Final Evaluation Report

Grant Recipient Details	
Full Name	John Reuben Hongoa
Project Title	Spatial Modelling of the Invasive Plant Opuntia: Habitat, Abundance and Distributions under Climate Change in Serengeti National Park
Application ID	30674-1
Grant Amount	£5610
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Date of this Report	02/11/2022

1. Indicate the level of achievement of the project's original objectives and include any relevant comments on factors affecting this.

Objective	Not achieved	Partially achieved	Fully achieved	Comments
To model the habitat distribution and abundance of Opuntia species under current environmental				The habitat distribution and abundance of *Opuntia* species under current environmental conditions was modelled successfully using presence data/*Opuntia* locations and explanatory variables of current climate as obtained from world climate data (https://www.worldclim.org/data/worldclim21.html)
To model the habitat, abundance and distribution of Opuntia species under future climatic condition.				The prediction of *Opuntia* species habitat distribution and abundance was done by subjecting response variables of *Opuntia* species and already modelled future environmental variables available in the world climate database (https://www.worldclim.org/data/cmip6/cmip6climate.html#)
To Identify primary explanatory variables/environmental factors which influence the spatial habitat distribution of Opuntia species				The results of this study revealed the environmental variables which played major role in the habitat distribution and *Opuntia* species abundance.
To Identify potential or critical areas of immediate conservation actions and advice				The predictive maps held to identify the areas of immediately conservation priorities in Serengeti National Park.

2. Please explain any unforeseen difficulties that arose during the project and how these were tackled.

Timeframe/activities time: This small project was planned to be conducted in 1 year, however the time was very limited since it was difficult to collect data during the rainy season. This delayed the whole process as some of planned field data collection activities needed to be postponed.

Field vehicle breakdown: Although this issue was sorted out immediately but was one of the challenges which delayed field work.

COVID-19 influence: Regardless all measures we managed to undertake as advised by local and international organisation. Covid19 caused delay on team organisation and field equipment collection.

3. Briefly describe the three most important outcomes of your project.

(i)Habitat suitability areas of invasive species *Opuntia* predicted under climate change (changing environmental conditions) in Serengeti National Park. Before invasive plant *Opuntia* was modelled in the species distribution model (SDM). The response variables were modelled in the current environmental dataset to give us the current distribution of invasive plant *Opuntia* under current environmental condition figure 1. This actually inform us the current spatial distribution of *Opuntia* in Serengeti National Park.

