012; Naidoo et al., 2014a).

2.3.3 Statistical analysis

All statistical analyses were performed using the R statistical software (R Core Team, 2014).The ltraj function from the “AdehabitatLT” package (Calenge, 2006) was used to generate step lengths (straight line distance between successive locations) and turn angles (the relative turn angle that the animal has taken compared to the direction of its previous step) for every observation (n= 54 729 observations, 36 individuals) in the dataset. Speed was derived as an additional variable by dividing step length by the time expired between successive locations. For each individual dataset, all observations > 5.1 hours apart were removed, and a time lag of one unit was created for speed turn angle. Each dataset was individually examined for GPS recording errors.

Two statistical analyses were performed, both using an information-theoretic approach (Burnham & Anderson, 2001). This method compares models in a candidate set between each other and ranks them based on the relative fit of each model given the data. An all-subsets multimodel averaging approach was used for both analyses, in order to explore and determine which coefficients had the greatest impact on buffalo movement, including the relative magnitude and direction of these effects (Burnham & Anderson, 2001). This resulted in 2^k candidate models for each analysis, where k is the number of parameters (including the intercept). The MuMIn package was used for this analysis (Barton, 2014). We used Akaike’s information criterion, with a finite sample size correction (AICc) to assess the relative fit of each candidate model to the data. AICc is recommended for use when the sample size is not many times larger than the square of the number of parameters. Use of AICc in this case avoids over fitting models (Burnham & Anderson, 2011). From AICc rankings, coefficients for the average

model were calculated as weighted averages of the coefficients from the full set of models, using Akaike weights derived from the AICc values. Model averaging was used to take into account uncertainty in model selection. Shrinkage coefficients were used in the model averaging process. Shrinkage coefficients are closer to zero as they include a zero for each model where the variable is not present when calculating of the average-model coefficient for each variable (Burnham & Anderson, 2001).

The first statistical analysis was an exploratory analysis of the relative impact of our various environmental variables, including linear features, on buffalo movement. The proxies for movement used in this analysis were speed and relative turn angle. These were modeled separately as dependent variables in linear models. Models were run for each individual GPS collar, as well as aggregated by collaring site (hereafter 'site', Figure 2.2), and all collars aggregated. We used collaring sites to group collars because each site has a distinct set of linear features that we expected to have important localized effects on movement and permeability of linear barriers.

Not all individual models contained all independent variables, since not all variables were relevant for the various study sites (for example, proximity to the veterinary fence is not relevant for animals in the eastern floodplains as the nearest such fence is over 200km away). Independent variables were chosen at the site level, so all models for each buffalo in a site (e.g., Susuwe, Horseshoe) contained the same set of independent variables (Figure 2.1). Dry and wet season movements were modeled separately. The variables of interest in the general movement models were: road buffer, river floodplain, and fence buffer. The models included additional variables that we hypothesized would influence buffalo movement: day, omuramba, rain, fire angle, speed, EVI and EVI^2, and lag speed/angle.

The second statistical analysis was an analysis of buffalo crossing behaviour in relation to potential linear barriers in the study area. Linear features in the study area were identified, including the main tar road, two secondary roads (Mahango and the ring road), the veterinary fence, and two major rivers: the Kavango and the Kwando rivers (Figure 2.1). The movement paths for all 36 animals were examined and each time they crossed one of the linear features, this was recorded.

A buffalo was deemed to have crossed a linear feature when the shortest straight line path between one location and the next location crossed a linear feature (given the nature of our linear features including roads and rivers, there were very few opportunities for animals to travel around these features). We expected fences to be impermeable barriers to buffalo as the veterinary fence in Namibia is aimed at prohibiting buffalo crossings, and is a barrier to other large wildlife in the region (Cozzi et al., 2013), rivers to be semi-permeable (as buffalo can cross rivers, depending on river depth and width, e.g. Ryan et al., 2006), and roads to be semi-permeable barriers (based on studies of other large herbivores, e.g. Dyer et al., 2002; Sheldon, 2005).

Buffers of 1km, 2km, and 5km were created surrounding each linear feature. These buffers were selected based on estimates of the influence of linear barriers on other large herbivores (Leblond et al., 2012). For each animal, the number of data points within each buffer was recorded. The percentage of crossing events compared to observations within the buffers varied from 0.5% to 11.3%. To avoid small sample bias, we used Firth's bias reduced logistic regression with the logistf package in R (Firth, 2008; Heinze et al., 2013). This method is used on rare events logistic data to account for the tendency to under-predict events with rare event data (Firth, 2008). The dependent variable was crossing a linear barrier (1 = crossed, 0 = not

crossed). The independent variables in this set of models included day (1 for daytime and 0 for night), season (1 for dry, 0 for wet), speed, angle, fraction tree cover, distance to nearest settlement (when applicable), and in or out of an omuramba (when applicable). We expected buffalo to be more likely to cross linear features when farther from settlements, as traffic, noise, and human presence are all higher closer to settlements and similar effects have been found with other herbivores (Sheldon 2005; Coulon et al., 2008). Presence in or out of an omuramba was included as an independent variable because omurambas are often used as travel corridors for buffalo and also contain ephemeral water sources that fill in the wet season, so we expected that buffalo may be more likely to cross linear barriers when traveling in an omuramba (Naidoo et al., 2012). Additionally, we expected to observe buffalo to display directed movement patterns (smaller turn angles, higher speeds), when crossing roads, as roads are perceived negatively by many herbivores (e.g. Leblond et al., 2012). We expected buffalo to be more likely to cross roads at nighttime, as traffic is likely lower. We also expected buffalo to be more likely to cross roads in the wet season, when they expand their range to track high quality forage.

2.4 Results

2.4.1 Movement models

Site-aggregated models and the 'all collars' aggregated models are reported in this section. For individual collar results, see Appendix A2. In the all collars models, buffalo moved significantly slower in river floodplains across the study area in both the wet and dry seasons (Table 2.1, 2.2), with a larger turn angle in the wet season (Appendix A1, A2). When split into site-level models, the results supported the all collars models, with buffalo moving faster in the river floodplain for all sites (in at least one season) except Mahango. Turn angle in the river

floodplain at the site level was variable; individuals in Buffalo Core had a larger turn angle (wet season) and in Susuwe, a smaller turn angle (dry season).

For the road buffer variable, in the all collars models buffalo moved significantly slower within the road buffer (dry season), with smaller turn angles (Table 2.2). Additionally, the road buffer variable was included in three of the site models (Buffalo Core, Mahango, and Susuwe). For the Buffalo Core site model, individuals moved faster in the road buffer. Conversely, buffalo moved slower in the road buffer for the Mahango (dry season) and Mudumu (wet season) site models, with smaller turn angles (dry season).

Distance to settlement was not included in the all collars models because two of the five sites either did not have settlements within access of the animals, or data was not available. At the site level, buffalo moved significantly slower when closer to human settlements in Horseshoe, Mudumu, and Nkasa Rupara. Conversely, in the wet season Susuwe model, buffalo moved faster when closer to human settlements.

There were too few data points within the fence buffer to model the effects of proximity to the fence when all collars were grouped together; at the site level, fence buffer was not significant at the three sites it was relevant for (Buffalo Core, Horseshoe, Mahango).

With respect to the additional variables in the movement analysis, buffalo moved faster with increased rainfall, faster in omurambas, fastest at intermediate EVI values in the dry season and at lower EVI in the wet season, faster at night, faster with a higher lag speed, and faster with a smaller turn angle (speed and angle had a significant negative relationship in the 6 of 16 speed models and 7 of 16 turn angle models) (Tables 2.1, 2.2 and Appendix A1). Fire was only included in one model, the Eastern Floodplains model, and these animals moved faster in areas where fire had occurred within 90 days.

Table 2.2 All collars, dry season, speed.

Variable	Estimate	Std. Error	z-value	Pr(>|z|)	Lower Confidence Interval (2.50%)	Upper Confidence Interval (97.50%)
River	-0.146	0.016	9.254	< 0.001	-0.177	-0.115
Road	-0.070	0.033	2.112	0.0347	-0.136	-0.005
Day	-0.054	0.015	3.518	< 0.001	-0.085	-0.024
In omuramba	0.1630	0.034	4.72	< 0.001	0.095	0.231
Rain	0.0949	0.023	4.176	< 0.001	0.050	0.139
Turn angle	-0.089	0.015	5.871	< 0.001	-0.118	-0.059
EVI	0.066	0.016	4.109	< 0.001	0.034	0.097
EVI^2	-0.075	0.018	4.084	< 0.001	-0.112	-0.039
Lag speed	0.058	0.015	3.812	< 0.001	0.028	0.089

Table 2.3 All collars, wet season, speed

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
River	-0.114	0.017	6.851	< 0.001	-0.147	-0.081
Road	0.019	0.025	0.788	0.431	-0.029	0.068
Day	-0.118	0.013	9.284	< 0.001	-0.143	-0.093
In omuramba	0.083	0.021	3.869	< 0.001	0.041	0.125
Rain	0.062	0.013	4.834	< 0.001	0.037	0.087
Turn angle	-0.096	0.013	7.653	< 0.001	-0.121	-0.072
EVI	-0.045	0.013	3.317	< 0.001	-0.071	-0.018
EVI^2	-0.065	0.013	5.106	< 0.001	-0.090	-0.040
Lag speed	0.192	0.013	15.109	< 0.001	0.167	0.217

2.4.2 Crossing models

Buffers around of 1, 2, and 5km, around roads in the study area, were all used for modeling the influence of different variables on crossing behaviour; the results reported in this section are only those for 2km buffers since results were similar across all buffer distances (see Appendix A3 for 1 and 5km buffer results).

Our results indicate both impermeable and semi-permeable barriers across the study area. Major rivers acted as an impermeable barrier to buffalo movement, except one occasion where a

buffalo in the Eastern Floodplains crossed the Chobe River. Out of 54 729 total data points collected, just over a quarter of those (15 488) were within 2km of a river. The Mahango park fence similarly acted as an impermeable barrier to buffalo movement; there were no crossings out of 505 observations within 2km of the Mahango fence (out of 1 973 data points in Mahango). The veterinary fence was a semi-permeable barrier to movement. There were two instances of buffalo crossing the veterinary fence out of 1 655 data points that were within 2km of it.

The roads in the study were semi-permeable barriers to movement. In Mahango, buffalo were observed to cross the road 48 times out of 505 instances of the animal being within 2km of the road. The Ring Road was crossed 115 times in 1 684 instances of an animal within 2km of the road). All 115 crossings were from Mudumu animals (1 523 observations); the Nkasa Rupara animals never crossed the road (161 instances)

The tar road in the study area was crossed by Buffalo Core and Susuwe animals, but not by Horseshoe animals. There were a total of 2 367 observations within 2km of the tar road and 128 crossings. Horseshoe buffalo were observed within 2km of the tar road 142 times while never crossing the road. There were 587 Buffalo Core animal observations within 2km of the tar road, and the road was crossed 12 times. Susuwe animals were recorded within 2km of the tar road 1 638 times, and crossed the road 116 times.

Crossing behaviour appears to be affected by the three roads in the study area. For all three roads, buffalo moved significantly faster when crossing the road than when not crossing (Tables 2.3-2.5). Additionally, for the Tar and Mahango roads, relative turn angle was significantly smaller when crossing versus not crossing (Tables 2.3, 2.4). In the Tar and Ring road crossing models, distance to settlement was positive and significant, indicating that buffalo were more likely to cross the road further from human settlements (Table 2.4). When models

were further split by site and individual collar, distance to settlement was significant and positive for the Mudumu crossing model and collar AG278 model (within Mudumu). For the rest of the collars that had enough data points to be modeled, speed was significant but not distance to settlement. In Mahango, buffalo were more likely to cross the road in the wet season than the dry season.

Table 2.4 Tar road crossing model, 2000m.

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.50%)	Upper Confidence Interval (97.50%)
Angle	-0.565	0.216	2.615	0.009	-0.988	-0.141
Settlement	0.793	0.285	2.785	0.005	0.235	1.351
Day	-0.380	0.234	1.623	0.104	-0.838	0.079
Dry season	0.194	0.266	0.729	0.466	-0.328	0.716
EVI	-0.172	0.251	0.685	0.493	-0.664	0.320
In omuramba	0.222	0.220	1.011	0.312	-0.209	0.653
Speed	2.13	0.263	8.089	<0.001	1.614	2.646

Table 2.5 Ring road crossing model, 2000m.

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Angle	0.063	0.212	0.299	0.765	-0.352	0.479
Settlement	2.041	0.462	4.416	<0.001	1.135	2.947
Day	-0.062	0.210	0.294	0.769	-0.472	0.349
Dry season	-0.164	0.387	0.425	0.671	-0.922	0.593
EVI	-0.452	0.479	0.943	0.346	-1.392	0.488
Speed	1.893	0.204	9.258	<0.001	1.492	2.293

Table 2.6 Mahango crossing model, 2000m.

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Angle	-1.048	0.37822	2.771	0.006	-1.78945	-0.30686
Day	-0.090	0.28206	0.318	0.751	-0.64239	0.463277
Dry	-4.190	0.95953	4.367	<0.001	-6.07095	-2.30968
Speed	1.792	0.30636	5.851	<0.001	1.191974	2.392878
EVI	0.096	0.32347	0.298	0.765	-0.53746	0.730497
In omuramba	-0.382	0.6839	0.559	0.576	-1.7225	0.958341

2.5 Discussion

In this study, we used a dataset of GPS collar locations and a multimodel averaging approach to demonstrate that connectivity in the KAZA TFCA is impacted in some places by man-made linear features, and that buffalo alter their behaviour in proximity to both man-made and natural linear barriers.

2.5.1 Which linear features on the landscape are barriers, and which of those are impermeable or semi permeable?

Our analysis revealed that permeability of linear barriers varied both among and within types of features on the landscape. The impermeability of the rivers in our study area restricts east-west movement of buffalo, and in the far east of the study area, north-south movement. Fences were only crossed when external circumstances (such as low water level, or a likely breach by elephants) allowed buffalo to cross, further restricting southward movement into Botswana in the eastern half of the study area. The roads were semi-permeable barriers, crossed in some places but not others, making northward movement partially (but not completely) compromised in some areas. There is a wealth of previous work examining the barrier effect of roads, and our results

are consistent with other work on large ungulates finding that the permeability of roads is variable depending on other factors such as traffic and fencing (Forman & Alexander, 1998; Shepard et al., 2008; Trombulak & Frissell, 2012). Rivers are impermeable barriers to cheetahs, hyenas, and wild dogs elsewhere in KAZA, but are permeable to lions (Cozzi et al., 2013). By gaining a more complete understanding of how linear barriers affect wildlife movement when in proximity to, and crossing, these features, managers can begin to understand how certain interventions may help restore connectivity, or mitigate further losses in connectivity.

2.5.2 How do buffalo behave in proximity to linear features?

We found that buffalo moved more slowly in the river floodplains, indicating that floodplains are used for encamped behaviour, such as grazing, drinking, and ruminating (Morales et al., 2004; Fryxell et al., 2008). This is consistent with previous work showing that when buffalo do not have easy access to many smaller permanent water sources (such as permanent water holes), they select habitat close to rivers and lakes (Sinclair, 1977; Prins, 1996; Redfern et al., 2003). River floodplains are also preferred land for agriculture, so there is the potential for human-wildlife conflict when buffalo range outside of protected areas. In a study of the Zambezi valley, researchers found buffalo use of river-adjacent habitats led to increased human-wildlife conflict in the area, as human development was also concentrated along the river floodplain, although buffalo did avoid agricultural land uses in the river floodplains (Matawa et al., 2012). Currently, the majority of buffalo use of river floodplains in the study area does not overlap with human use, but as the region develops, agriculture may expand. Potential solutions exist, such as the expansion of protected area for buffalo, or use of artificial water sources for wildlife. A conservation intervention in South Africa allowed elephants to rely much less on river floodplain

habitat (Loarie et al., 2009). As a consequence, though, the animals did not vary their space use seasonally. This could lead to overexploitation of the local flora with no time for recovery, which could lead to significant habitat changes. Habitat alterations by large herbivores can cause cascading effects to other herbivores, ultimately altering ecosystem structure and function and potentially rendering the habitat unsuitable for certain species (Ripple, 2015).

The effect of road proximity on behaviour has been studied on other large mammals, including ungulates, but not extensively on buffalo (Dyer et al., 2001; Dyer et al., 2002; Sheldon, 2005; Waller & Servheen, 2005; Holdo et al., 2011; Leblond et al., 2012; Rytwinski & Fahrig, 2013; Sawyer et al., 2013b; Beyer et al., 2014; Elliot et al., 2014; Frair et al., 2014; Seidler & Long, 2014). Studies have found that large ungulates avoid roads up to a distance of 1.25km, and behavioural effects of roads on ungulate movement extend up to 5km, including the effect of moving faster when closer to roads for both mule deer and caribou (Dyer et al., 2001; Sawyer et al., 2009; Leblond et al., 2012; Sawyer et al., 2013b; Beyer et al., 2014). In this study, buffalo moved faster within the Tar Road buffer, suggesting that the habitat surrounding the tar road is sub-optimal (Sawyer et al., 2013b). The Tar road is the road in the study area with the highest traffic and has many settlements along it (Figure 1), so this could contribute to creating adjacent undesirable habitat, due to increased human presence and the noise and vehicle disturbance associated with human settlements. Conversely, buffalo moved slower in the Mahango and Ring Road buffers than outside. There are no settlements along the Mahango road, and none along the section of the Ring Road where the Mudumu buffalo reside, so there might be less of an indirect undesirable habitat effect. The Ring and Mahango roads are also less than 5km from major rivers in both Mudumu and Mahango sites, so the habitat within 2km of the road could be ideal graze.

The differing effects of the roads in the study area on buffalo movement show that the effect on behaviour is more nuanced than simply the physical structure of a road, and there must be other contributing factors, such as traffic, or proximity to necessary resources such as water. All three roads in the study area cross through protected areas, and therefore their effects on animal behaviour are important for conservation planning. Planners must be able to anticipate when a road will cause a buffer of undesirable habitat, as this can fragment habitat in protected areas. The results of the crossing analysis add additional insight into the impact of roads in the study area on buffalo movement.