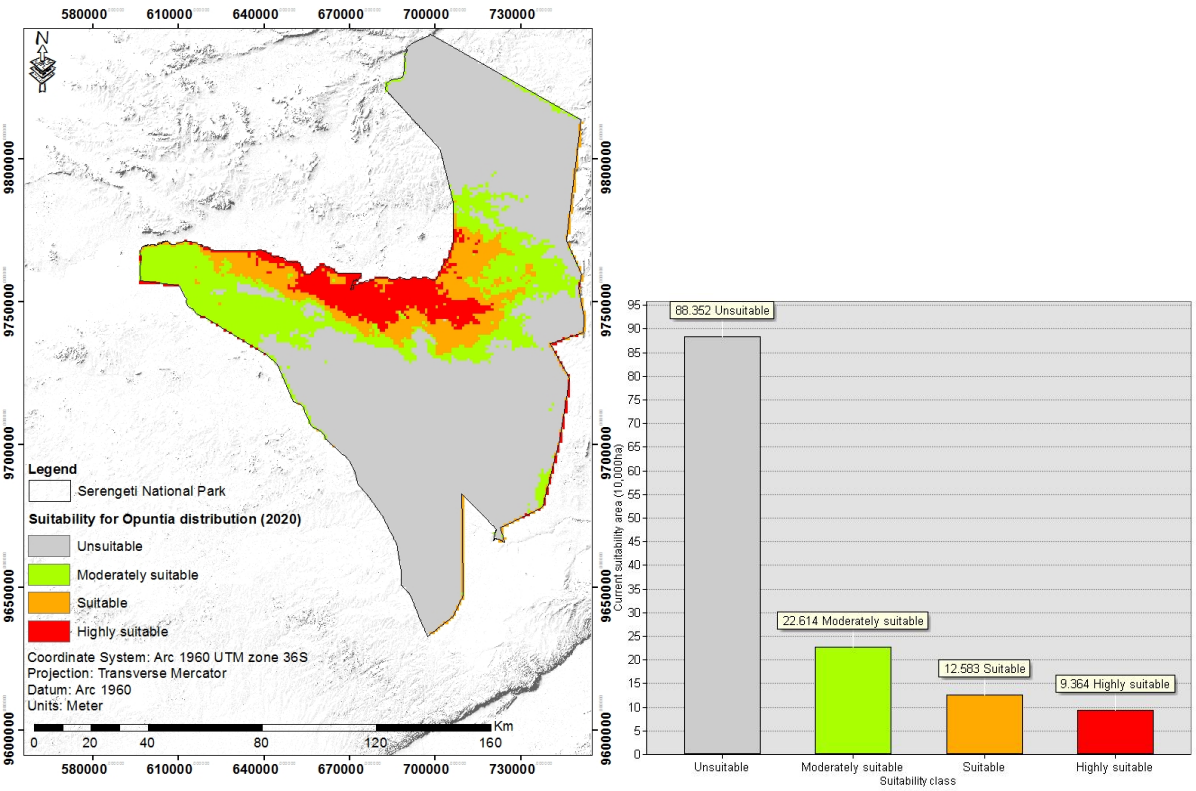


Figure 1: Habitat suitability model of invasive plant Opuntia under current environmental conditions.

Again, the presence variables were modelled in the future environmental dataset, in order to reveal how the presence *Opuntia* will be influenced by climate change. The result revealed that invasive plant *Opuntia* will spread more in future than in the current situation figure 2.

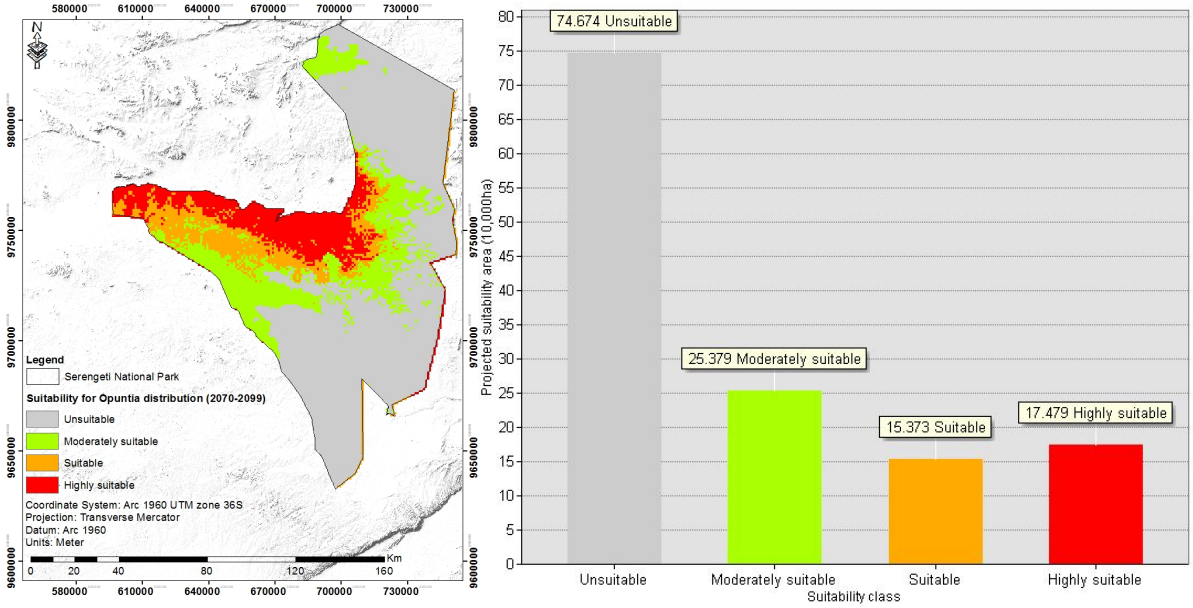


Figure 2: Habitat suitability model of invasive plant Opuntia under future environmental conditions.

(ii)Areas of critical conservation importance was identified; Special distribution modelling of *Opuntia* species revealed areas which need quick conservation action, the model was able to discover areas which needed special attention. The model revealed the area of persistence, which is area where there is no *Opuntia* invasion recently, areas of colonisation where *Opuntia* species present and will continue to dominate in future and also the model discovered areas where *Opuntia* species is expect to extinct figure 3.

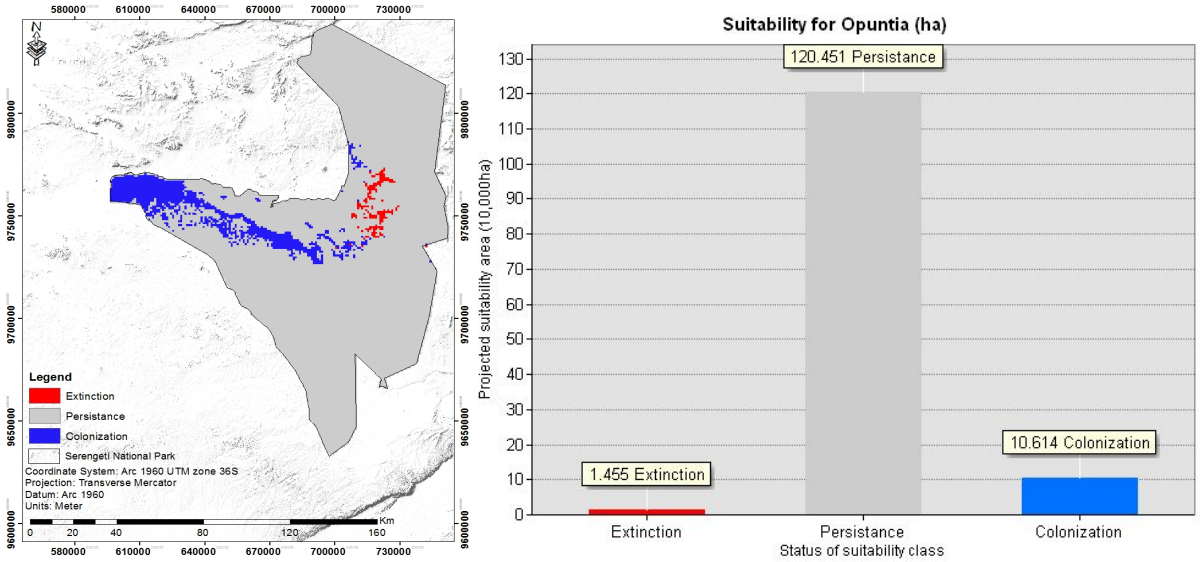


Figure 3: Predictive map indicating persistence, extinction and colonisation of invasive plant Opuntia under future environmental conditions.

(iii)Key environmental factors which influenced spatial distribution of invasive plants *Opuntia* were Identified figure 4. The factors identified was very important to help

ecologists in understanding potential threats which might occur in future so that they can develop possible mitigation measures/plans. The following were the explanatory variables which influenced the response variables.

- BIO1 = Annual Mean Temperature
- BIO2 = Mean Diurnal Range (Mean of monthly (max temp - min temp))
- BIO3 = Isothermality (BIO2/BIO7) (×100)
- BIO4 = Temperature Seasonality (standard deviation ×100)
- BIO5 = Max Temperature of Warmest Month
- BIO6 = Min Temperature of Coldest Month
- BIO7 = Temperature Annual Range (BIO5-BIO6)
- BIO8 = Mean Temperature of Wettest Quarter
- BIO9 = Mean Temperature of Driest Quarter
- BIO10 = Mean Temperature of Warmest Quarter
- BIO11 = Mean Temperature of Coldest Quarter
- BIO12 = Annual Precipitation
- BIO13 = Precipitation of Wettest Month
- BIO14 = Precipitation of Driest Month
- BIO15 = Precipitation Seasonality (Coefficient of Variation)
- BIO16 = Precipitation of Wettest Quarter
- BIO17 = Precipitation of Driest Quarter
- BIO18 = Precipitation of Warmest Quarter
- BIO19 = Precipitation of Coldest Quarter
-