2.5.3 How do buffalo behave when crossing linear features?

Our finding that buffalo moved faster when crossing roads suggests that roads have a negative effect on buffalo in the study area and that buffalo perceive roads as undesirable habitat. We also found that buffalo were more likely to cross the tar road when further from settlements, suggesting an indirect effect of settlements that causes the road to become an impermeable barrier. This is likely the extra traffic, physical infrastructure, and human presence located in and around settlements. Lions in KAZA TFCA have also been found to avoid settlements (Elliot et al., 2014), and studies in the northern hemisphere have revealed traffic to be an important factor in determining the permeability of roads to large mammal movement, along with road network density and road fencing (Dyer et al., 2002; Sheldon, 2005; Waller & Servheen, 2005; Leblond et al., 2012; Sawyer et al., 2013a; Frair et al., 2014; Siedler & Long, 2014). With the development of KAZA TFCA, there is an expected increase in human presence that will take the form of increased traffic from tourists and additional human infrastructure to accommodate this tourism. This anticipated development could reduce the permeability of roads in the study area to

buffalo movement, decreasing connectivity and possibly barring wildlife from dispersing and migrating between seasonal ranges.

A limitation of our study is that the buffalo were almost all adult females so we were unable to test for differences in behaviour related to linear barriers by age and sex. Of the two male buffalo included in the analysis, one was in the eastern floodplains, where there were no anthropogenic linear barriers to movement, and one was in Susuwe with insufficient observations to model this animal's road-crossing behaviour individually. A study of lion movement in KAZA revealed that behaviour around barriers (avoidance, willingness to cross) was related to sex and demographic status, which predicted different levels of risk adverse behaviour in individuals (Elliot et al., 2014). For a complete understanding of buffalo behaviour in relation to linear barriers, it's important to consider the behaviour of not just herding females, but also reproductive-aged males that do not travel in herds. Young, dispersing juvenile lions were more risk averse, which could also be the case for young male buffalo (Elliot et al., 2014). Failure to take these differences into account could limit the success of a conservation plan.

2.5.4 General discussion and conclusions

In planning for the conservation side of the KAZA initiative, priority corridors for wildlife movement have been identified. The top priority corridor passes from Botswana through Namibia to Angola and Zambia, crossing through Nkasa Rupara, Mudumu, Susuwe, and Horseshoe (Ferguson & Hanks, 2010). The potential barriers to the connectivity of this corridor include settlements, roads, fences, and land use. This study contributes to our understanding of how those potential barriers buffalo, a large, wide-ranging mammal. The major north-south barrier to this migratory route is the Tar Road, which is currently crossed by Susuwe animals but

not Horseshoe animals. We also found that proximity to human settlements influences the ability of buffalo to cross roads in the study area, and that fences are impermeable barriers. These empirical results can guide management of this corridor in KAZA to ensure that it links wildlife populations on the ground, and continues to do so as the region develops.

Overall, we found that connectivity in the study area is compromised in some places by human development. This supports the findings of a recent genetic analysis that revealed that gene flow between buffalo in the study area are is more restricted than it historically (Epps et al., 2013). As heterozygosity in buffalo populations elsewhere in the KAZA TFCA have also decreased, it is possible that the loss in connectivity has had a negative effect on the genetic diversity of buffalo in the Namibia part of KAZA as well.

We also found areas of high buffalo preference, river floodplains, which are also areas where human development tends to focus. These findings highlight the tensions between human development and biodiversity conservation that are on the ground realities in conservation landscapes where wildlife and humans must coexist, and specifically in the development of KAZA TFCA. Through coordinated management efforts, there is the possibility of mitigating further losses in connectivity by carefully managing human development along linear features, both the rivers and roads. This study contributes to a quantitative understanding of the impact of linear structures on connectivity, which could add an extra layer of insight to connectivity planning in KAZA TFCA and other multi-use landscapes.

Chapter 3: Conclusion

3.1 Overall significance and contribution

The results of this thesis demonstrate that there are a number of linear features in the study area acting as barriers to movement of varying permeability. These results indicate that connectivity in the study area is compromised by a combination of man-made and natural features. The movement and crossing models reveal that buffalo alter their behaviour when in proximity to, and crossing, linear barriers. Natural linear features such as rivers contain adjacent habitat for buffalo, which slow their movement in river floodplains. Humans also prefer this high quality habitat, and so the potential for human-wildlife conflict may arise as the human population in this region continues to grow (this has been observed in adjacent Zambia; Matawa et al., 2012). Buffalo increase their speed when crossing roads, and are more likely to cross roads further from human settlements. This suggests that roads are undesirable habitat for buffalo. The avoidance of crossing near human settlements is likely due to the associated human presence, infrastructure, and traffic. Roads bisect the study area from east to west and are a potential source of further connectivity loss in the region. Fences were opportunistically crossed, indicating that, were there no fence, buffalo would likely roam freely between Botswana and Namibia. These results are significant for the planning of the KAZA TFCA and Namibia's CBNRM program, both of which rely on healthy wildlife populations for generating revenue.

As the human population in Namibia (and sub-Saharan Africa in general) is increasing, it's likely that these connectivity issues will become exacerbated in the future, as the landscape matrix outside of protected areas becomes more crowded, and roads become busier. Conservation managers will likely need to think creatively about how to maintain functional

connectivity within KAZA to ensure that it works as a connected network of protected areas, and not a set of isolated habitat patches.

3.2 Analysis and integration of the research

The research performed in this thesis contributes a novel application to two niches of movement ecology studies: those that aim to provide tangible results for applied conservation problems, and those that aim to further the scientific understanding of linear barriers on wildlife movement. There is some overlap between these two aims in movement ecology – all studies of impacts of linear barriers can contribute to conservation initiatives, but not all are directly relevant to a specific initiative. Many studies of the impacts of linear barriers on movement occur in industrial landscapes, due to the prevalence of roads, fences, seismic lines, and other human developments in these areas that pose as threats to wildlife movement. In the KAZA TFCA, connectivity has been studied in lions, and a predator guild including lions, cheetahs, hyena, and wild dog (Cozzi et al., 2013; Elliot et al., 2014). This study adds an understanding of impacts of linear barriers on the movement of a large herbivore to the body of connectivity knowledge for KAZA. The aforementioned studies examined crossing behaviour in the first case, and full movement paths in the second case; our study examined both crossing behaviour and behaviour in proximity to impermeable barriers, demonstrating that understanding both crossing and non-crossing proximate behaviour are important to understanding the influence of linear features and barriers on wildlife movement. There are other similar initiatives to KAZA and the CBNRM program in southern Africa, and the findings of this study can apply broadly to the understanding of barriers on wildlife movement throughout multi-use regions aiming to balance biodiversity conservation with human wellbeing.

With respect to methods in the analysis of the impacts of linear barriers on movement, we are unaware of another study that has employed multi-model averaging. This method is relatively simple compared to those employed in other studies, but we have shown that it can provide meaningful results contributing to conservation planning and the general understanding of wildlife movement, especially in response to potential barriers to movement. Our general movement model method is similar to the step selection function (e.g. Coulon et al., 2008; Roever et al., 2010), but rather than comparing used steps to "available" steps, we modeled observed movement metrics. Unlike the more sophisticated state space models, our model does not incorporate multiple behavioural modes into the model itself, but from our results we were able to infer different behaviours in relation to environmental variables (such as buffalo moving more slowly, with wider turn angles, in the river floodplain, indicating encamped behaviour).

Additionally, in the study of linear barrier effects on wildlife movement, researchers in the northern hemisphere have begun to quantify not just the effects of roads on movement, but the additional effects of traffic on wildlife behaviour in proximity to, and when crossing roads. Findings have demonstrated that traffic volume can create a threshold to the willingness of wildlife species to cross a road (e.g. Sheldon, 2005; Northrup et al., 2012). This has not been examined in the southern hemisphere, as far as we know. While we did not have traffic data, we were able to use human settlement data to find a similar effect – that buffalo were less likely to cross roads when closer to human settlements. This finding supports what has been found in the northern hemisphere, and demonstrates that the effect of traffic can be approximated with data that is often more freely available and does not require field work (such as recording traffic levels).

3.3 Strengths and limitations

The scope of the thesis research was limited firstly by the study dataset. The data were collected prior to my entry into the master's program. The selection of (approximately) five-hour intervals between GPS recordings fixes limited the types of behaviour could be studied. There has been a focus in the movement ecology literature on scales of movement (both temporal and spatial), and what GPS fix intervals are appropriate for scales of behavioural study (e.g. Levin, 2000; Leblond et al., 2011; Kawai & Petrovskii, 2012; Thiebault & Tremblay, 2013; Benhamou, 2014). For example, a collar set with a fix rate of <60 seconds is useful for studying fine scale movements such as area-restricted searches or similar foraging search patterns, but is not useful for the study of home range size, or migration (due to battery life restrictions of GPS units) (Fryxell et al., 2008; Postlethwaite & Dennis, 2013). Daily or less frequent GPS are useful for quantifying home ranges or tracking the larger scale movements of introduced species as they establish new home ranges (John et al., 2008). Additionally, as temporal resolution of GPS fixes becomes coarser, it becomes more difficult to use turn-angle data to distinguish between foraging and travelling states (Postlethwaite & Dennis, 2013). This can be seen in our study results, as the speed models had many more significant variables than the turn-angle models.

Another limitation to the study was the resolution of freely available satellite data. The highest resolution for freely available satellite data (EVI, rainfall, and fire data) was 250x250m. The dataset and resolution of available spatial guided our selection of analysis. Initially, we hoped to build a predictive model of buffalo movement, but buffalo select forage based on grass species, or the protein content in grasses, and a 250x250m resolution is too coarse to distinguish grass species composition. Additionally, migrating or dispersing buffalo track pans in the wet season for their water sources, but pans are also smaller than 250x250m (in most cases) and

could not be detected by the EVI data. Buffalo are driven by bottom up process more than top down (although predation does have an influence on movement) (Grange & Duncan, 2006; Winnie et al., 2008), and it would be difficult to model their movement accurately without taking into account these two major drivers of movement.

Just as the GPS fix resolution limits the type of analysis, it also suits certain analyses quite well. The GPS fix rate of five hours allowed the collars to run for multiple years. Data were collected over the course of six years on 36 different buffalo, and overall there are data from six wet seasons and five dry seasons. Having multi-year data dampens the effect of seasonal variability on buffalo movement, and helps to draw out the effect of the variables of interest, linear barriers. Additionally, the 36 buffalo in the dataset were collared in seven different sites, allowing us to explore the different movement patterns between sites with different features (e.g. some sites were partially or fully fenced, and some had no fences nearby).

The analysis would have benefitted from additional data describing factors relevant to buffalo movement, such as hunting pressure and lion predation. As the conservancies in Namibia's CBNRM program rely on trophy hunting for a significant portion of their income, it would be important to understand if hunting pressure affects buffalo movement (NACSO, 2014). More generally, including hunting and predation in the analysis would create a fuller understanding of the drivers of buffalo movement, allowing us to more accurately predict the effect of linear barriers on movement.

The simplicity of the analysis is one of the strengths of the study. The analysis performed was transparent and replicable, requiring knowledge of the software programs R and ArcGIS, and much of the data, particularly relating to environmental and infrastructure development is freely available. More sophisticated methods are often employed in movement modeling, with

state-space models (requiring the ability to understand and build state-space equations) being at the forefront of movement ecology methods. Although we sacrificed sophisticated computation methods, this study shows that relevant results can be obtained from using much simpler methods.

The interpretation of movement model results is limited by the way we constructed this set of models. We chose to model all collars individually, as well as grouped by site, and finally all animals grouped together. For the model with all buffalo together, the individuals with a larger number of data points would have a stronger influence on parameter estimation than the individuals with less data points. This may have resulted in some bias in the results toward over-representing the sites that had more data points. We compensated for this by modeling all collars individually; this allowed us to compare what variables were significant between the overall models and the site/individual models. This approach allowed us to discern patterns that were common across the entire study area, such as buffalo moving more slowly in the river floodplains, versus site level or individual differences in what variables were important to movement. An alternate approach would have been to construct a hierarchical model with individual as a random effect, which would have been a compromise between modeling all buffalo individually and the fully pooled model (Jackman, 2008). As we have individual and pooled results, our analysis spans what we would expect a hierarchical analysis to produce.

3.4 Potential applications

The findings from this study are relevant for the planning of Namibia's CBNRM program and the KAZA TFCA. Both programs are focused on the conservation of wildlife species while also encouraging economic growth. The population in Namibia is growing, and with this growth

will come further human development (Namibia Statistics Agency, 2011). This development has the potential to impact buffalo movement by increasing traffic along roads, increasing the size of urban areas, adding infrastructure such as fences and roads, and crowding high quality habitat areas (such as river floodplains) preferred by both humans and buffalo. This study has provided the beginnings of an understanding of how linear features in the study area affect buffalo movement, and what factors contribute to the permeability of roads.

As noted in Chapter 2, researchers have identified a set of important corridors throughout the KAZA TFCA, and the top priority corridor passes through the Kavango and Zambezi regions of Namibia. The researchers outlined potential impediments to movement through these corridors, including human use. This study confirms that anthropogenic presence and structures can potentially impact the functioning of this corridor, especially with further human growth expected in the region.

3.5 Possible future research directions

Building upon this analysis, it is possible to delve further into the impacts of barriers on buffalo movement. Similar studies have built least-cost path networks based on resistance surfaces to demonstrate the best possible dispersal and migratory corridors for wildlife species (Coulon et al., 2008; Cushman & Lewis, 2010; Squires et al., 2013; Elliot et al., 2014). These studies can help planners identify current best options for corridors, and view visually on a map the least amenable regions to wildlife travel.

With the addition of traffic data, it would be possible to more completely understand the role of the roads in the study area as barriers to movement. Studies have found traffic thresholds where a road switches from semi-permeable to impermeable; such a threshold would be very

useful to planners in the region and simple monitoring techniques could mitigate the loss of road permeability to wildlife.

Hunting pressure would be another relevant layer of data to add into the study in the future. Anthropogenic hunting pressure data could be collected through the CBNRM program in Namibia; currently kills are recorded at the resolution of the conservancy, which is too low resolution to be of use in a statistical analysis (R. Naidoo pers. comm.). Lion hunting pressure could be accounted for by GPS collaring lions and tracking their movement, and/or by having local people and hunters collect data on buffalo kills, as other than humans, lions are the main predator for buffalo.

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Appendices

Appendix A Additional Statistical Results

This appendix contains additional statistical results, referred to in the results section of Chapter 2.

A.1 Additional results from movement model, split by site

Table A.1 All collars, dry season, turn angle model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
River buffer	0.013	0.015	0.875	0.381	-0.016	0.043
Road buffer	-0.079	0.026	3.039	0.002	-0.130	-0.028
Rain	0.022	0.023	0.955	0.340	-0.023	0.067
Lag angle	0.080	0.013	6.076	< 0.001	0.054	0.106
Speed	-0.082	0.013	6.140	< 0.001	-0.108	-0.056
EVI^2	-0.001	0.009	0.159	0.874	-0.018	0.015
EVI	-0.001	0.007	0.107	0.915	-0.015	0.014
In omuramba	-0.002	0.016	0.144	0.885	-0.035	0.030
Day	0.000	0.007	0.010	0.992	-0.014	0.013

Table A.2 All collars, wet season, turn angle model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
River buffer	0.045	0.018	2.506	0.012	0.010	0.081
Day	-0.014	0.014	0.998	0.318	-0.043	0.014
Rain	0.013	0.014	0.943	0.346	-0.015	0.041
EVI	-0.025	0.016	1.634	0.102	-0.056	0.005
Lag angle	0.055	0.012	4.474	<0.001	0.031	0.079
Speed	-0.098	0.012	7.990	<0.001	-0.122	-0.074
In omuramba	-0.002	0.011	0.197	0.844	-0.025	0.020
Road buffer	-0.002	0.012	0.138	0.890	-0.025	0.022
EVI^2	-0.001	0.007	0.099	0.921	-0.013	0.012

Table A.3 Buffalo Core, dry season, turn angle model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
In omuramba	-0.117	0.090	1.297	0.194	-0.293	0.060
EVI	-0.076	0.047	1.626	0.104	-0.167	0.016
Speed	-0.036	0.041	0.882	0.378	-0.116	0.044
Settlement	-0.021	0.035	0.603	0.547	-0.090	0.048
River buffer	0.017	0.033	0.518	0.604	-0.048	0.082
Pan	0.006	0.022	0.257	0.797	-0.038	0.050
Road buffer	0.010	0.046	0.214	0.831	-0.080	0.100
Day	-0.003	0.020	0.154	0.878	-0.042	0.036
Rain	0.003	0.025	0.120	0.904	-0.046	0.053
EVI^2	-0.006	0.032	0.178	0.858	-0.068	0.057
Lag angle	0.002	0.019	0.119	0.905	-0.036	0.040

Table A.4 Buffalo core, dry season, speed model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Intercept	-1.815	0.027	67.938	< 0.001	-1.867	-1.762
River buffer	-0.251	0.057	4.403	< 0.001	-0.362	-0.139
Road buffer	-0.216	0.133	1.624	0.104	-0.476	0.045
Day	-0.226	0.048	4.704	< 0.001	-0.320	-0.132
Rain	0.088	0.078	1.137	0.255	-0.064	0.240
Angle	-0.040	0.051	0.785	0.432	-0.139	0.060
Pan	0.114	0.062	1.828	0.067	-0.008	0.236
Settlement	-0.117	0.067	1.744	0.081	-0.248	0.014
EVI	0.051	0.057	0.888	0.374	-0.061	0.163
Lag speed	0.174	0.049	3.514	< 0.001	0.077	0.270
EVI^2	0.016	0.048	0.340	0.734	-0.078	0.111
In omuramba	-0.003	0.050	0.068	0.946	-0.102	0.095

Table A.5 Buffalo core, wet season, turn angle model

Variable	Estimate	Std. Error Ad	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
River buffer	0.140	0.052	2.714	0.007	0.039	0.241
Day	0.031	0.034	0.892	0.373	-0.037	0.098
Lag angle	0.050	0.038	1.320	0.187	-0.024	0.124
Speed	-0.077	0.036	2.139	0.032	-0.147	-0.006
Fence buffer	-0.029	0.054	0.534	0.594	-0.134	0.076
EVI	-0.013	0.025	0.506	0.613	-0.062	0.037
In omuramba	0.018	0.038	0.488	0.626	-0.056	0.092
Road buffer	0.016	0.040	0.395	0.693	-0.063	0.094
Settlement	-0.004	0.022	0.200	0.841	-0.048	0.039
Pan	-0.002	0.017	0.140	0.889	-0.036	0.031
Rain	0.001	0.016	0.052	0.959	-0.030	0.032
EVI^2	0.001	0.018	0.078	0.938	-0.033	0.036

Table A.6 Buffalo core, wet season, speed model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
River buffer	0.123	0.074	1.664	0.096	-0.022	0.267
Road buffer	-0.219	0.075	2.915	0.004	-0.366	-0.072
Day	-0.129	0.037	3.505	0.000	-0.202	-0.057
Angle	-0.082	0.043	1.892	0.058	-0.167	0.003
Pan	-0.102	0.045	2.269	0.023	-0.189	-0.014
EVI	-0.229	0.038	6.038	< 0.001	-0.303	-0.154
EVI^2	0.148	0.042	3.554	< 0.001	0.066	0.230
Lag speed	0.114	0.039	2.938	0.003	0.038	0.190
Fence buffer	-0.025	0.057	0.431	0.666	-0.137	0.087
Settlement	-0.021	0.041	0.524	0.600	-0.102	0.059
Rain	0.009	0.025	0.378	0.705	-0.039	0.057
In omuramba	0.012	0.037	0.333	0.739	-0.060	0.085

Table A.7 Eastern floodplain, dry season, turn angle model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Day	0.017	0.035	0.505	0.614	-0.050	0.085
River buffer	0.016	0.034	0.480	0.631	-0.050	0.083
Fire	-0.033	0.069	0.482	0.630	-0.169	0.102
Lag angle	0.015	0.032	0.453	0.650	-0.048	0.078
Speed	-0.011	0.029	0.372	0.710	-0.068	0.046
EVI^2	0.010	0.037	0.271	0.787	-0.062	0.082
EVI	0.007	0.026	0.256	0.798	-0.043	0.057
Rain	0.000	0.034	0.011	0.991	-0.067	0.067

Table A.8 Eastern floodplain, dry season, speed model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
River buffer	-0.114	0.061	1.884	0.060	-0.233	0.005
Day	-0.260	0.050	5.220	0.000	-0.357	-0.162
Fire	0.274	0.117	2.335	0.020	0.044	0.504
EVI	0.319	0.050	6.385	<2e-16	0.221	0.417
EVI^2	-0.391	0.071	5.544	<2e-16	-0.529	-0.253
Rain	0.037	0.066	0.564	0.573	-0.092	0.167
Angle	-0.010	0.031	0.313	0.755	-0.070	0.051
Lag Speed	0.004	0.028	0.155	0.877	-0.050	0.059

Table A.9 Eastern floodplain, wet season, turn angle model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
River buffer	0.050	0.045	1.111	0.267	-0.038	0.137
Day	-0.233	0.035	6.701	<0.001	-0.301	-0.165
Lag angle	0.027	0.035	0.760	0.447	-0.043	0.097
Speed	-0.053	0.043	1.247	0.213	-0.136	0.030
EVI	0.013	0.028	0.449	0.654	-0.043	0.068
EVI^2	0.008	0.024	0.349	0.727	-0.039	0.056
Rain	0.006	0.021	0.268	0.789	-0.035	0.047

Table A.10 Eastern floodplain, wet season, speed model

Variable	Estimate	Std. Error	z-value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
River buffer	-0.126	0.040	3.122	0.002	-0.205	-0.047
Day	-0.199	0.035	5.654	<0.001	-0.269	-0.130
Angle	-0.052	0.042	1.235	0.217	-0.136	0.031
EVI	0.246	0.037	6.643	<0.001	0.174	0.319
EVI^2	-0.217	0.036	5.943	<0.001	-0.288	-0.145
Rain	-0.008	0.023	0.357	0.721	-0.054	0.037
Lag speed	-0.003	0.020	0.173	0.863	-0.042	0.035

Table A.11 Horseshoe, dry season, turn angle model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Settlement	-0.047	0.061	0.769	0.442	-0.166	0.073
Lag angle	0.049	0.053	0.920	0.358	-0.056	0.154
Speed	-0.042	0.051	0.821	0.412	-0.141	0.058
EVI	0.054	0.063	0.845	0.398	-0.071	0.178
EVI^2	-0.019	0.053	0.355	0.723	-0.124	0.086
Rain	-0.016	0.050	0.328	0.743	-0.115	0.082
Day	-0.012	0.032	0.373	0.709	-0.075	0.051
In omuramba	-0.002	0.043	0.057	0.955	-0.088	0.083
River buffer	0.004	0.036	0.098	0.922	-0.068	0.075

Table A.12 Horseshoe, dry season, speed model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Day	0.100	0.066	1.517	0.129	-0.029	0.229
Rain	0.247	0.097	2.542	0.011	0.057	0.438
Lag speed	0.224	0.053	4.237	0.000	0.120	0.327
Angle	-0.036	0.052	0.691	0.490	-0.137	0.066
Settlement	-0.034	0.061	0.565	0.572	-0.153	0.085
EVI	-0.024	0.055	0.436	0.663	-0.131	0.084
In omuramba	0.005	0.048	0.111	0.912	-0.089	0.100
River buffer	0.009	0.044	0.201	0.840	-0.077	0.095
EVI^2	0.006	0.047	0.137	0.891	-0.086	0.099

Table A.13 Horseshoe, wet season, turn angle model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Speed	-0.082	0.051	1.613	0.107	-0.181	0.018
EVI	-0.030	0.043	0.691	0.489	-0.114	0.055
EVI^2	0.018	0.034	0.520	0.603	-0.049	0.085
In omuramba	-0.014	0.033	0.433	0.665	-0.078	0.050
Rain	-0.006	0.024	0.249	0.803	-0.054	0.041
Day	-0.005	0.023	0.208	0.835	-0.049	0.040
Settlement	-0.010	0.028	0.347	0.729	-0.066	0.046
Fence buffer	0.007	0.037	0.198	0.843	-0.065	0.079
Lag angle	0.001	0.021	0.055	0.956	-0.040	0.042

Table A.14 Horseshoe, wet season, speed model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Day	-0.047	0.052	0.903	0.367	-0.150	0.055
Angle	-0.098	0.055	1.782	0.075	-0.206	0.010
Settlement	0.124	0.057	2.177	0.030	0.012	0.236
EVI	-0.347	0.050	6.984	<0.001	-0.445	-0.250
Lag speed	0.567	0.047	12.135	<0.001	0.475	0.658
Fence buffer	-0.035	0.063	0.546	0.585	-0.158	0.089
In omuramba	0.016	0.037	0.425	0.671	-0.056	0.087
Rain	0.013	0.033	0.388	0.698	-0.052	0.078
EVI^2	0.005	0.026	0.178	0.858	-0.047	0.056

Table A.15 Mahango, dry season, turn angle model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Road buffer	-0.177	0.085	2.084	0.037	-0.343	-0.010
Day	-0.065	0.073	0.888	0.375	-0.207	0.078
In omuramba	0.174	0.163	1.068	0.285	-0.145	0.493
EVI^2	-0.042	0.059	0.719	0.472	-0.157	0.073
Lag angle	0.033	0.054	0.604	0.546	-0.073	0.138
Rain	-0.026	0.055	0.469	0.639	-0.133	0.081
River buffer	-0.018	0.053	0.343	0.732	-0.122	0.085
Speed	-0.008	0.035	0.217	0.828	-0.075	0.060
EVI	0.008	0.039	0.213	0.831	-0.067	0.084

Table A.16 Mahango, dry season, speed model

Variable	Estimate	Std. Error	value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Road buffer	0.339	0.115	2.955	0.003	0.114	0.564
Day	-0.381	0.099	3.837	0.000	-0.576	-0.186
In omuramba	0.142	0.204	0.694	0.488	-0.258	0.542
Rain	0.096	0.118	0.816	0.414	-0.135	0.327
EVI^2	0.236	0.103	2.287	0.022	0.034	0.438
Lag speed	-0.152	0.116	1.311	0.190	-0.379	0.075
EVI	0.020	0.065	0.304	0.761	-0.107	0.147
Angle	-0.011	0.052	0.216	0.829	-0.113	0.091
River buffer	-0.003	0.062	0.050	0.960	-0.125	0.119

Table A.17 Mahango, wet season, turn angle model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
In omuramba	0.226	0.164	1.378	0.168	-0.095	0.546
Lag angle	0.255	0.072	3.543	<0.001	0.114	0.397
Speed	-0.119	0.089	1.338	0.181	-0.292	0.055
Fence buffer	0.060	0.084	0.707	0.479	-0.106	0.225
River buffer	0.054	0.114	0.475	0.635	-0.170	0.279
EVI	0.022	0.054	0.414	0.679	-0.084	0.128
Road buffer	-0.015	0.047	0.317	0.751	-0.106	0.077
EVI^2	0.004	0.026	0.168	0.867	-0.047	0.055
Day	0.011	0.044	0.245	0.806	-0.076	0.098
Rain	-0.003	0.037	0.070	0.944	-0.075	0.070

Table A.18 Mahango, wet season, speed model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Day	-0.485	0.078	6.193	<0.001	-0.638	-0.331
In omuramba	0.211	0.173	1.216	0.224	-0.129	0.551
Angle	-0.156	0.092	1.692	0.091	-0.336	0.025
Lag speed	-0.577	0.076	7.605	<0.001	-0.725	-0.428
Rain	0.041	0.068	0.608	0.543	-0.092	0.175
Road buffer	-0.027	0.058	0.454	0.650	-0.141	0.088
Fence buffer	0.027	0.064	0.419	0.675	-0.099	0.152
River buffer	0.025	0.093	0.266	0.790	-0.158	0.208
EVI	0.008	0.045	0.185	0.854	-0.080	0.097
EVI^2	-0.006	0.028	0.217	0.828	-0.061	0.048

Table A.19 Nkasa Rupara, dry season, turn angle model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Rain	0.056	0.053	1.069	0.285	-0.047	0.159
Lag angle	0.139	0.028	4.954	<0.001	0.084	0.193
Day	-0.017	0.026	0.631	0.528	-0.069	0.035
Settlement	-0.015	0.025	0.599	0.549	-0.065	0.035
EVI	0.012	0.023	0.500	0.617	-0.034	0.057
EVI^2	-0.009	0.025	0.374	0.708	-0.058	0.040
Speed	-0.002	0.015	0.104	0.917	-0.031	0.028
River buffer	0.002	0.017	0.121	0.903	-0.031	0.036

Table A.20 Nkasa Rupara, dry season, speed model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
River buffer	-0.048	0.037	1.300	0.194	-0.121	0.025
Day	0.270	0.027	10.120	<0.001	0.218	0.322
Rain	0.077	0.051	1.514	0.130	-0.023	0.176
Settlement	0.206	0.027	7.703	<0.001	0.154	0.258
Lag speed	0.052	0.033	1.581	0.114	-0.012	0.116
EVI^2	0.018	0.031	0.600	0.549	-0.042	0.079
EVI	-0.002	0.015	0.145	0.885	-0.031	0.027
Angle	0.000	0.014	0.000	1.000	-0.027	0.027

Table A.21 Nkasa Rupara, wet season, turn angle model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
River buffer	-0.030	0.037	0.808	0.419	-0.101	0.042
Day	-0.036	0.034	1.063	0.288	-0.103	0.031
Settlement	-0.063	0.035	1.787	0.074	-0.132	0.006
EVI	0.032	0.036	0.885	0.376	-0.039	0.104
EVI^2	-0.129	0.034	3.784	< 0.001	-0.196	-0.062
Lag angle	0.114	0.028	4.021	< 0.001	0.058	0.169
Speed	-0.030	0.033	0.921	0.357	-0.094	0.034
Rain	0.003	0.016	0.200	0.842	-0.029	0.036

Table A.22 Nkasa Rupara, wet season, speed model

Variable	Estimate	Std. Error	z-value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
River buffer	0.027	0.032	0.838	0.402	-0.036	0.091
Day	-0.055	0.030	1.828	0.067	-0.115	0.004
Rain	0.120	0.025	4.712	<0.001	0.070	0.169
Angle	-0.026	0.028	0.922	0.356	-0.081	0.029
Settlement	0.212	0.025	8.463	<0.001	0.163	0.261
EVI	-0.100	0.030	3.374	0.001	-0.158	-0.042
EVI^2	0.104	0.030	3.509	<0.001	0.046	0.162
Lag speed	-0.053	0.031	1.751	0.080	-0.113	0.006

Table A.23 Mudumu, dry season, turn angle model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Road buffer	-0.159	0.043	3.718	<0.001	-0.243	-0.075
Day	0.058	0.037	1.554	0.120	-0.015	0.130
Pan	0.089	0.037	2.414	0.016	0.017	0.162
Lag angle	0.098	0.031	3.222	0.001	0.039	0.158
Speed	-0.096	0.031	3.088	0.002	-0.157	-0.035
River buffer	0.028	0.041	0.699	0.484	-0.051	0.108
Settlement	0.026	0.038	0.681	0.496	-0.048	0.100
EVI	0.020	0.034	0.582	0.561	-0.046	0.086
EVI^2	-0.017	0.034	0.503	0.615	-0.085	0.050
Rain	0.003	0.028	0.118	0.906	-0.052	0.059

Table A.24 Mudumu, dry season, speed model

Variable	Estimate	Std. Error	value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
River buffer	-0.284	0.046	6.222	<0.001	-0.374	-0.195
Day	-0.104	0.036	2.913	0.004	-0.174	-0.034
Rain	0.255	0.060	4.271	<0.001	0.138	0.372
Angle	-0.108	0.034	3.150	0.002	-0.175	-0.041
Settlement	0.261	0.039	6.677	<0.001	0.184	0.337
EVI	-0.139	0.040	3.435	0.001	-0.218	-0.060
Lag speed	-0.245	0.033	7.417	<0.001	-0.309	-0.180
Road buffer	0.011	0.031	0.374	0.708	-0.049	0.072
EVI^2	0.009	0.030	0.311	0.756	-0.049	0.068
Pan	-0.003	0.020	0.159	0.873	-0.042	0.035

Table A.25 Mudumu, wet season, turn angle model

Variables	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Rain	0.067	0.036	1.876	0.061	-0.003	0.137
Speed	-0.133	0.029	4.552	<0.001	-0.191	-0.076
River buffer	-0.029	0.042	0.682	0.496	-0.111	0.054
Pan	-0.017	0.027	0.637	0.524	-0.071	0.036
Settlement	-0.006	0.021	0.274	0.784	-0.047	0.035
Road buffer	-0.003	0.032	0.098	0.922	-0.066	0.060
EVI^2	-0.001	0.018	0.070	0.944	-0.036	0.034
EVI	0.001	0.016	0.059	0.953	-0.030	0.032
Lag angle	-0.001	0.015	0.074	0.941	-0.031	0.029
Day	-0.001	0.015	0.059	0.953	-0.031	0.029

Table A.26 Mudumu, wet season, speed model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Road buffer	0.024	0.033	0.725	0.468	-0.040	0.088
Day	-0.127	0.023	5.584	<0.001	-0.172	-0.083
Rain	0.086	0.023	3.720	<0.001	0.041	0.132
Angle	-0.081	0.023	3.524	<0.001	-0.126	-0.036
EVI	-0.330	0.024	13.872	<0.001	-0.377	-0.283
EVI^2	0.102	0.025	4.149	<0.001	0.054	0.150
Lag speed	0.288	0.023	12.517	<0.001	0.243	0.333
In omuramba	0.019	0.027	0.733	0.463	-0.033	0.072
Fence butter	-0.020	0.043	0.465	0.642	-0.104	0.064
Settlement	0.001	0.012	0.101	0.919	-0.023	0.025

Table A.27 Susuwe, dry season, turn angle model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
River buffer	-0.083	0.042	1.976	0.048	-0.166	-0.001
Road buffer	0.100	0.079	1.271	0.204	-0.054	0.255
Rain	0.050	0.048	1.043	0.297	-0.044	0.145
Pan	0.110	0.035	3.181	0.001	0.042	0.177
EVI	-0.096	0.034	2.856	0.004	-0.162	-0.030
Speed	-0.128	0.029	4.457	<0.001	-0.184	-0.071
Day	-0.006	0.018	0.312	0.755	-0.042	0.030
In omuramba	0.012	0.033	0.371	0.710	-0.052	0.076
EVI^2	-0.007	0.025	0.265	0.791	-0.055	0.042
Lag angle	0.002	0.015	0.108	0.914	-0.028	0.031
Settlement	-0.005	0.027	0.187	0.852	-0.059	0.049

Table A.28 Susuwe, dry season, speed model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
River buffer	-0.170	0.041	4.137	<0.001	-0.250	-0.089
Day	-0.262	0.032	8.303	<0.001	-0.324	-0.200
Angle	-0.143	0.031	4.605	<0.001	-0.205	-0.082
Pan	-0.089	0.043	2.089	0.037	-0.173	-0.006
EVI	-0.046	0.042	1.090	0.276	-0.130	0.037
EVI^2	0.127	0.051	2.510	0.012	0.028	0.227
Lag speed	-0.114	0.032	3.572	<0.001	-0.176	-0.051
Road buffer	0.029	0.057	0.515	0.607	-0.082	0.140
Rain	0.008	0.027	0.295	0.768	-0.046	0.062
Settlement	-0.014	0.035	0.403	0.687	-0.083	0.055
In omuramba	0.003	0.028	0.115	0.909	-0.052	0.059