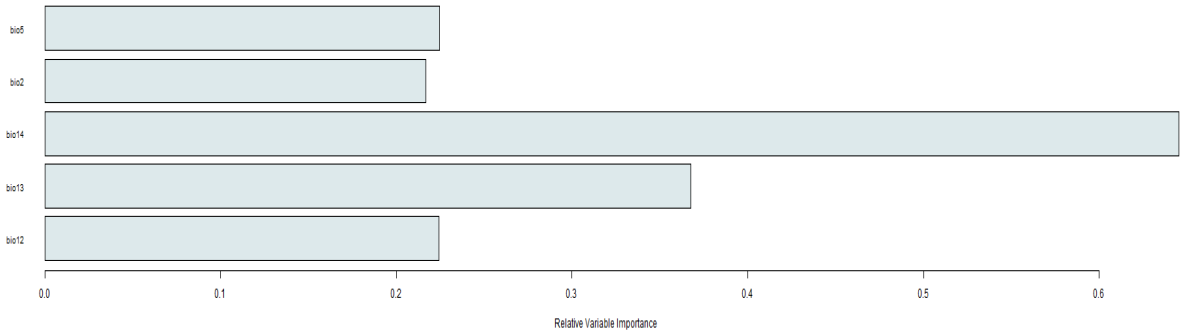


Figure 4: Variable's importance in influencing spread of Opuntia species in the park.

(iv)Inform Park management/awareness raising on the magnitude and intensity of spread of the invasive plant *Opuntia* in Serengeti National Park. The park management are aware of the potential threats and spread of invasive plant *Opuntia*. This was done through the presentation which was conducted to the ecologists figure5. Currently the park managers have understood the magnitude of the problems and have committed to learn scientific and environmentally friendly methods to eradicate the invasive species, although they have yet started killing the invasive plant *Opuntia* with limited knowledge to avoid more spread.

Figure 5: Presentation of habitat distribution of invasive plant Opuntia Serengeti National Park.

4. Briefly describe the involvement of local communities and how they have benefitted from the project.

Local communities surrounding Serengeti National Park in collaboration with park ecologists have started eradicating invasive plant *Opuntia*, although currently they encountered challenges in best knowledge on how to fight against spread of *Opuntia*. But they have tried to spray chemicals and burn the invasive when dried figure 6. Villagers from four villages found adjacent the park have been involved. This villages include the Park Nyigoti, Mereshi, Fort Ikoma and Robanda. The team was trained by the ecologist on how to spread environmentally friendly chemical which dries *Opuntia* species. After dried the invasive plants *Opuntia* were burnt.

5. Are there any plans to continue this work?

Yes, as explained above, this project involved single species (*Opuntia*) modelling in Serengeti National Park, and it intended to reveal how invasive plant *Opuntia* spatially distributed in the park in the current and future climate change. However, during survey (field data collection) we encountered many other invasive species spread in the park and therefore I think it will be very important to conduct more broader study on multi-species habitat distribution of invaded species figure 7. This project will be important because will assist the park management to understand

the magnitude of the problem and therefore set appropriate adaptation/mitigation actions.

Figure 6: Ecologist and Villagers involved in Opuntia eradication

Figure 7: invasive plant found in the park (Datura stramoniuma na xanthium strumarium)

6. How do you plan to share the results of your work with others?

The results have been shared to Serengeti National Park management and ecology team. Again, the findings were presented in the workshop named Workshop on the use of Geographic Information Systems (GIS) and Earth Observation (EO) in Protected Area Management (Virtual workshop which was prepared by Map Tailor Geospatial Consulting (German based company) funded by KfW. Additionally, I also intend to present my findings in forthcoming TAWIRI scientific conference which normally bring together outstanding research scientists (at least 500) from within and outside the country. Additionally, the results will be shared through scientific publications in the international journal and therefore our contribution in scientific communities. Furthermore, I am planning to submit the full report to Tanzania National Parks who is the custodian of Serengeti National Park.