Table A.29 Susuwe, wet season, turn angle model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Day	0.022	0.027	0.802	0.423	-0.032	0.076
Speed	-0.083	0.027	3.040	0.002	-0.136	-0.029
River buffer	0.031	0.051	0.598	0.550	-0.070	0.131
Rain	0.010	0.020	0.486	0.627	-0.030	0.050
Pan	0.009	0.020	0.427	0.669	-0.031	0.049
Road buffer	0.007	0.022	0.302	0.762	-0.036	0.049
EVI^2	0.003	0.017	0.172	0.863	-0.031	0.037
Lag angle	0.002	0.014	0.166	0.868	-0.025	0.030
Settlement	-0.007	0.019	0.359	0.720	-0.045	0.031
EVI	0.000	0.014	0.025	0.980	-0.028	0.028
In omuramba	0.002	0.017	0.134	0.893	-0.030	0.035

Table A.30 Susuwe, wet season, speed model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Road buffer	0.020	0.032	0.628	0.530	-0.043	0.084
Day	-0.171	0.026	6.602	<0.001	-0.221	-0.120
Rain	0.148	0.026	5.668	<0.001	0.097	0.199
Angle	-0.080	0.027	2.955	0.003	-0.134	-0.027
Settlement	-0.101	0.030	3.325	0.001	-0.161	-0.041
EVI	-0.304	0.028	11.030	<0.001	-0.358	-0.250
EVI^2	0.162	0.032	5.079	<0.001	0.099	0.224
Lag speed	0.159	0.026	6.073	<0.001	0.107	0.210
Pan	-0.012	0.024	0.491	0.623	-0.059	0.035
In omuramba	0.011	0.024	0.467	0.641	-0.036	0.059
River buffer	-0.020	0.045	0.440	0.660	-0.108	0.068

A.2 Additional results from movement model, split by collar

Table A.31 77264, dry season, angle model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Settlement	-0.062	0.088	0.705	0.481	-0.236	0.111
Speed	0.094	0.099	0.951	0.342	-0.100	0.287
EVI^2	-0.028	0.076	0.361	0.718	-0.177	0.122
Day	0.022	0.060	0.374	0.708	-0.095	0.140
Rain	0.030	0.081	0.372	0.710	-0.129	0.189
River buffer	0.006	0.050	0.122	0.903	-0.092	0.104
Lag angle	-0.012	0.049	0.240	0.810	-0.108	0.085
EVI	0.006	0.046	0.138	0.890	-0.083	0.096

Table A.32 77264, dry season, speed model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Day	0.255	0.100	2.542	0.011	0.058	0.451
Rain	0.121	0.137	0.884	0.377	-0.148	0.390
Angle	0.090	0.098	0.920	0.357	-0.102	0.282
Settlement	0.174	0.113	1.541	0.123	-0.047	0.396
Lag speed	0.048	0.079	0.604	0.546	-0.107	0.203
River buffer	-0.024	0.065	0.360	0.719	-0.151	0.104
EVI	0.016	0.053	0.293	0.769	-0.089	0.119
EVI^2	-0.01	0.062	0.104	0.917	-0.128	0.115

Table A.33 77264, wet season, angle model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
River buffer	0.139	0.160	0.867	0.386	-0.175	0.453
Settlement	-0.427	0.159	2.675	0.007	-0.739	-0.114
EVI^2	-0.422	0.150	2.816	0.005	-0.716	-0.128
Speed	0.035	0.083	0.423	0.672	-0.128	0.198
Lag angle	-0.006	0.060	0.093	0.926	-0.123	0.112
EVI	0.001	0.070	0.018	0.986	-0.137	0.140
Rain	0.000	0.058	0.008	0.994	-0.114	0.115
Day	0.000	0.058	0.002	0.998	-0.115	0.115

Table A.34 77264, wet season, speed model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Settlement	0.323	0.106	3.028	0.002	0.114	0.532
EVI	-0.095	0.105	0.899	0.369	-0.301	0.112
Lag speed	0.078	0.094	0.831	0.406	-0.106	0.262
Day	0.038	0.072	0.532	0.595	-0.102	0.179
Rain	0.030	0.067	0.454	0.650	-0.101	0.161
Angle	0.032	0.067	0.472	0.637	-0.100	0.163
River buffer	0.020	0.068	0.285	0.776	-0.115	0.154
EVI^2	-0.005	0.061	0.080	0.936	-0.126	0.116

Table A.35 77264new, dry season, angle model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Lag angle	0.054	0.066	0.816	0.415	-0.075	0.183
Rain	0.053	0.094	0.563	0.573	-0.131	0.236
River buffer	-0.027	0.057	0.479	0.632	-0.139	0.084
Day	-0.007	0.034	0.195	0.846	-0.073	0.060
Settlement	-0.002	0.032	0.072	0.943	-0.065	0.060
EVI	-0.002	0.033	0.075	0.940	-0.067	0.062
Speed	-0.001	0.032	0.040	0.968	-0.063	0.061
EVI^2	-0.001	0.044	0.026	0.979	-0.087	0.085

Table A.36 77264new, dry season, speed model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
River buffer	-0.067	0.070	0.951	0.342	-0.204	0.071
Day	0.195	0.051	3.814	<0.001	0.095	0.296
Settlement	0.159	0.055	2.898	0.004	0.051	0.266
Lag speed	0.045	0.055	0.817	0.414	-0.063	0.152
EVI^2	0.040	0.065	0.622	0.534	-0.086	0.167
Rain	0.006	0.048	0.131	0.896	-0.088	0.101
EVI	-0.004	0.028	0.152	0.879	-0.060	0.051
Angle	0.000	0.026	0.001	1.000	-0.051	0.051

Table A.37 77264new, wet season, angle model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Rain	-0.089	0.072	1.222	0.222	-0.231	0.054
EVI	0.115	0.073	1.576	0.115	-0.028	0.258
Speed	-0.078	0.070	1.126	0.260	-0.215	0.058
Settlement	-0.045	0.060	0.754	0.451	-0.163	0.072
Lag angle	0.021	0.044	0.481	0.630	-0.065	0.108
River buffer	0.018	0.047	0.381	0.703	-0.075	0.111
EVI^2	-0.015	0.051	0.288	0.773	-0.114	0.085
Day	-0.006	0.032	0.182	0.856	-0.068	0.056

Table A.38 77264new, wet season, speed model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Day	-0.039	0.053	0.737	0.461	-0.143	0.065
Rain	0.079	0.066	1.193	0.233	-0.051	0.208
Angle	-0.062	0.061	1.011	0.312	-0.181	0.058
Settlement	0.220	0.052	4.179	<0.001	0.117	0.322
EVI^2	0.173	0.082	2.114	0.035	0.013	0.334
Lag speed	0.014	0.036	0.382	0.703	-0.056	0.084
River buffer	0.006	0.035	0.178	0.859	-0.062	0.074
EVI	0.006	0.032	0.198	0.843	-0.057	0.069

Table A.39 77266, dry season, angle model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Rain	0.066	0.083	0.789	0.430	-0.097	0.229
Settlement	0.158	0.060	2.653	0.008	-0.275	-0.041
Lag angle	0.167	0.057	2.948	0.003	0.056	0.278
River buffer	0.034	0.054	0.631	0.528	-0.072	0.141
Day	-0.022	0.044	0.504	0.614	-0.108	0.064
EVI^2	-0.022	0.052	0.424	0.672	-0.125	0.080
Speed	-0.009	0.032	0.271	0.787	-0.072	0.054
EVI	0.005	0.030	0.177	0.859	-0.053	0.064

Table A.40 77266, dry season, speed model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Day	0.284	0.048	5.882	<0.001	0.189	0.378
Settlement	0.115	0.058	1.971	0.049	0.001	0.229
EVI	-0.054	0.055	0.971	0.332	-0.163	0.055
EVI^2	0.073	0.075	0.972	0.331	-0.074	0.219
Rain	0.023	0.052	0.438	0.661	-0.080	0.125
Angle	-0.009	0.029	0.309	0.757	-0.067	0.049
River buffer	-0.004	0.028	0.159	0.874	-0.060	0.051
Lag speed	0.003	0.025	0.126	0.899	-0.046	0.053

Table A.41 77266, wet season, angle model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
River buffer	-0.053	0.070	0.755	0.450	-0.191	0.085
EVI^2	-0.199	0.064	3.109	0.002	-0.325	-0.074
Lag angle	0.261	0.057	4.582	<0.001	0.149	0.372
EVI	0.013	0.043	0.311	0.755	-0.070	0.097
Speed	-0.011	0.035	0.302	0.763	-0.080	0.059
Settlement	-0.013	0.038	0.338	0.735	-0.087	0.061
Day	-0.011	0.036	0.301	0.763	-0.081	0.059
Rain	0.009	0.035	0.255	0.799	-0.059	0.077

Table A.42 77266, wet season, speed model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Rain	0.163	0.048	3.407	0.001	0.069	0.256
EVI	-0.046	0.058	0.785	0.433	-0.161	0.069
EVI^2	0.045	0.056	0.795	0.426	-0.066	0.155
Lag speed	-0.074	0.055	1.345	0.179	-0.182	0.034
Settlement	-0.034	0.046	0.741	0.459	-0.125	0.056
Angle	-0.011	0.029	0.362	0.717	-0.068	0.047
Day	0.001	0.024	0.022	0.982	-0.046	0.047
River buffer	-0.001	0.027	0.048	0.962	-0.055	0.052

Table A.43 77266new, dry season, angle model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Fire	0.312	0.207	1.503	0.133	-0.095	0.719
Lag angle	0.195	0.103	1.898	0.0577	-0.006	0.397
EVI	-0.042	0.075	0.556	0.578	-0.189	0.106
Rain	0.046	0.118	0.387	0.699	-0.185	0.276
Speed	-0.014	0.052	0.273	0.785	-0.115	0.087
Day	-0.014	0.051	0.269	0.788	-0.114	0.087
Settlement	-0.007	0.046	0.155	0.877	-0.098	0.084
EVI^2	-0.007	0.061	0.110	0.912	-0.127	0.113
River buffer	0.000	0.054	0.003	0.997	-0.106	0.107

Table A.44 77266new, dry season, speed model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
River buffer	-0.120	0.110	1.088	0.276	-0.337	0.096
Day	0.317	0.074	4.301	<0.001	0.173	0.462
Settlement	0.253	0.078	3.253	0.001	0.101	0.406
EVI	0.073	0.085	0.855	0.393	-0.094	0.240
Lag speed	0.196	0.085	2.302	0.021	0.029	0.363
EVI^2	-0.044	0.084	0.529	0.597	-0.208	0.120
Rain	0.060	0.119	0.507	0.612	-0.173	0.294
Angle	-0.004	0.038	0.100	0.920	-0.079	0.071
Fire	0.002	0.074	0.030	0.976	-0.142	0.147

Table A.45 77266new, wet season, angle model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Lag angle	0.035	0.059	0.588	0.557	-0.081	0.151
Speed	-0.034	0.059	0.577	0.564	-0.150	0.082
Day	-0.030	0.056	0.532	0.595	-0.139	0.080
Road buffer	0.024	0.082	0.293	0.770	-0.138	0.186
EVI^2	0.008	0.042	0.195	0.845	-0.074	0.090
River buffer	-0.009	0.048	0.185	0.853	-0.104	0.086
Rain	0.007	0.038	0.187	0.851	-0.067	0.081
Settlement	0.001	0.039	0.028	0.978	-0.075	0.077
EVI	-0.005	0.037	0.131	0.895	-0.078	0.068

Table A.46 77266new, wet season, speed model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Road buffer	0.426	0.158	2.688	0.007	0.115	0.737
Day	-0.097	0.077	1.258	0.209	-0.248	0.054
Settlement	0.375	0.079	4.743	<0.001	0.220	0.529
EVI	-0.216	0.074	2.894	0.004	-0.362	-0.070
EVI^2	0.125	0.092	1.358	0.175	-0.056	0.306
Angle	-0.035	0.057	0.621	0.535	-0.146	0.076
Rain	0.039	0.060	0.657	0.511	-0.078	0.157
Lag speed	-0.012	0.040	0.310	0.757	-0.090	0.065
River buffer	0.013	0.048	0.263	0.793	-0.081	0.106

Table A.47 AM290, dry season, angle model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Settlement	-0.124	0.061	2.030	0.042	-0.243	-0.004
EVI	0.113	0.063	1.776	0.076	-0.012	0.237
Lag angle	0.100	0.063	1.581	0.114	-0.024	0.224
River buffer	-0.025	0.049	0.516	0.606	-0.121	0.070
EVI^2	0.012	0.040	0.296	0.767	-0.066	0.090
Speed	-0.008	0.031	0.271	0.786	-0.068	0.052
Rain	-0.009	0.042	0.207	0.836	-0.091	0.073
Day	0.002	0.029	0.076	0.940	-0.054	0.058

Table A.48 AM290, dry season, speed model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
River buffer	-0.077	0.076	1.004	0.315	-0.226	0.073
Day	0.362	0.059	6.138	<0.001	0.2462	0.477
Settlement	0.084	0.068	1.229	0.219	-0.050	0.218
Rain	0.044	0.072	0.617	0.538	-0.096	0.185
EVI^2	0.024	0.051	0.476	0.634	-0.076	0.125
Angle	-0.010	0.034	0.299	0.765	-0.076	0.056
EVI	-0.052	0.029	0.002	0.999	-0.058	0.057
Lag speed	-0.019	0.027	0.068	0.946	-0.058	0.054

Table A.49 AM290, wet season, angle model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
River buffer	-0.115	0.082	1.401	0.161	-0.276	0.046
Rain	0.056	0.063	0.896	0.370	-0.067	0.179
Settlement	-0.152	0.062	2.448	0.014	-0.274	-0.030
EVI^2	-0.034	0.057	0.593	0.553	-0.146	0.078
Day	-0.041	0.057	0.723	0.470	-0.154	0.071
Lag angle	0.028	0.048	0.581	0.561	-0.066	0.122
EVI	-0.005	0.035	0.144	0.885	-0.074	0.064
Speed	-0.003	0.029	0.105	0.917	-0.059	0.053

Table A.50 AM290, wet season, speed model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Day	-0.043	0.053	0.803	0.422	-0.147	0.062
Rain	0.045	0.055	0.809	0.419	-0.064	0.153
Settlement	0.152	0.052	2.905	0.004	0.050	0.255
EVI	-0.085	0.074	1.142	0.254	-0.231	0.061
EVI^2	0.098	0.080	1.220	0.222	-0.059	0.255
Lag speed	-0.243	0.048	5.061	<0.001	-0.338	-0.149
River buffer	0.006	0.032	0.180	0.857	-0.058	0.069
Angle	-0.004	0.026	0.153	0.879	-0.055	0.047

Table A.51 94043, dry season, angle model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Omuramba	-0.208	0.211	0.986	0.324	-0.621	0.205
Settlement	-0.171	0.129	1.322	0.186	-0.425	0.083
Lag angle	0.076	0.086	0.885	0.376	-0.093	0.246
Rain	-0.079	0.123	0.640	0.522	-0.320	0.163
EVI	0.092	0.110	0.831	0.406	-0.125	0.308
Speed	-0.016	0.049	0.316	0.752	-0.112	0.081
EVI^2	-0.037	0.097	0.379	0.705	-0.227	0.154
River buffer	-0.020	0.070	0.286	0.775	-0.157	0.117
Day	-0.005	0.043	0.120	0.904	-0.090	0.080

Table A.52 94043, dry season, speed model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)	Variable
Rain	0.584	0.155	0.155	3.757	<0.001	0.279	0.889
Settlement	-0.313	0.129	0.129	2.419	0.016	-0.567	-0.059
EVI	-0.272	0.136	0.136	1.992	0.046	-0.539	-0.004
Lag speed	0.271	0.097	0.097	2.798	0.005	0.081	0.461
River buffer	-0.048	0.102	0.102	0.468	0.640	-0.247	0.152
EVI^2	-0.024	0.096	0.096	0.247	0.805	-0.213	0.165
Angle	-0.009	0.049	0.049	0.175	0.861	-0.104	0.087
Omuramba	-0.017	0.114	0.114	0.149	0.882	-0.240	0.206
Day	0.000	0.048	0.048	0.003	0.998	-0.095	0.095

Table A.53 94043, wet season, angle model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Day	-0.060	0.068	0.884	0.377	-0.194	0.073
Settlement	-0.056	0.072	0.784	0.433	-0.197	0.084
EVI	-0.060	0.073	0.817	0.414	-0.203	0.084
EVI^2	0.053	0.074	0.713	0.476	-0.092	0.197
Speed	-0.073	0.071	1.034	0.301	-0.212	0.066
Lag angle	0.024	0.047	0.512	0.609	-0.068	0.116
Omuramba	-0.022	0.050	0.437	0.662	-0.121	0.077
Rain	-0.001	0.033	0.036	0.971	-0.067	0.064
Road buffer	0.007	0.064	0.106	0.916	-0.118	0.131

Table A.54 94043, wet season, speed model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Day	-0.261	0.065	4.019	<0.001	-0.388	-0.134
Omuramba	0.114	0.089	1.278	0.201	-0.061	0.289
Rain	-0.060	0.073	0.825	0.410	-0.203	0.083
Angle	-0.096	0.075	1.273	0.203	-0.244	0.052
Settlement	0.225	0.077	2.922	0.003	0.074	0.376
EVI	-0.208	0.075	2.794	0.005	-0.355	-0.062
Lag speed	0.435	0.063	6.880	<0.001	0.311	0.559
Road buffer	0.020	0.075	0.264	0.791	-0.127	0.166
EVI^2	-0.007	0.042	0.156	0.876	-0.088	0.075

Table A.55 AG275, dry season, angle model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Road buffer	-0.058	0.140	0.412	0.680	-0.333	0.217
Settlement	0.037	0.075	0.489	0.625	-0.110	0.184
Omuramba	0.035	0.078	0.447	0.655	-0.117	0.187
Day	-0.026	0.061	0.421	0.674	-0.146	0.094
Speed	-0.015	0.052	0.290	0.772	-0.117	0.087
EVI^2	-0.012	0.064	0.187	0.852	-0.138	0.114
Rain	0.008	0.069	0.116	0.907	-0.128	0.144
EVI	-0.002	0.048	0.045	0.964	-0.097	0.093
River buffer	-0.015	0.093	0.159	0.873	-0.198	0.168
Lag angle	0.003	0.044	0.079	0.937	-0.083	0.090

Table A.56 AG275, dry season, speed model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Settlement	0.113	0.124	0.911	0.362	-0.130	0.355
EVI^2	0.167	0.154	1.087	0.277	-0.134	0.469
River buffer	-0.094	0.169	0.554	0.579	-0.427	0.238
Lag speed	0.044	0.079	0.549	0.583	-0.112	0.199
Day	0.032	0.070	0.461	0.645	-0.106	0.171
Omuramba	0.022	0.071	0.304	0.761	-0.118	0.162
Rain	0.039	0.100	0.388	0.698	-0.157	0.235
Angle	-0.016	0.056	0.282	0.778	-0.125	0.094
EVI	-0.002	0.058	0.042	0.966	-0.117	0.112
Road buffer	0.000	0.118	0.002	0.999	-0.232	0.231

Table A.57 AG275, wet season, angle model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Speed	-0.068	0.080	0.849	0.396	-0.224	0.089
EVI^2	0.023	0.043	0.529	0.597	-0.061	0.106
EVI	0.031	0.060	0.516	0.606	-0.087	0.149
Lag angle	-0.027	0.056	0.480	0.631	-0.137	0.083
Rain	-0.026	0.057	0.462	0.644	-0.138	0.085
Day	0.025	0.055	0.458	0.647	-0.083	0.133
Settlement	-0.006	0.040	0.156	0.876	-0.084	0.072
Omuramba	0.005	0.041	0.126	0.900	-0.075	0.085
Fence buffer	0.001	0.058	0.014	0.989	-0.113	0.114

Table A.58 AG275, wet season, speed model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Omuramba	0.110	0.095	1.159	0.246	-0.076	0.296
Angle	-0.063	0.078	0.808	0.419	-0.217	0.090
EVI	-0.207	0.086	2.416	0.016	-0.375	-0.039
EVI^2	0.051	0.059	0.865	0.387	-0.064	0.166
Day	-0.026	0.057	0.465	0.642	-0.137	0.085
Rain	0.023	0.055	0.424	0.672	-0.084	0.131
Fence buffer	-0.035	0.082	0.420	0.674	-0.195	0.126
Lag speed	-0.011	0.044	0.241	0.810	-0.096	0.075
Settlement	-0.006	0.041	0.154	0.877	-0.087	0.074

Table A.59 AG273, dry season, angle model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Rain	0.193	0.209	0.916	0.359	-0.219	0.605
Day	0.108	0.162	0.666	0.505	-0.210	0.427
River buffer	0.142	0.211	0.670	0.503	-0.273	0.557
Speed	0.073	0.137	0.534	0.593	-0.196	0.343
Lag angle	0.025	0.098	0.249	0.803	-0.168	0.217
EVI^2	-0.007	0.059	0.125	0.901	-0.125	0.110
EVI	-0.013	0.092	0.141	0.888	-0.195	0.169

Table A.60 AG273, dry season, speed model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Lag speed	0.657	0.222	2.926	0.003	0.2167	1.097
Angle	0.087	0.167	0.516	0.606	-0.243	0.417
EVI^2	0.055	0.113	0.485	0.627	-0.167	0.277
River buffer	-0.038	0.155	0.244	0.807	-0.345	0.269
EVI	-0.026	0.121	0.214	0.830	-0.266	0.213
Rain	-0.004	0.115	0.035	0.972	-0.231	0.223
Day	-0.002	0.108	0.023	0.982	-0.215	0.211

Table A.61 AG273, wet season, angle model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Day	-0.293	0.078	3.744	<0.001	-0.447	-0.140
Lag angle	-0.073	0.085	0.869	0.385	-0.240	0.093
Speed	-0.029	0.060	0.492	0.623	-0.147	0.088
EVI^2	0.015	0.034	0.461	0.645	-0.051	0.082
EVI	0.013	0.048	0.278	0.781	-0.081	0.107
Rain	0.011	0.045	0.252	0.801	-0.076	0.098
River buffer	0.001	0.048	0.024	0.981	-0.094	0.096

Table A.62 AG273, wet season, speed model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
River buffer	-0.219	0.123	1.782	0.075	-0.460	0.022
Rain	-0.050	0.078	0.647	0.517	-0.202	0.102
Day	-0.047	0.076	0.614	0.539	-0.195	0.102
Angle	-0.025	0.058	0.426	0.670	-0.140	0.090
EVI^2	-0.005	0.026	0.195	0.845	-0.057	0.046
EVI	-0.005	0.044	0.108	0.914	-0.091	0.081
Lag speed	-0.001	0.043	0.02	0.984	-0.086	0.084

Table A.63 AG276, dry season, angle model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Speed	-0.265	0.151	1.753	0.080	-0.560	0.031
River buffer	0.074	0.115	0.638	0.523	-0.153	0.300
Day	0.080	0.119	0.671	0.502	-0.153	0.313
Rain	-0.075	0.131	0.572	0.568	-0.332	0.182
EVI	0.002	0.071	0.024	0.981	-0.138	0.142
EVI^2	-0.035	0.201	0.175	0.861	-0.430	0.360
Lag angle	-0.005	0.063	0.072	0.943	-0.128	0.118

Table A.64 AG276, dry season, speed model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Day	-0.167	0.174	0.962	0.336	-0.509	0.174
Angle	-0.251	0.180	1.391	0.164	-0.604	0.103
EVI	0.683	0.157	4.319	<0.001	0.373	0.993
Lag speed	0.298	0.189	1.571	0.116	-0.074	0.669
River buffer	-0.035	0.098	0.358	0.720	-0.228	0.158
EVI^2	-0.056	0.254	0.219	0.827	-0.556	0.444
Rain	0.016	0.098	0.164	0.869	-0.176	0.208

Table A.65 AG276, wet season, angle model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Day	-0.294	0.067	4.349	<0.001	-0.426	-0.161
River buffer	-0.029	0.059	0.485	0.628	-0.144	0.087
Speed	-0.021	0.049	0.432	0.666	-0.118	0.076
EVI^2	0.025	0.059	0.415	0.678	-0.091	0.140
Rain	0.005	0.036	0.130	0.896	-0.066	0.075
Lag angle	-0.003	0.035	0.096	0.924	-0.072	0.066
EVI	0.010	0.042	0.235	0.814	-0.073	0.093

Table A.66 AG276, wet season, speed model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Day	-0.097	0.089	1.082	0.279	-0.272	0.079
EVI	0.183	0.093	1.964	0.050	<0.001	0.366
EVI^2	-0.389	0.092	4.208	<0.001	-0.569	-0.208
Angle	-0.017	0.049	0.359	0.720	-0.113	0.078
Lag speed	0.024	0.056	0.424	0.671	-0.086	0.133
Rain	-0.006	0.039	0.156	0.876	-0.083	0.070
River buffer	<0.001	0.045	0.004	0.997	-0.088	0.088

Table A.67 AG277, dry season, angle model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Fire	-0.032	0.069	0.465	0.642	-0.166	0.103
Lag angle	0.012	0.033	0.382	0.702	-0.051	0.076
EVI	0.011	0.031	0.341	0.733	-0.050	0.072
EVI^2	0.012	0.040	0.293	0.770	-0.066	0.089
Rain	-0.005	0.044	0.121	0.904	-0.091	0.080
Day	0.003	0.025	0.104	0.917	-0.047	0.052
River buffer	<0.001	0.025	0.013	0.989	-0.049	0.050
Speed	<0.001	0.025	0.017	0.987	-0.048	0.049

Table A.68 AG277, dry season, speed model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Day	-0.298	0.056	5.340	<0.001	-0.408	-0.189
Fire	0.182	0.127	1.434	0.152	-0.067	0.430
Rain	0.135	0.114	1.179	0.238	-0.089	0.358
EVI	0.318	0.055	5.806	<0.001	0.211	0.426
EVI^2	-0.417	0.073	5.679	<0.001	-0.561	-0.273
Lag speed	-0.133	0.067	1.983	0.047	-0.265	-0.002
River buffer	-0.025	0.046	0.536	0.592	-0.115	0.066
Angle	0.001	0.028	0.019	0.985	-0.054	0.055

Table A.69 AG277, wet season, angle model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
River buffer	0.101	0.059	1.702	0.089	-0.015	0.216
Day	-0.192	0.047	4.077	<0.001	-0.284	-0.100
Lag angle	0.098	0.057	1.731	0.084	-0.013	0.209
Speed	-0.032	0.046	0.698	0.485	-0.122	0.058
EVI	0.002	0.028	0.065	0.948	-0.053	0.056
EVI^2	0.000	0.028	0.003	0.998	-0.055	0.055
Rain	0.001	0.025	0.058	0.954	-0.047	0.050

Table A.70 AG277, wet season, speed model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
River buffer	-0.123	0.057	2.138	0.033	-0.235	-0.010
Day	-0.238	0.046	5.161	0.001	-0.328	-0.148
EVI	0.290	0.050	5.808	<0.001	0.192	0.387
EVI^2	-0.208	0.053	3.959	0.001	-0.311	-0.105
Angle	-0.032	0.045	0.708	0.479	-0.119	0.056
Lag speed	-0.017	0.036	0.464	0.642	-0.087	0.054
Rain	-0.001	0.024	0.023	0.982	-0.047	0.046

Table A.71 AM291, dry season, angle model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Road buffer	-0.177	0.085	2.084	0.037	-0.343	-0.010
Day	-0.065	0.073	0.888	0.375	-0.207	0.078
In omuramba	0.174	0.163	1.068	0.285	-0.145	0.493
EVI^2	-0.042	0.059	0.719	0.472	-0.157	0.073
Lag angle	0.033	0.054	0.604	0.546	-0.073	0.138
Rain	-0.026	0.055	0.469	0.639	-0.133	0.081
River buffer	-0.018	0.053	0.343	0.732	-0.122	0.085
Speed	-0.008	0.035	0.217	0.828	-0.075	0.060
EVI	0.008	0.039	0.213	0.831	-0.067	0.084

Table A.72 AM291, dry season, speed model

Variable	Estimate	Std. Error	value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Road buffer	0.339	0.115	2.955	0.003	0.114	0.564
Day	-0.381	0.099	3.837	<0.001	-0.576	-0.186
In omuramba	0.142	0.204	0.694	0.488	-0.258	0.542
Rain	0.096	0.118	0.816	0.414	-0.135	0.327
EVI^2	0.236	0.103	2.287	0.022	0.034	0.438
Lag speed	-0.152	0.116	1.311	0.190	-0.379	0.075
EVI	0.020	0.065	0.304	0.761	-0.107	0.147
Angle	-0.011	0.052	0.216	0.829	-0.113	0.091
River buffer	-0.003	0.062	0.050	0.960	-0.125	0.119

Table A.73 AM291, wet season, angle model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
In omuramba	0.226	0.164	1.378	0.168	-0.095	0.546
Lag angle	0.255	0.072	3.543	<0.001	0.114	0.397
Speed	-0.119	0.089	1.338	0.181	-0.292	0.055
Fence buffer	0.060	0.084	0.707	0.479	-0.106	0.225
River buffer	0.054	0.114	0.475	0.635	-0.170	0.279
EVI	0.022	0.054	0.414	0.679	-0.084	0.128
Road buffer	-0.015	0.047	0.317	0.751	-0.106	0.077
EVI^2	0.004	0.026	0.168	0.867	-0.047	0.055
Day	0.011	0.044	0.245	0.806	-0.076	0.098
Rain	-0.003	0.037	0.070	0.944	-0.075	0.070

Table A.74 AM291, wet season, speed model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Day	-0.485	0.078	6.193	<0.001	-0.638	-0.331
In omuramba	0.211	0.173	1.216	0.224	-0.129	0.551
Angle	-0.156	0.092	1.692	0.091	-0.336	0.025
Lag speed	-0.577	0.076	7.605	<0.001	-0.725	-0.428
Rain	0.041	0.068	0.608	0.543	-0.092	0.175
Road buffer	-0.027	0.058	0.454	0.650	-0.141	0.088
Fence buffer	0.027	0.064	0.419	0.675	-0.099	0.152
River buffer	0.025	0.093	0.266	0.790	-0.158	0.208
EVI	0.008	0.045	0.185	0.854	-0.080	0.097
EVI^2	-0.006	0.028	0.217	0.828	-0.061	0.048

Table A.75 77259, dry season, angle model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Pan	0.105	0.111	0.948	0.343	-0.112	0.322
Lag angle	-0.071	0.093	0.761	0.447	-0.254	0.112
River buffer	-0.097	0.142	0.680	0.497	-0.375	0.182
EVI	-0.052	0.089	0.582	0.561	-0.226	0.122
EVI^2	0.047	0.093	0.504	0.614	-0.135	0.229
Settlement	0.013	0.067	0.196	0.844	-0.118	0.145
Speed	-0.020	0.059	0.339	0.734	-0.136	0.096
Day	0.006	0.048	0.130	0.896	-0.088	0.101
Fence buffer	-0.011	0.059	0.183	0.855	-0.127	0.106
Rain	0.005	0.053	0.087	0.931	-0.100	0.109

Table A.76 77259, dry season, speed model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Fence buffer	-0.681	0.123	5.517	<0.001	-0.923	-0.439
River buffer	-0.501	0.169	2.961	0.003	-0.832	-0.169
EVI^2	0.148	0.155	0.956	0.339	-0.155	0.451
Lag speed	-0.125	0.124	1.004	0.315	-0.368	0.119
Angle	-0.030	0.072	0.421	0.674	-0.172	0.111
Day	0.025	0.069	0.362	0.717	-0.111	0.162
Pan	-0.009	0.057	0.154	0.877	-0.121	0.103
Rain	0.014	0.065	0.216	0.829	-0.113	0.141
EVI	-0.008	0.061	0.122	0.903	-0.128	0.113
Settlement	0.005	0.062	0.086	0.932	-0.116	0.126

Table A.77 77259, wet season, angle model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Day	0.103	0.123	0.831	0.406	-0.139	0.345
Settlement	-0.088	0.123	0.714	0.475	-0.329	0.153
Speed	-0.051	0.093	0.548	0.584	-0.234	0.132
Fence buffer	0.049	0.102	0.477	0.633	-0.151	0.249
EVI^2	-0.057	0.109	0.521	0.603	-0.272	0.158
Omuramba	-0.042	0.124	0.333	0.739	-0.286	0.203
Lag angle	-0.024	0.070	0.341	0.733	-0.162	0.114
EVI	0.046	0.100	0.459	0.647	-0.151	0.243
River buffer	-0.051	0.143	0.354	0.723	-0.331	0.230
Pan	-0.015	0.065	0.237	0.813	-0.143	0.112
Rain	0.006	0.057	0.106	0.915	-0.106	0.118

Table A.78 77259, wet season, speed model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
River buffer	0.330	0.288	1.145	0.252	-0.235	0.894
Day	-0.451	0.129	3.495	<0.001	-0.703	-0.198
Settlement	-0.099	0.138	0.715	0.475	-0.371	0.173
EVI	0.143	0.155	0.925	0.355	-0.160	0.447
Pan	0.060	0.109	0.552	0.581	-0.154	0.275
Angle	-0.048	0.096	0.494	0.621	-0.236	0.141
Lag speed	0.044	0.094	0.470	0.638	-0.140	0.229
Rain	0.038	0.088	0.431	0.667	-0.135	0.211
EVI^2	-0.015	0.089	0.171	0.865	-0.190	0.159
Fence buffer	-0.024	0.091	0.268	0.789	-0.202	0.154
Omuramba	-0.003	0.115	0.027	0.978	-0.228	0.222

Table A.79 77261new, wet season, speed model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
River buffer	0.131	0.090	1.454	0.146	-0.046	0.308
Road buffer	0.073	0.103	0.711	0.477	-0.129	0.275
Omuramba	-0.198	0.096	2.059	0.040	-0.386	-0.010
EVI	-0.057	0.067	0.845	0.398	-0.188	0.075
Day	-0.039	0.053	0.731	0.465	-0.143	0.065
Speed	-0.028	0.047	0.598	0.550	-0.120	0.064
Pan	0.029	0.050	0.592	0.554	-0.068	0.127
Settlement	-0.030	0.053	0.562	0.574	-0.134	0.074
EVI^2	-0.020	0.056	0.359	0.720	-0.130	0.089
Lag angle	-0.007	0.030	0.244	0.808	-0.066	0.051
Rain	0.021	0.061	0.342	0.732	-0.099	0.141
Fence buffer	0.010	0.056	0.170	0.865	-0.100	0.119

Table A.80 77261new, wet season, speed model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
River buffer	-0.171	0.140	1.214	0.225	-0.446	0.105
Day	-0.532	0.075	7.131	<0.001	-0.678	-0.386
Rain	0.376	0.157	2.388	0.017	0.067	0.684
Settlement	0.123	0.101	1.217	0.224	-0.075	0.322
Angle	-0.048	0.072	0.673	0.501	-0.190	0.093
EVI^2	0.062	0.103	0.597	0.550	-0.141	0.264
Fence buffer	-0.104	0.139	0.751	0.453	-0.377	0.168
Road buffer	-0.066	0.123	0.534	0.593	-0.306	0.175
Pan	-0.015	0.052	0.294	0.769	-0.117	0.086
Lag speed	0.013	0.046	0.280	0.779	-0.077	0.102
EVI	-0.012	0.055	0.211	0.833	-0.120	0.097
Omuramba	0.000	0.062	0.002	0.999	-0.121	0.121