7. Timescale: Over what period was the grant used? How does this compare to the anticipated or actual length of the project?

The grant was used in a period one year (i.e., August 2020 to July 2021). Some of the field and data analysis work was extended for the reasons already stated in the previous section.

8. Budget: Provide a breakdown of budgeted versus actual expenditure and the reasons for any differences. All figures should be in £ sterling, indicating the local exchange rate used. It is important that you retain the management accounts and all paid invoices relating to the project for at least 2 years as these may be required for inspection at our discretion.

Item	Budgeted Amount	Actual Amount	Difference	Comments
Accounting services (File and maintaining field costs and equipment receipts)	200	200		
Two GPS (Garmin GPS), GPS charger and GPS rechargeable battery	800	754	-46	
Field Camera (Canon)	350	492	+142	
Report production, dissemination and publication	200	394	+194	
Accommodation for field team	700	1272	+572	Since number of days in the field were increased, it had some cost implication which we deviated from food item line of the budget.

Food per team during field work	1400	222	-1178	We managed to save significant amount of money in this line budget which helped to save deficit appeared in other budget lines.
Fuel	960	1463	+503	It was challenging to collect data during wet/rain season, we exceeded number of days in the field that was expected
Car maintenance and Hiring vehicle	520	531	+11	
Stationaries, Report production and dissemination	480	393	-87	
TOTAL	**5610**	**5722**	**+112**	

9. Looking ahead, what do you feel are the important next steps?

- Submitting the full project report to Serengeti National Park management as it has jurisdiction of conserving the park.
- Submitting of manuscripts to the international journal in order to share my findings to local and international scientific communities.
- Spatial location of all *Opuntia* species will be uploaded in the presence Serengeti National Park Geo-database.
- Preparing the project proposal on multi-species distribution modelling under current and future climate condition with other explanatory variables such as elevation, Euclidian distance to road and park boundary.

10. Did you use The Rufford Foundation logo in any materials produced in relation to this project? Did the Foundation receive any publicity during the course of your work?

- Rufford Foundation logo was used in the first page of the presentation conducted to Tanzania National Park ecology team and also in the virtual workshop which was prepared by map tailor Geospatial Consulting Company.
- Rufford Small Grant will be acknowledged in the manuscript which will be submitted in the peer reviewed international scientific journals.

11. Please provide a full list of all the members of your team and briefly what was their role in the project.

John Reuben Hongoa (Project Investigator)
He was leading the whole process from the main idea of the project, proposal development, data collection, analysis and report writing.

Kelvin Munisi
He was the field assistant who played major role in data collection

Alli Kassimu Shakha
He is GIS officer of Serengeti National Park, he played crucial role in data collection including marking spatial location of all plots and Opuntia species

Seph Frowin Choma
He is Serengeti National Park's ecologists who played vital role in data collection

12. Any other comments?

I am grateful to The Rufford Foundation for offering/donating funds which enabled us to conduct *Opuntia* species modelling study. My sincere appreciation and gratitude are extended to our employer for allowing us to undertake this project.