Table A.81 77261new, wet season, angle model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
EVI	-0.076	0.064	1.175	0.240	-0.202	0.051
Speed	-0.097	0.065	1.494	0.135	-0.224	0.030
Lag angle	0.033	0.049	0.664	0.507	-0.064	0.129
EVI^2	0.037	0.060	0.621	0.534	-0.080	0.154
Settlement	0.021	0.043	0.485	0.628	-0.063	0.104
Omuramba	0.010	0.035	0.280	0.780	-0.060	0.080
Rain	0.005	0.029	0.187	0.851	-0.051	0.061
Day	0.005	0.028	0.180	0.857	-0.051	0.061
Fence buffer	-0.015	0.060	0.259	0.796	-0.133	0.102
Road buffer	0.001	0.040	0.024	0.981	-0.077	0.078
Pan	-0.002	0.028	0.080	0.936	-0.058	0.053

Table A.82 77261new, wet season, speed model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Day	-0.106	0.076	1.389	0.165	-0.255	0.043
Rain	-0.087	0.074	1.176	0.239	-0.233	0.058
Angle	-0.111	0.075	1.475	0.140	-0.259	0.037
Settlement	0.045	0.064	0.705	0.481	-0.081	0.171
EVI	-0.335	0.061	5.444	<0.001	-0.455	-0.214
Lag speed	0.035	0.056	0.614	0.539	-0.076	0.145
Road buffer	-0.027	0.064	0.418	0.676	-0.153	0.100
EVI^2	0.008	0.043	0.189	0.850	-0.076	0.092
Pan	0.009	0.038	0.230	0.818	-0.065	0.082
Omuramba	0.005	0.037	0.131	0.895	-0.068	0.077
Fence buffer	0.001	0.061	0.019	0.985	-0.119	0.122

Table A.83 77262, dry season, angle model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Fence buffer	-0.520	0.161	3.235	0.001	-0.836	-0.205
Pan	0.102	0.103	0.985	0.325	-0.101	0.304
Lag angle	0.025	0.059	0.430	0.667	-0.090	0.141
EVI	-0.026	0.060	0.428	0.669	-0.143	0.092
Rain	0.027	0.070	0.387	0.698	-0.110	0.164
Settlement	-0.055	0.092	0.598	0.550	-0.235	0.125
EVI^2	-0.018	0.063	0.286	0.775	-0.141	0.105
Day	0.008	0.044	0.171	0.864	-0.079	0.095
River buffer	-0.015	0.058	0.261	0.794	-0.129	0.098
Speed	0.005	0.043	0.122	0.903	-0.079	0.090
Omuramba	0.000	0.106	0.002	0.999	-0.209	0.209

Table A.84 77262, dry season, speed model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Fence buffer	-0.332	0.228	1.455	0.146	-0.780	0.115
Omuramba	0.190	0.255	0.742	0.458	-0.311	0.690
Rain	-0.181	0.150	1.209	0.227	-0.474	0.112
EVI	0.034	0.075	0.449	0.653	-0.114	0.181
River buffer	-0.060	0.100	0.601	0.548	-0.257	0.136
Lag speed	-0.031	0.072	0.436	0.663	-0.172	0.110
EVI^2	0.041	0.093	0.444	0.657	-0.140	0.223
Pan	0.013	0.060	0.224	0.823	-0.104	0.131
Angle	0.008	0.053	0.157	0.875	-0.097	0.113
Settlement	0.011	0.067	0.162	0.871	-0.121	0.142
Day	0.001	0.050	0.015	0.988	-0.098	0.100

Table A.85 77262, wet season, angle model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Rain	-0.058	0.087	0.670	0.503	-0.229	0.112
Speed	0.068	0.091	0.741	0.459	-0.111	0.246
Settlement	-0.064	0.096	0.669	0.504	-0.252	0.124
EVI	-0.032	0.072	0.448	0.654	-0.175	0.110
Day	0.017	0.055	0.311	0.756	-0.092	0.126
EVI^2	-0.016	0.067	0.235	0.814	-0.148	0.116
Pan	0.000	0.055	0.003	0.998	-0.108	0.108
Lag angle	0.005	0.047	0.109	0.913	-0.087	0.097
River buffer	-0.013	0.062	0.213	0.832	-0.134	0.108

Table A.86 77262, wet season, speed model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Angle	0.105	0.133	0.790	0.430	-0.155	0.365
Pan	-0.268	0.172	1.557	0.119	-0.605	0.069
Lag speed	0.087	0.125	0.695	0.487	-0.158	0.331
EVI	0.096	0.134	0.717	0.473	-0.167	0.359
Day	0.082	0.121	0.678	0.498	-0.155	0.320
Settlement	0.057	0.122	0.463	0.644	-0.183	0.297
River buffer	-0.016	0.083	0.195	0.845	-0.178	0.146
EVI^2	-0.022	0.101	0.219	0.827	-0.221	0.177
Rain	-0.025	0.081	0.309	0.758	-0.184	0.134

Table A.87 77265new, dry season, angle model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Settlement	0.095	0.135	0.703	0.482	-0.170	0.359
EVI^2	-0.149	0.197	0.756	0.450	-0.537	0.238
Speed	-0.128	0.139	0.919	0.358	-0.402	0.145
Lag angle	-0.061	0.106	0.575	0.566	-0.270	0.147
Rain	0.063	0.147	0.428	0.669	-0.226	0.352
Pan	-0.018	0.087	0.206	0.837	-0.189	0.153
EVI	-0.020	0.076	0.267	0.790	-0.170	0.129
River buffer	-0.034	0.121	0.277	0.782	-0.273	0.205
Fire	0.020	0.143	0.143	0.887	-0.261	0.301
Day	0.005	0.065	0.073	0.942	-0.123	0.132
Fence buffer	0.019	0.110	0.171	0.864	-0.198	0.236

Table A.88 77265new, dry season, speed model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
River buffer	-0.204	0.258	0.789	0.430	-0.709	0.302
Day	0.206	0.180	1.143	0.253	-0.147	0.558
Fire	-0.240	0.322	0.744	0.457	-0.873	0.393
Angle	-0.154	0.163	0.940	0.347	-0.474	0.167
Pan	-0.136	0.172	0.789	0.430	-0.474	0.202
Settlement	0.048	0.121	0.392	0.695	-0.190	0.285
EVI	0.046	0.110	0.418	0.676	-0.170	0.263
Rain	0.037	0.141	0.263	0.792	-0.241	0.316
Fence	0.020	0.136	0.144	0.885	-0.247	0.287
EVI^2	0.033	0.132	0.248	0.804	-0.227	0.293
Lag speed	-0.016	0.080	0.195	0.845	-0.172	0.141

Table A.89 77265new, wet season, angle model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
River buffer	0.361	0.127	2.833	0.005	0.111	0.611
Speed	-0.178	0.101	1.765	0.078	-0.375	0.020
Omuramba	0.081	0.131	0.619	0.536	-0.175	0.337
Road buffer	0.035	0.115	0.305	0.760	-0.190	0.261
Day	-0.014	0.050	0.279	0.781	-0.112	0.084
EVI	0.011	0.049	0.229	0.819	-0.084	0.107
Rain	-0.007	0.045	0.162	0.871	-0.095	0.080
Settlement	-0.009	0.053	0.177	0.860	-0.113	0.094
Lag angle	0.002	0.042	0.050	0.960	-0.081	0.085
EVI^2	-0.004	0.063	0.057	0.955	-0.128	0.121
Pan	-0.001	0.044	0.013	0.989	-0.087	0.085

Table A.90 77265new, wet season, speed model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
River buffer	-0.109	0.132	0.828	0.408	-0.367	0.149
Road buffer	-0.481	0.181	2.659	0.008	-0.836	-0.127
Day	-0.080	0.085	0.938	0.348	-0.246	0.087
Omuramba	0.136	0.146	0.928	0.353	-0.151	0.423
Angle	-0.151	0.089	1.693	0.090	-0.327	0.024
Settlement	-0.171	0.106	1.608	0.108	-0.379	0.037
EVI	-0.302	0.076	3.940	<0.001	-0.452	-0.152
EVI^2	0.176	0.134	1.314	0.189	-0.087	0.439
Rain	0.037	0.065	0.570	0.569	-0.090	0.165
Lag speed	-0.029	0.059	0.491	0.623	-0.145	0.087
Pan	0.017	0.054	0.319	0.749	-0.089	0.124

Table A.91 SAT508, dry season, angle model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Rain	0.270	0.218	1.233	0.218	-0.159	0.699
Speed	-0.155	0.193	0.801	0.423	-0.534	0.224
Lag angle	0.092	0.154	0.595	0.552	-0.211	0.396
Day	0.122	0.176	0.689	0.491	-0.224	0.468
Settlement	-0.120	0.274	0.436	0.663	-0.659	0.419
EVI	0.025	0.107	0.231	0.817	-0.187	0.237
Fire	-0.069	0.193	0.355	0.723	-0.449	0.312
Pan	-0.006	0.134	0.046	0.963	-0.271	0.259
EVI^2	0.044	0.200	0.218	0.828	-0.350	0.438
Road buffer	-0.076	0.290	0.261	0.794	-0.648	0.495

Table A.92 SAT508, dry season, speed model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Road buffer	-0.531	0.520	1.017	0.309	-1.555	0.492
Day	-0.875	0.232	3.733	<0.001	-1.334	-0.416
Fire	0.740	0.475	1.549	0.121	-0.196	1.676
Angle	-0.105	0.192	0.541	0.588	-0.484	0.274
EVI	0.084	0.183	0.459	0.646	-0.276	0.445
EVI^2	0.074	0.274	0.267	0.790	-0.468	0.615
Settlement	0.002	0.332	0.005	0.996	-0.653	0.656
Rain	0.042	0.146	0.288	0.773	-0.246	0.330
Pan	0.001	0.173	0.003	0.997	-0.341	0.343
Lag speed	0.005	0.119	0.046	0.964	-0.230	0.241

Table A.93 SAT508, wet season, angle model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Rain	0.074	0.085	0.868	0.385	-0.093	0.241
Speed	-0.185	0.091	2.028	0.043	-0.363	-0.006
Lag angle	0.048	0.073	0.663	0.507	-0.094	0.191
Day	0.035	0.064	0.545	0.586	-0.091	0.160
Settlement	0.024	0.065	0.370	0.711	-0.104	0.152
EVI	0.013	0.050	0.263	0.793	-0.085	0.111
Pan	-0.010	0.059	0.169	0.866	-0.127	0.107
EVI^2	-0.002	0.058	0.028	0.977	-0.115	0.112

Table A.94 SAT508, wet season, speed model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Angle	-0.215	0.108	1.988	0.047	-0.428	-0.003
Pan	-0.443	0.158	2.796	0.005	-0.754	-0.133
Settlement	0.134	0.152	0.881	0.378	-0.165	0.433
EVI	-0.267	0.130	2.054	0.040	-0.522	-0.012
EVI^2	0.046	0.108	0.422	0.673	-0.166	0.258
Day	-0.016	0.056	0.291	0.771	-0.125	0.093
Lag speed	-0.003	0.049	0.072	0.943	-0.099	0.092
Rain	0.000	0.049	0.004	0.997	-0.097	0.097

Table A.95 SAT509, dry season, angle model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
River buffer	2.456	0.965	2.532	0.011	0.555	4.357
Rain	-0.196	0.271	0.718	0.473	-0.730	0.338
Settlement	0.919	0.492	1.859	0.063	-0.050	1.888
EVI^2	-0.394	0.432	0.909	0.363	-1.244	0.456
EVI	0.128	0.222	0.576	0.565	-0.308	0.565
Omuramba	0.090	0.225	0.399	0.690	-0.353	0.534
Speed	0.065	0.165	0.389	0.697	-0.261	0.390
Road buffer	-0.015	0.135	0.112	0.911	-0.282	0.251
Day	0.019	0.122	0.150	0.880	-0.223	0.260
Pan	-0.020	0.133	0.148	0.882	-0.283	0.244
Fire	0.038	0.247	0.154	0.878	-0.449	0.526
Lag angle	0.014	0.121	0.117	0.907	-0.224	0.253

Table A.96 SAT509, dry season, speed model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Road buffer	-0.331	0.301	1.096	0.273	-0.923	0.261
Day	-0.558	0.283	1.961	0.050	-1.115	0.000
Settlement	-0.573	0.361	1.580	0.114	-1.283	0.138
Rain	0.097	0.208	0.465	0.642	-0.312	0.506
Fire	0.165	0.349	0.469	0.639	-0.523	0.852
Angle	0.065	0.159	0.408	0.683	-0.249	0.379
EVI^2	-0.112	0.262	0.425	0.671	-0.627	0.404
Lag speed	-0.047	0.161	0.291	0.771	-0.365	0.271
EVI	0.034	0.141	0.237	0.813	-0.245	0.313
Omuramba	-0.048	0.181	0.260	0.795	-0.405	0.310
River buffer	0.131	0.510	0.255	0.799	-0.874	1.136
Pan	0.006	0.122	0.050	0.960	-0.235	0.247

Table A.97 SAT509, wet season, angle model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
River buffer	0.174	0.132	1.314	0.189	-0.086	0.434
EVI	-0.067	0.085	0.789	0.430	-0.234	0.100
Lag angle	0.066	0.082	0.806	0.420	-0.095	0.228
Speed	-0.036	0.066	0.546	0.585	-0.165	0.093
Rain	-0.031	0.063	0.484	0.629	-0.154	0.093
Road buffer	-0.030	0.088	0.337	0.736	-0.203	0.143
Pan	0.021	0.054	0.382	0.702	-0.085	0.126
Day	0.012	0.046	0.253	0.801	-0.079	0.102
EVI^2	-0.019	0.078	0.240	0.810	-0.172	0.135
Omuramba	-0.008	0.085	0.089	0.929	-0.174	0.159
Settlement	-0.006	0.062	0.099	0.921	-0.129	0.116

Table A.98 SAT509, wet season, speed model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Road buffer	-0.451	0.158	2.848	0.004	-0.762	-0.141
Day	-0.481	0.085	5.673	<0.001	-0.647	-0.315
Rain	0.135	0.106	1.263	0.207	-0.074	0.343
EVI	-0.323	0.089	3.639	<0.001	-0.497	-0.149
Lag speed	-0.153	0.106	1.448	0.148	-0.360	0.054
Angle	-0.046	0.075	0.611	0.541	-0.192	0.101
EVI^2	0.059	0.118	0.501	0.616	-0.172	0.291
Pan	0.027	0.064	0.427	0.669	-0.098	0.152
River buffer	0.043	0.096	0.442	0.658	-0.146	0.231
Settlement	0.028	0.074	0.375	0.707	-0.118	0.174
Omuramba	-0.005	0.091	0.059	0.953	-0.183	0.173

Table A.99 77263, dry season, angle model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
River buffer	-0.279	0.114	2.452	0.014	-0.502	-0.056
Pan	0.221	0.109	2.023	0.043	0.007	0.434
Settlement	0.064	0.092	0.694	0.488	-0.116	0.243
Speed	-0.045	0.078	0.579	0.563	-0.198	0.107
Day	-0.045	0.081	0.557	0.577	-0.204	0.114
Lag angle	-0.018	0.056	0.317	0.751	-0.128	0.092
EVI	-0.022	0.068	0.326	0.745	-0.156	0.111
EVI^2	-0.014	0.063	0.229	0.819	-0.138	0.109
Rain	-0.002	0.054	0.038	0.970	-0.108	0.104

Table A.100 77263, dry season, speed model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Day	-0.337	0.104	3.242	0.001	-0.540	-0.133
Rain	-0.173	0.139	1.241	0.215	-0.446	0.100
Settlement	-0.114	0.115	0.988	0.323	-0.340	0.112
EVI^2	0.072	0.111	0.642	0.521	-0.147	0.290
Lag speed	-0.110	0.111	0.987	0.324	-0.328	0.108
EVI	0.046	0.085	0.535	0.593	-0.122	0.213
Angle	-0.055	0.088	0.630	0.528	-0.228	0.117
River buffer	-0.044	0.089	0.496	0.620	-0.219	0.131
Pan	-0.020	0.063	0.320	0.749	-0.143	0.103

Table A.101 77263, wet season, angle model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
River buffer	-0.485	0.222	2.180	0.029	-0.920	-0.049
Road buffer	0.116	0.160	0.723	0.470	-0.198	0.430
Omuramba	0.067	0.117	0.569	0.569	-0.163	0.296
EVI^2	0.062	0.120	0.514	0.607	-0.173	0.297
Day	0.027	0.074	0.368	0.713	-0.117	0.172
Pan	-0.036	0.081	0.439	0.661	-0.194	0.123
Lag angle	-0.020	0.066	0.304	0.761	-0.149	0.109
Rain	-0.017	0.067	0.258	0.797	-0.149	0.114
Settlement	0.014	0.077	0.181	0.856	-0.137	0.165
Speed	-0.007	0.056	0.128	0.899	-0.117	0.103
EVI	0.010	0.083	0.125	0.901	-0.152	0.173

Table A.102 77263, wet season, speed model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Omuramba	-0.187	0.201	0.928	0.354	-0.582	0.208
Lag speed	0.221	0.175	1.261	0.207	-0.123	0.565
Rain	-0.064	0.122	0.519	0.604	-0.304	0.177
EVI^2	-0.068	0.147	0.461	0.645	-0.357	0.221
Road buffer	-0.083	0.169	0.489	0.625	-0.415	0.249
EVI	-0.026	0.104	0.247	0.805	-0.230	0.179
River buffer	0.061	0.169	0.360	0.719	-0.271	0.393
Angle	-0.022	0.084	0.258	0.796	-0.188	0.144
Pan	-0.024	0.087	0.280	0.780	-0.196	0.147
Settlement	0.007	0.087	0.079	0.937	-0.164	0.178
Day	0.008	0.076	0.102	0.919	-0.142	0.157