(a)Appendix: Field data

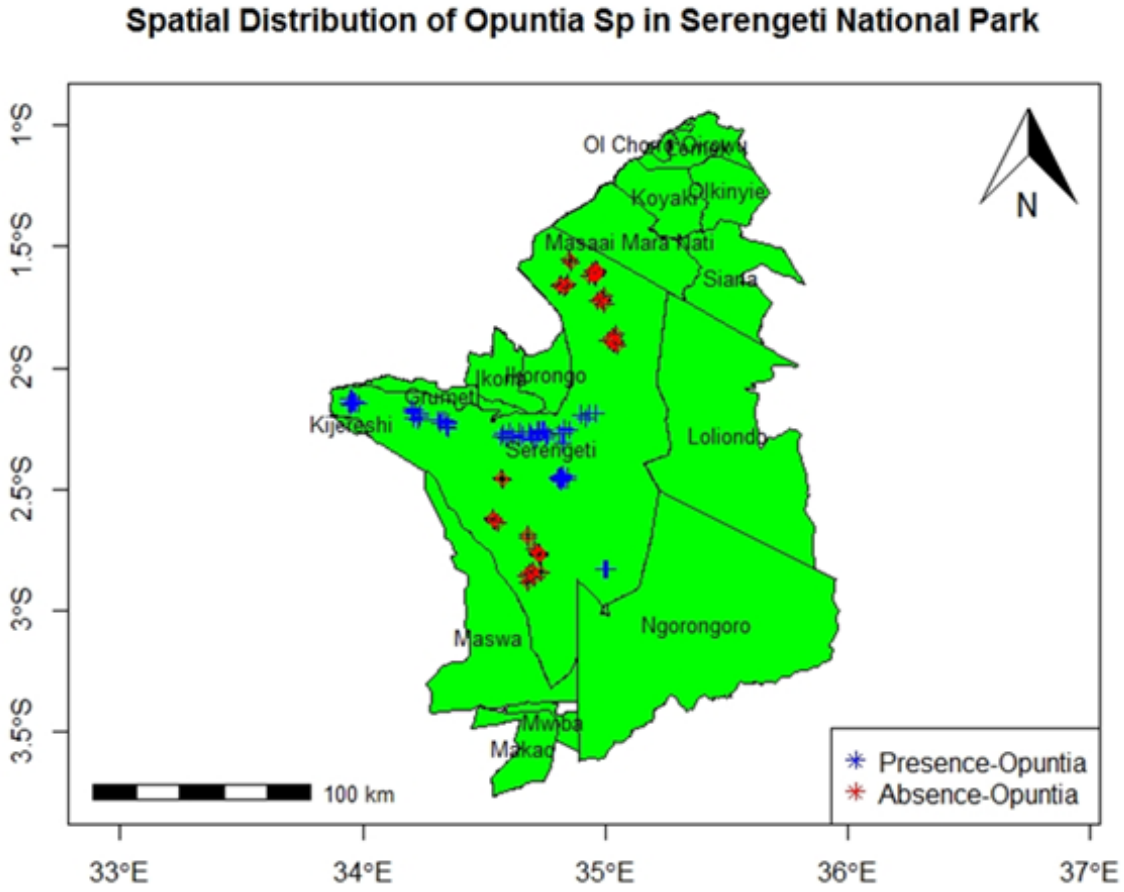
					Cover								Biomass					
Date	**Sample ID**	**Broad scale habitat**	**X**	**Y**	**soil-Scratch**	**Litter-Scratch**	**Grass-Scratch**	**Gravel-Scratch**	**soil-Good**	**Litter-Good**	**Grass-Good**	**Gravel - Good**	**1**	**2**	**3**	**4**	**5**	**Soil**
14/9/20	RPM64v1	SW	693952	9689828	50	10	40	0	40	10	50	0	3	3	4	2	3	Clay
14/9/20	RPM53v1	SW	694201	9693419	0	10	90	0	0	20	80	0	7	21	14.5	14	14	Clay
14/9/20	RPM65v1	SW	691015	983178	0	20	90	0	0	10	90	0	4	7	7	12	13	Clay
14/9/20	RPM60v1	SW	687548	9678819	0	20	90	0	0	10	90	0	7	10.5	12	3	3	Clay
14/9/20	RPM56v1	SW	690180	9673388	10	40	60	0	10	30	60	0	5	6	5	10	4	Clay
14/9/20	RPM61v1	SW	694753	9664153	20	60	40	0	10	50	40	0	1.5	4.5	7.5	1.5	2	Clay
28/8/20	RPW98	WCM	645508	9730830	53	5	40	0	55	5	40	0	2	3	5	2	2	Clay
28/8/20	RPW9v1	NW	738871	9784812	60	15	30	0	55	15	30	0	3	2	3.5	2.5	2	Clay
28/8/20	RPN7v1	NW	737244	9786991	0	0	0	0	0	0	0	0	7	3	4	4	3.5	Clay
28/8/20	RPN14v1	NW	745006	9777586	0	50	50	0	0	0	0	0	5	7	6	6.5	4.5	Clay
20/8/20	PW83	WCM	689292	9753769	40	25	50	0	40	20	40	0	2	2.5	3	4	3.5	Clay
20/8/20	RPW96v1	WCM	699891	9746819	40	10	55	0	40	10	50	0	1.5	1	1.5	1.5	2	Sand
20/8/20	RPW97v1	WCM	698684	9738070	30	10	30	70	20	10	20	50	0					Loam
22/8/20	RPW94	WCM	675340	9747332	30	30	45	0	20	30	50	0	8	5	12	5	8.5	Loam
22/8/20	RPW82	WCM	673257 2	9741414	40	25	50	0	40	20	40	0	3.5	3	2	4.5	2	Loam
22/8/20	PPW91v1	WCM	659886	9748120	15	10	30	60	10	5	35	50	4.5	4	4.5	5.5	7	Loam & Gravel small particles
22/8/20	RPW86	WCM	657693	9751483	5	40	50	0	5	45	50	0	5	10	3	7	9	Loam
22/8/20	RPW78	WCM	656587	9755831	5	25	60	20	5	25	50	20	7	5	5	4	3	Clay
22/8/20	RPW88v1	RIVERI	647113	9754817	0	20	80	0	0	20	80	0	8	14	12	13	9	Clay