Table A.103 77263new, dry season, angle model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Rain	0.170	0.148	1.151	0.250	-0.120	0.460
Speed	-0.176	0.110	1.596	0.111	-0.391	0.040
Omuramba	-0.051	0.085	0.598	0.550	-0.219	0.117
EVI	-0.065	0.094	0.684	0.494	-0.250	0.121
Day	0.054	0.084	0.641	0.522	-0.111	0.219
Road buffer	0.047	0.087	0.535	0.593	-0.124	0.218
EVI^2	-0.049	0.103	0.473	0.636	-0.251	0.153
Settlement	0.023	0.060	0.383	0.702	-0.095	0.142
Pan	0.012	0.052	0.227	0.820	-0.091	0.115
Lag angle	-0.011	0.050	0.225	0.822	-0.109	0.086

Table A.104 77263new, dry season, speed model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Day	-0.513	0.107	4.783	<0.001	-0.723	-0.303
Angle	-0.192	0.132	1.456	0.145	-0.450	0.066
Pan	0.113	0.123	0.915	0.360	-0.129	0.354
EVI	-0.311	0.129	2.400	0.016	-0.564	-0.057
EVI^2	0.354	0.200	1.773	0.076	-0.037	0.746
Lag speed	-0.226	0.132	1.704	0.088	-0.485	0.034
Rain	0.067	0.124	0.538	0.591	-0.176	0.310
Omuramba	-0.039	0.087	0.441	0.660	-0.210	0.133
Road buffer	-0.015	0.072	0.208	0.836	-0.157	0.127
Settlement	-0.006	0.056	0.101	0.920	-0.116	0.105

Table A.105 77263new, wet season, angle model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Rain	0.065	0.083	0.779	0.436	-0.098	0.227
EVI^2	-0.096	0.123	0.780	0.435	-0.337	0.145
Lag angle	-0.037	0.065	0.561	0.575	-0.165	0.091
Day	0.034	0.063	0.533	0.594	-0.090	0.157
Omuramba	0.019	0.057	0.325	0.745	-0.094	0.131
Speed	0.016	0.049	0.332	0.740	-0.079	0.112
EVI	0.014	0.049	0.280	0.780	-0.082	0.110
Settlement	0.001	0.043	0.021	0.984	-0.083	0.085
Road buffer	-0.003	0.060	0.056	0.955	-0.122	0.115
Pan	0.001	0.040	0.013	0.989	-0.079	0.080

Table A.106 77263new, wet season, speed model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Road buffer	0.149	0.131	1.131	0.258	-0.109	0.406
Day	-0.061	0.075	0.810	0.418	-0.209	0.087
Rain	0.119	0.092	1.295	0.195	-0.061	0.298
EVI^2	0.041	0.085	0.484	0.628	-0.125	0.208
Settlement	0.015	0.050	0.306	0.760	-0.083	0.114
Omuramba	0.028	0.064	0.440	0.660	-0.098	0.155
Angle	0.014	0.044	0.318	0.750	-0.073	0.101
EVI	-0.003	0.039	0.069	0.945	-0.080	0.075
Lag speed	-0.002	0.037	0.054	0.957	-0.074	0.070
Pan	-0.003	0.039	0.088	0.930	-0.079	0.073

Table A.107 94041, dry season, angle model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Pan	0.056	0.073	0.776	0.438	-0.086	0.199
Speed	-0.095	0.077	1.225	0.220	-0.247	0.057
Rain	0.045	0.085	0.529	0.597	-0.122	0.212
EVI^2	0.046	0.088	0.521	0.603	-0.127	0.219
Day	0.023	0.049	0.467	0.641	-0.073	0.118
River buffer	-0.027	0.058	0.455	0.649	-0.141	0.088
EVI	-0.018	0.049	0.373	0.709	-0.114	0.078
Lag angle	0.004	0.033	0.134	0.893	-0.061	0.070
Omuramba	0.002	0.082	0.021	0.984	-0.158	0.162
Settlement	0.016	0.051	0.303	0.762	-0.085	0.116

Table A.108 94041, dry season, speed model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Day	-0.244	0.066	3.672	<0.001	-0.374	-0.114
Rain	0.141	0.128	1.100	0.271	-0.110	0.392
Angle	-0.094	0.080	1.177	0.239	-0.250	0.062
Pan	-0.074	0.082	0.899	0.369	-0.236	0.088
Lag speed	-0.091	0.079	1.149	0.250	-0.247	0.064
River buffer	-0.025	0.060	0.412	0.680	-0.142	0.093
EVI	-0.005	0.041	0.114	0.909	-0.085	0.076
Settlement	0.015	0.054	0.276	0.783	-0.090	0.120
EVI^2	0.005	0.059	0.087	0.931	-0.110	0.120
Omuramba	0.014	0.088	0.163	0.870	-0.159	0.188

Table A.109 94041, wet season, angle model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Speed	-0.111	0.081	1.370	0.171	-0.271	0.048
Omuramba	-0.029	0.058	0.499	0.618	-0.143	0.085
Day	-0.026	0.051	0.497	0.619	-0.126	0.075
Settlement	0.010	0.042	0.242	0.808	-0.073	0.093
River buffer	0.030	0.091	0.323	0.747	-0.150	0.209
Lag angle	0.012	0.040	0.311	0.756	-0.065	0.090
Road buffer	0.019	0.054	0.353	0.724	-0.086	0.124
EVI^2	0.009	0.057	0.156	0.876	-0.103	0.121
Pan	0.003	0.037	0.085	0.933	-0.069	0.075
Rain	-0.002	0.035	0.070	0.944	-0.071	0.067
EVI	0.005	0.038	0.122	0.903	-0.069	0.078

Table A.110 94041, wet season, speed model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Road buffer	0.120	0.103	1.160	0.246	-0.082	0.322
Day	-0.146	0.077	1.902	0.057	-0.297	0.004
Rain	0.229	0.070	3.268	0.001	0.092	0.366
Angle	-0.125	0.076	1.646	0.100	-0.275	0.024
Settlement	0.070	0.081	0.865	0.387	-0.089	0.228
EVI	-0.466	0.072	6.466	<0.001	-0.607	-0.325
EVI^2	0.586	0.105	5.569	<0.001	0.380	0.792
Lag speed	0.287	0.068	4.223	<0.001	0.154	0.420
Pan	0.028	0.058	0.489	0.625	-0.086	0.143
River buffer	-0.023	0.088	0.258	0.797	-0.195	0.150
Omuramba	0.006	0.045	0.129	0.897	-0.082	0.094

Table A.111 94042, dry season, angle model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Day	0.056	0.069	0.808	0.419	-0.080	0.192
EVI	-0.058	0.071	0.823	0.410	-0.198	0.081
Settlement	0.0408	0.062	0.663	0.508	-0.080	0.162
EVI^2	-0.063	0.101	0.626	0.531	-0.261	0.135
Lag angle	-0.019	0.046	0.415	0.678	-0.109	0.071
Speed	-0.012	0.040	0.298	0.766	-0.091	0.067
Road buffer	0.008	0.043	0.187	0.852	-0.077	0.093
Rain	0.002	0.049	0.038	0.969	-0.095	0.099
Pan	-0.001	0.033	0.038	0.969	-0.066	0.064
Omuramba	0.004	0.036	0.110	0.912	-0.066	0.074

Table A.112 94042, dry season, speed model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Day	-0.562	0.098	5.743	<0.001	-0.754	-0.370
Rain	0.164	0.169	0.970	0.332	-0.167	0.496
EVI	-0.125	0.123	1.016	0.310	-0.366	0.116
EVI^2	0.401	0.197	2.035	0.042	0.015	0.786
Lag speed	-0.080	0.103	0.773	0.440	-0.282	0.123
Road buffer	0.087	0.121	0.721	0.471	-0.150	0.325
Pan	0.060	0.093	0.643	0.520	-0.122	0.241
Omuramba	0.037	0.078	0.468	0.640	-0.117	0.190
Angle	-0.016	0.058	0.267	0.790	-0.130	0.099
Settlement	-0.007	0.052	0.138	0.890	-0.109	0.095

Table A.113 94042, wet season, angle model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
EVI^2	-0.084	0.115	0.726	0.468	-0.309	0.142
Speed	-0.171	0.082	2.065	0.039	-0.332	-0.009
Rain	0.034	0.060	0.560	0.576	-0.085	0.152
Day	0.015	0.045	0.333	0.739	-0.073	0.103
EVI	0.014	0.045	0.300	0.764	-0.075	0.102
Settlement	0.002	0.037	0.040	0.968	-0.070	0.073
Lag angle	-0.003	0.036	0.085	0.932	-0.074	0.068
Pan	-0.004	0.037	0.098	0.922	-0.076	0.069
Road buffer	0.001	0.051	0.022	0.982	-0.099	0.102
Omuramba	0.003	0.039	0.071	0.943	-0.075	0.080

Table A.114 94042, wet season, speed model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Day	-0.212	0.078	2.700	0.007	-0.365	-0.058
Omuramba	0.084	0.091	0.926	0.354	-0.094	0.263
Rain	0.196	0.083	2.366	0.018	0.034	0.358
Angle	-0.173	0.084	2.056	0.040	-0.337	-0.008
Settlement	0.187	0.085	2.195	0.028	0.020	0.355
Pan	0.049	0.072	0.674	0.500	-0.093	0.190
Road buffer	0.073	0.104	0.698	0.485	-0.131	0.276
EVI^2	-0.014	0.066	0.209	0.835	-0.143	0.116
Lag speed	-0.003	0.038	0.091	0.927	-0.078	0.071
EVI	-0.006	0.042	0.153	0.878	-0.088	0.075

Table A.115 AG269, dry season, angle model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Rain	0.194	0.133	1.458	0.145	-0.067	0.454
Pan	0.150	0.070	2.126	0.034	0.012	0.288
EVI	-0.158	0.072	2.187	0.029	-0.300	-0.016
Speed	-0.173	0.063	2.762	0.006	-0.296	-0.050
Day	-0.040	0.057	0.702	0.483	-0.153	0.072
Settlement	0.012	0.040	0.305	0.760	-0.067	0.091
Lag angle	0.010	0.035	0.278	0.781	-0.059	0.078
River buffer	0.003	0.041	0.083	0.933	-0.076	0.083
EVI^2	-0.003	0.054	0.058	0.953	-0.108	0.102

Table A.116 AG269, dry season, speed model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
River buffer	-0.065	0.072	0.890	0.373	-0.207	0.078
Angle	-0.160	0.056	2.866	0.004	-0.269	-0.051
Pan	-0.035	0.053	0.662	0.508	-0.139	0.069
Lag speed	-0.070	0.063	1.111	0.267	-0.192	0.053
EVI	-0.022	0.044	0.489	0.625	-0.108	0.065
Settlement	-0.015	0.043	0.350	0.726	-0.100	0.070
Day	-0.011	0.034	0.339	0.734	-0.077	0.055
EVI^2	0.014	0.052	0.261	0.794	-0.089	0.116
Rain	-0.006	0.050	0.116	0.908	-0.104	0.092

Table A.117 AG269, wet season, angle model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
River buffer	0.099	0.100	0.990	0.322	-0.097	0.296
Road buffer	-0.086	0.083	1.035	0.301	-0.248	0.077
Day	0.040	0.053	0.761	0.447	-0.064	0.145
Speed	-0.015	0.036	0.407	0.684	-0.086	0.056
Omuramba	0.017	0.051	0.325	0.745	-0.083	0.117
Pan	0.017	0.042	0.405	0.685	-0.065	0.099
Rain	-0.007	0.030	0.229	0.819	-0.066	0.052
Settlement	0.005	0.032	0.142	0.887	-0.058	0.067
EVI	-0.004	0.034	0.114	0.910	-0.071	0.063
Lag angle	0.001	0.026	0.024	0.981	-0.051	0.052
EVI^2	0.002	0.030	0.075	0.940	-0.057	0.061

Table A.118 AG269, wet season, speed model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
River buffer	-0.128	0.107	1.189	0.235	-0.338	0.083
Day	-0.172	0.051	3.368	0.001	-0.271	-0.072
Omuramba	0.273	0.076	3.591	<0.001	0.124	0.423
EVI	-0.288	0.059	4.858	<0.001	-0.405	-0.172
Lag speed	0.160	0.052	3.046	0.002	0.057	0.263
Settlement	-0.022	0.044	0.491	0.623	-0.107	0.064
Road buffer	0.018	0.046	0.389	0.697	-0.072	0.108
Rain	0.011	0.033	0.349	0.727	-0.052	0.075
Angle	-0.009	0.030	0.303	0.762	-0.067	0.049
EVI^2	-0.012	0.036	0.338	0.735	-0.084	0.059
Pan	0.007	0.034	0.201	0.841	-0.060	0.074

Table A.119 AG270, dry season, angle model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
River buffer	0.240	0.137	1.751	0.080	-0.029	0.508
Road buffer	-0.253	0.092	2.753	0.006	-0.433	-0.073
Settlement	0.084	0.085	0.991	0.322	-0.083	0.252
EVI^2	0.082	0.091	0.901	0.368	-0.097	0.261
Lag angle	0.103	0.071	1.449	0.147	-0.036	0.243
Pan	0.039	0.064	0.609	0.543	-0.087	0.165
Speed	-0.033	0.053	0.628	0.530	-0.137	0.071
Day	0.040	0.058	0.698	0.485	-0.073	0.154
EVI	0.024	0.053	0.462	0.644	-0.079	0.127
Rain	0.011	0.061	0.188	0.851	-0.108	0.131

Table A.120 AG270, dry season, speed model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
River buffer	-0.346	0.137	2.531	0.011	-0.614	-0.078
Angle	-0.049	0.066	0.735	0.462	-0.179	0.081
Settlement	0.308	0.073	4.215	<0.001	0.165	0.451
EVI	-0.055	0.074	0.743	0.458	-0.201	0.091
Lag speed	-0.305	0.065	4.703	<0.001	-0.432	-0.178
Road buffer	0.040	0.073	0.544	0.586	-0.104	0.183
Rain	0.037	0.089	0.416	0.678	-0.137	0.211
EVI^2	0.007	0.054	0.139	0.889	-0.098	0.113
Pan	-0.007	0.041	0.181	0.857	-0.088	0.073
Day	-0.003	0.034	0.075	0.940	-0.070	0.065

Table A.121 AG270, wet season, angle model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Lag angle	-0.065	0.071	0.918	0.359	-0.205	0.074
Road buffer	-0.046	0.093	0.500	0.617	-0.228	0.135
River buffer	-0.033	0.067	0.492	0.622	-0.163	0.098
Speed	-0.025	0.050	0.501	0.616	-0.123	0.073
Settlement	0.013	0.043	0.303	0.762	-0.071	0.097
Day	-0.017	0.043	0.387	0.699	-0.101	0.068
Rain	0.009	0.037	0.233	0.816	-0.064	0.081
EVI^2	-0.010	0.056	0.185	0.853	-0.119	0.099
Pan	0.003	0.033	0.079	0.937	-0.062	0.067
EVI	-0.007	0.037	0.192	0.848	-0.079	0.065

Table A.122 AG270, wet season, speed model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
River buffer	-0.167	0.114	1.469	0.142	-0.390	0.056
Pan	-0.105	0.078	1.341	0.180	-0.259	0.049
EVI	-0.167	0.078	2.140	0.032	-0.320	-0.014
EVI^2	0.208	0.125	1.666	0.096	-0.037	0.452
Lag speed	0.034	0.056	0.597	0.550	-0.077	0.144
Angle	-0.028	0.051	0.536	0.592	-0.128	0.073
Settlement	0.050	0.073	0.682	0.495	-0.094	0.194
Road buffer	0.040	0.088	0.450	0.653	-0.133	0.213
Day	-0.017	0.043	0.395	0.693	-0.102	0.067
Rain	-0.013	0.042	0.321	0.749	-0.096	0.069

Table A.123 77265, dry season, angle model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Speed	-0.040	0.061	0.658	0.511	-0.160	0.079
Rain	-0.040	0.081	0.486	0.627	-0.199	0.120
Road buffer	-0.023	0.059	0.386	0.700	-0.138	0.093
River buffer	-0.013	0.044	0.301	0.764	-0.099	0.073
EVI	0.009	0.037	0.232	0.816	-0.065	0.082
Settlement	0.009	0.040	0.230	0.818	-0.069	0.087
Lag angle	0.005	0.034	0.135	0.893	-0.062	0.071
Day	-0.004	0.034	0.131	0.896	-0.071	0.063
EVI^2	0.003	0.040	0.067	0.947	-0.075	0.081
Pan	0.001	0.034	0.042	0.966	-0.065	0.068

Table A.124 77265, dry season, speed model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
River buffer	-0.525	0.076	6.852	<0.001	-0.675	-0.375
Day	-0.140	0.082	1.716	0.086	-0.301	0.020
Rain	0.097	0.117	0.827	0.408	-0.133	0.326
Angle	-0.047	0.065	0.723	0.470	-0.175	0.081
Pan	-0.156	0.088	1.767	0.077	-0.329	0.017
Settlement	0.144	0.099	1.458	0.145	-0.050	0.338
EVI	-0.148	0.084	1.762	0.078	-0.312	0.017
Lag speed	-0.207	0.072	2.872	0.004	-0.348	-0.066
Road buffer	0.035	0.080	0.435	0.664	-0.122	0.191
EVI^2	-0.010	0.046	0.205	0.837	-0.101	0.082

Table A.125 77265, wet season, angle model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Rain	0.070	0.088	0.795	0.427	-0.103	0.242
Speed	-0.046	0.074	0.620	0.536	-0.190	0.099
Lag angle	0.027	0.060	0.454	0.650	-0.091	0.146
EVI	0.033	0.068	0.488	0.626	-0.100	0.166
Road buffer	0.021	0.068	0.302	0.763	-0.113	0.154
Day	0.014	0.049	0.290	0.772	-0.082	0.110
Settlement	0.004	0.046	0.095	0.925	-0.094	0.085
Pan	0.007	0.044	0.157	0.875	-0.079	0.093
EVI^2	-0.005	0.042	0.128	0.898	-0.088	0.077
River buffer	-0.001	0.044	0.033	0.974	-0.089	0.086

Table A.126 77265, wet season, speed model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
River buffer	-0.146	0.106	1.379	0.168	-0.354	0.062
EVI^2	0.119	0.093	1.273	0.203	-0.064	0.302
Angle	-0.042	0.069	0.605	0.545	-0.178	0.094
Settlement	0.034	0.071	0.486	0.627	-0.104	0.173
Lag speed	0.017	0.051	0.345	0.730	-0.082	0.117
Rain	0.022	0.056	0.397	0.691	-0.087	0.131
Road buffer	0.027	0.072	0.367	0.713	-0.115	0.169
EVI	-0.015	0.054	0.284	0.777	-0.122	0.091
Pan	-0.012	0.046	0.262	0.793	-0.103	0.078
Day	-0.002	0.040	0.056	0.955	-0.081	0.076

Table A.127 AG278, dry season, angle model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Road buffer	-0.090	0.081	1.106	0.269	-0.249	0.069
Day	0.068	0.060	1.134	0.257	-0.050	0.187
Pan	0.110	0.066	1.672	0.094	-0.019	0.240
Lag angle	0.123	0.058	2.095	0.036	0.008	0.237
Speed	-0.080	0.061	1.299	0.194	-0.200	0.041
Fire	0.044	0.087	0.505	0.613	-0.126	0.214
EVI^2	-0.024	0.060	0.406	0.685	-0.142	0.093
Settlement	-0.010	0.043	0.245	0.807	-0.094	0.073
EVI	0.022	0.049	0.444	0.657	-0.074	0.118
River buffer	0.011	0.042	0.254	0.799	-0.071	0.093
Rain	-0.005	0.050	0.099	0.921	-0.104	0.094

Table A.128 AG278, dry season, speed model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Day	-0.092	0.068	1.365	0.172	-0.225	0.040
Fire	0.121	0.133	0.908	0.364	-0.140	0.381
Rain	0.321	0.111	2.885	0.004	0.103	0.540
Angle	-0.084	0.066	1.273	0.203	-0.212	0.045
Settlement	0.183	0.078	2.346	0.019	0.030	0.335
EVI	-0.176	0.099	1.779	0.075	-0.369	0.018
EVI^2	0.121	0.116	1.044	0.296	-0.106	0.348
Lag speed	-0.235	0.053	4.413	0.000	-0.339	-0.130
Road buffer	0.035	0.064	0.552	0.581	-0.090	0.161
River buffer	-0.016	0.051	0.323	0.747	-0.116	0.083
Pan	-0.002	0.032	0.071	0.943	-0.065	0.061

Table A.129 AG278, wet season, angle model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Rain	0.046	0.053	0.879	0.379	-0.057	0.150
Pan	-0.035	0.048	0.726	0.468	-0.128	0.059
Speed	-0.164	0.048	3.398	0.001	-0.258	-0.069
EVI	-0.021	0.040	0.539	0.590	-0.100	0.057
Settlement	-0.028	0.046	0.592	0.554	-0.119	0.064
River buffer	-0.047	0.086	0.548	0.584	-0.216	0.122
EVI^2	-0.010	0.033	0.314	0.754	-0.075	0.054
Day	0.009	0.030	0.309	0.757	-0.049	0.067
Lag angle	0.006	0.027	0.239	0.811	-0.047	0.060

Table A.130 AG278, wet season, speed model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
River buffer	0.073	0.092	0.797	0.425	-0.106	0.252
Angle	-0.140	0.040	3.488	<0.001	-0.218	-0.061
Settlement	0.103	0.052	1.967	0.049	0.000	0.205
EVI	-0.164	0.040	4.123	<0.001	-0.242	-0.086
Lag speed	-0.034	0.042	0.798	0.425	-0.116	0.049
EVI^2	0.016	0.034	0.479	0.632	-0.050	0.082
Day	-0.005	0.023	0.222	0.824	-0.050	0.039
Rain	0.004	0.022	0.203	0.839	-0.039	0.048
Pan	0.002	0.021	0.075	0.940	-0.039	0.042

Table A.131 AG279, dry season, angle model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Road buffer	-0.590	0.348	1.687	0.092	-1.274	0.095
Settlement	0.190	0.241	0.787	0.432	-0.283	0.663
EVI	-0.271	0.242	1.116	0.265	-0.747	0.205
EVI^2	-0.839	0.345	2.415	0.016	-1.519	-0.158
Lag angle	-0.141	0.182	0.768	0.442	-0.500	0.218
Day	0.067	0.140	0.479	0.632	-0.208	0.343
Fire	0.044	0.200	0.216	0.829	-0.352	0.439
Speed	0.025	0.096	0.254	0.799	-0.165	0.214
River buffer	0.013	0.152	0.086	0.932	-0.286	0.313
Pan	-0.016	0.107	0.145	0.885	-0.227	0.196
Rain	0.014	0.103	0.138	0.890	-0.190	0.219

Table A.132 AG279, dry season, speed model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
River buffer	-0.140	0.213	0.656	0.512	-0.560	0.279
Rain	0.137	0.196	0.694	0.487	-0.250	0.524
EVI^2	0.183	0.290	0.629	0.530	-0.388	0.754
Pan	-0.075	0.157	0.473	0.636	-0.384	0.235
Day	-0.078	0.152	0.512	0.609	-0.377	0.221
Lag speed	-0.039	0.117	0.333	0.739	-0.270	0.192
EVI	-0.018	0.113	0.158	0.874	-0.241	0.205
Road buffer	-0.011	0.162	0.065	0.948	-0.332	0.310
Settlement	0.006	0.128	0.049	0.961	-0.246	0.258
Angle	0.014	0.097	0.148	0.883	-0.177	0.206
Fire	0.044	0.209	0.209	0.834	-0.368	0.456

Table A.133 AG279, wet season, angle model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Road buffer	0.277	0.284	0.973	0.330	-0.281	0.835
Rain	0.125	0.104	1.195	0.232	-0.080	0.329
EVI^2	0.036	0.065	0.557	0.578	-0.091	0.163
Day	-0.035	0.068	0.507	0.612	-0.168	0.099
Lag angle	-0.021	0.056	0.365	0.715	-0.131	0.090
Speed	-0.016	0.054	0.294	0.769	-0.123	0.091
Settlement	-0.016	0.057	0.286	0.775	-0.128	0.096
River buffer	0.013	0.066	0.204	0.838	-0.116	0.143
EVI	0.004	0.049	0.089	0.929	-0.091	0.100
Pan	-0.007	0.047	0.147	0.883	-0.100	0.086

Table A.134 AG279, wet season, speed model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
River buffer	-0.709	0.160	4.418	<0.001	-1.023	-0.394
Road buffer	0.351	0.349	1.003	0.316	-0.335	1.036
Rain	-0.080	0.104	0.770	0.441	-0.284	0.124
Pan	-0.194	0.126	1.536	0.124	-0.442	0.054
Settlement	0.144	0.144	0.997	0.319	-0.139	0.427
EVI	0.100	0.122	0.818	0.413	-0.139	0.338
EVI^2	-0.222	0.110	2.014	0.044	-0.438	-0.006
Lag speed	0.768	0.109	7.034	<0.001	0.554	0.982
Day	-0.017	0.059	0.290	0.772	-0.134	0.099
Angle	0.012	0.055	0.219	0.827	-0.096	0.120

Table A.135 AM291, dry season, angle model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Day	-0.072	0.074	0.970	0.332	-0.216	0.073
Settlement	0.059	0.071	0.823	0.410	-0.081	0.199
EVI^2	-0.035	0.052	0.680	0.496	-0.137	0.066
River buffer	-0.188	0.221	0.849	0.396	-0.621	0.246
Rain	-0.034	0.062	0.549	0.583	-0.157	0.088
Lag angle	0.025	0.049	0.511	0.609	-0.070	0.120
Pan	-0.010	0.043	0.240	0.811	-0.095	0.074
Speed	-0.014	0.040	0.341	0.733	-0.091	0.064
EVI	0.002	0.035	0.065	0.948	-0.067	0.071

Table A.136 AM291, dry season, speed model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
River buffer	-0.858	0.352	2.435	0.015	-1.549	-0.167
Day	-0.369	0.098	3.745	<0.001	-0.562	-0.176
Pan	0.353	0.116	3.057	0.002	0.127	0.580
EVI^2	0.258	0.090	2.868	0.004	0.082	0.434
Lag speed	-0.215	0.113	1.906	0.057	-0.435	0.006
Settlement	0.067	0.107	0.625	0.532	-0.142	0.276
EVI	0.047	0.089	0.531	0.595	-0.127	0.221
Rain	0.034	0.081	0.419	0.675	-0.125	0.192
Angle	-0.022	0.061	0.367	0.713	-0.142	0.097

Table A.137 AM291, wet season, angle model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Settlement	0.103	0.095	1.087	0.277	-0.083	0.289
Lag angle	0.256	0.072	3.554	<0.001	0.115	0.398
Speed	-0.117	0.089	1.315	0.189	-0.291	0.057
Pan	-0.037	0.065	0.565	0.572	-0.164	0.091
EVI	0.014	0.048	0.293	0.769	-0.080	0.108
EVI^2	0.005	0.029	0.168	0.867	-0.053	0.062
River buffer	-0.026	0.065	0.403	0.687	-0.155	0.102
Rain	-0.005	0.039	0.133	0.894	-0.081	0.071
Day	0.003	0.039	0.087	0.931	-0.072	0.079

Table A.138 AM291, wet season, speed model

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Day	-0.497	0.076	6.534	<0.001	-0.646	-0.348
Angle	-0.160	0.091	1.754	0.079	-0.338	0.019
Settlement	0.255	0.097	2.610	0.009	0.063	0.446
Lag speed	-0.574	0.075	7.657	<0.001	-0.720	-0.427
River buffer	0.056	0.088	0.630	0.529	-0.117	0.229
Rain	0.032	0.062	0.521	0.603	-0.089	0.154
EVI^2	-0.007	0.031	0.218	0.827	-0.069	0.055
EVI	-0.006	0.043	0.128	0.898	-0.091	0.080
Pan	0.001	0.041	0.021	0.983	-0.080	0.082

A.3 Additional results from crossing model

Table A.139 Mahango crossing model, 1000m.

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Angle	-1.455	0.479	3.040	0.002	-2.393	-0.517
Dry season	-2.837	1.015	2.793	0.005	-4.828	-0.846
Speed	1.928	0.442	4.358	<0.001	1.061	2.795
Day	-0.140	0.3945	0.356	0.722	-0.914	0.633
EVI	-0.354	0.672	0.527	0.598	-1.670	0.963
In omuramba	-0.211	0.644	0.327	0.743	-1.472	1.051

Table A.140 Mahango crossing model, 5000m.

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.50%)
Angle	-1.184	0.307	3.862	<0.001	-1.785	-0.583
Day	-0.253	0.300	0.843	0.399	-0.842	0.336
Dry season	-3.372	0.673	5.011	<0.001	-4.689	-2.052
EVI	0.399	0.274	1.454	0.146	-0.139	0.936
Speed	0.686	0.172	3.997	<0.001	0.350	1.023

Table A.141 Ring road crossing model, 1000m.

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Settlement	2.234	0.718	3.11	0.002	0.826	3.641
Day	0.050	0.256	0.155	0.878	-0.462	0.541
EVI	-0.469	0.562	0.835	0.404	-1.570	0.632
Speed	1.774	0.323	5.483	< 0.001	1.140	2.408
Angle	0.021	0.257	0.081	0.935	-0.483	0.5245
Dry season	0.048	0.415	0.116	0.908	-0.765	0.861

Table A.142 Ring road crossing model, 5000m.

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Angle	-0.040	0.169	0.236	0.8132	-0.371	0.291
Settlement	0.989	0.281	3.517	<0.001	0.438	1.541
Day	-0.125	0.193	0.644	0.520	-0.504	0.255
Dry season	-0.494	0.388	1.273	0.203	-1.254	0.267
EVI	-0.636	0.412	1.543	0.123	-1.443	0.172
Speed	1.901	0.122	15.547	<0.001	1.662	2.141

Table A.143 Tar road crossing model, 1000m.

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Angle	-0.722	0.255	2.826	0.005	-1.222	-0.221
Settlement	0.333	0.323	1.031	0.303	-0.301	0.967
Day	-0.279	0.285	0.979	0.327	-0.838	0.280
Dry season	0.115	0.282	0.406	0.685	-0.439	0.668
EVI	-0.367	0.335	1.097	0.273	-1.024	0.289
In omuramba	0.260	0.265	0.981	0.327	-0.259	0.779
Speed	1.783	0.294	6.057	<0.001	1.206	2.360

Table A.144 Tar road crossing model, 5000m

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.50%)
Angle	-0.412	0.199	2.064	0.039	-0.802	-0.021
Settlement	1.128	0.241	4.676	<0.001	0.655	1.600
Day	-0.466	0.201	2.313	0.021	-0.861	-0.071
Dry season	0.508	0.263	1.93	0.054	-0.008	1.025
EVI	0.026	0.203	0.129	0.898	-0.372	0.424
In omuramba	-0.060	0.162	0.369	0.712	-0.377	0.258
Speed	2.321	0.225	10.314	<0.001	1.880	2.762

Table. A.145 Buffalo Core (Tar road) crossing model, 1000m

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Settlement	-2.243	1.224	1.832	0.067	-4.643	0.157
EVI	-2.037	1.461	1.395	0.163	-4.899	0.826
Angle	-0.564	0.954	0.591	0.555	-2.435	1.307
Speed	0.516	0.956	0.539	0.590	-1.359	2.390
In omuramba	0.553	1.172	0.472	0.637	-1.744	2.850
Dry season	0.161	0.713	0.226	0.821	-1.236	1.558
Day	-0.087	0.745	0.117	0.907	-1.548	1.374

Table A.146 Buffalo Core (Tar road) crossing model, 2000m

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Settlement	-2.518	0.648	3.888	<0.001	-3.787	-1.248
Dry season	1.523	1.371	1.112	0.266	-1.163	4.2096
EVI	-1.686	1.411	1.195	0.232	-4.452	1.0788
Speed	0.727	0.997	0.729	0.466	-1.227	2.6809
Angle	-0.324	0.642	0.505	0.614	-1.582	0.9341
Day	-0.164	0.582	0.282	0.778	-1.306	0.9771
In omuramba	0.264	0.893	0.296	0.767	-1.487	2.0154

Table A.147 Buffalo Core (Tar road) crossing model, 5000m

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Angle	-0.880	0.753	1.169	0.243	-2.355	0.596
Settlement	-2.185	0.450	4.856	<0.001	-3.067	-1.303
Dry season	1.784	1.167	1.529	0.126	-0.503	4.071
EVI	-1.133	1.250	0.907	0.365	-3.584	1.317
Speed	1.514	0.967	1.565	0.118	-0.382	3.410
Day	-0.295	0.578	0.511	0.609	-1.428	0.838
In omuramba	-0.088	0.485	0.182	0.856	-1.040	0.863

Table A.148 Mudumu (Ring road) crossing model, 1000m

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Settlement	0.882	0.473	1.863	0.062	-0.046	1.810
Day	0.030	0.253	0.120	0.904	-0.466	0.527
EVI	-0.320	0.472	0.679	0.497	-1.245	0.604
Speed	1.823	0.333	5.466	<0.001	1.169	2.476
Angle	0.020	0.257	0.079	0.937	-0.483	0.523
Dry season	-0.013	0.408	0.033	0.974	-0.813	0.786

Table A.149 Mudumu (Ring road) crossing model, 2000m

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Angle	0.067	0.213	0.316	0.7521	-0.350	0.484
Settlement	1.116	0.338	3.302	0.001	0.453	1.778
Day	-0.061	0.210	0.293	0.770	-0.473	0.350
Dry season	-0.221	0.405	0.545	0.585	-1.014	0.573
EVI	-0.330	0.425	0.776	0.438	-1.163	0.503
Speed	1.947	0.212	9.179	<0.001	1.531	2.362

Table A.150 Mudumu (Ring road) crossing model, 5000m

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Angle	0.0152	0.169	0.09	0.928	-0.317	0.347
Settlement	0.176	0.239	0.739	0.46	-0.291	0.644
Day	-0.060	0.178	0.335	0.738	-0.410	0.290
Dry season	-0.662	0.403	1.642	0.100	-1.451	0.128
EVI	-0.448	0.393	1.14	0.254	-1.218	0.322
Speed	2.063	0.136	15.167	<0.001	1.797	2.330

Table A.151 Susuwe (Tar road) crossing model, 1000m

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Angle	-0.685	0.274	2.500	0.012	-1.222	-0.148
Settlement	0.071	0.233	0.304	0.761	-0.386	0.528
Day	-0.212	0.273	0.779	0.436	-0.747	0.322
Dry season	0.148	0.314	0.471	0.638	-0.467	0.763
EVI	-0.399	0.355	1.125	0.261	-1.095	0.296
In omuramba	0.421	0.294	1.432	0.152	-0.155	0.996
Speed	1.901	0.317	5.993	<0.001	1.279	2.523

Table A.152 Susuwe (Tar road) crossing model, 2000m

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Angle	-0.505	0.241	2.098	0.036	-0.977	-0.033
Settlement	0.361	0.298	1.212	0.225	-0.223	0.946
Day	-0.285	0.240	1.187	0.235	-0.757	0.186
Dry season	0.0651	0.261	0.249	0.803	-0.446	0.577
EVI	-0.335	0.306	1.095	0.274	-0.934	0.264
In omuramba	0.503	0.245	2.056	0.040	0.024	0.983
Speed	2.248	0.286	7.852	<0.001	1.687	2.809

Table A.153 Susuwe (tar road) crossing model, 5000m

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Lower Confidence Interval (2.5%)	Upper Confidence Interval (97.5%)
Angle	-0.294	0.218	1.351	0.177	-0.721	0.132
Settlement	0.7662	0.246	3.114	0.002	0.284	1.248
Day	-0.463	0.216	2.149	0.032	-0.886	-0.041
Dry season	0.242	0.276	0.876	0.381	-0.299	0.783
EVI	-0.166	0.252	0.657	0.511	-0.661	0.329
In omuramba	0.126	0.193	0.653	0.5135	-0.253	0.506
Speed	2.662	0.265	10.059	<0.001	2.143	3.181