		NE															
22/8/20	RPW95	RIVERINE	634123	9759640	2	48	45	0	2	48	50	0	5	9	19	6	3	Clay
22/8/20	RPW79	WCM	637134	9763734	20	10	60	0	20	10	70	0	1.5	2	3.5	6.5	4	Clay
24/8/20	RPW91	WCW	603995	9761799	50	10	30	0	60	10	30	0	5	14	4	12	2	Clay
24/8/20	RPW85	WCW	623218	9743463	50	15	40	0	60	10	30	0	3	6	3	7.5	2.5	Clay
24/8/20	RPW77	WCW	626446	9747530	40	10	45	0	40	10	50	0	4.5	5	2.5	4.5	2.5	Loam
24/8/20	RPW84		601444	9760756	8	25	80	0	5	25	70	0	3	7	13	24	12	Clay
24/8/20	RPW93	WCW	641823	9740129	40	15	50	0	40	10	50	0	6	4	3	8	3	Clay
31/8/20	RPC36	CW	709279	9769666	25	20	50	0	20	20	60	0	5	4.5	5	4	9	Loam
31/8/20	RPC35v1		712407	9770136	0	40	60	0	0	45	55	0	3	5	6	7	7	Loam
31/8/20	RPN15	NW	719758	9774814	20	30	60	0	20	20	40	0	4	4	5	5	4	Loam
31/8/20	RPN13	NW	721825	9776527	20	20	60	0	25	15	60	0	2.5	4	4.5	4	4.5	Loam
31/8/20	RPN0v1	NW	711449	9781186	0	0	0	0	0	0	0	0	5	4.5	4	2.5	2	Loam
31/8/20	RPN6v1		713798	9780328	0	0	0	0	0	0	0	0	8	8	5.5	5	4.5	Clay
31/8/20	RPN20v1				20	15	45	0	30	15	55	0	5	7	5	6	4.5	Loam
31/8/20	RPN21v1		707750	9771730	40	20	60	0	30	10	60	0	12	7	5	3.5	3	Loam
1/9/20	RPM70	CW	700736	9699422	20	10	60	0	30	10	60	0	7	11	8	16	7	Clay
1/8//20	RPW76	WCW	697307	9711935	40	10	30	0	60	10	30	0	1.5	3	2	4	2	Clay
1/9/20	RPW87	SG	699763	9715380	60	10	30	0	65	15	20	0	3	4	2.5	2	2	Clay
1/9/20	RPW99	SG	701938	9712643	0	0	0	0	0	0	0	0	10	9	36	27	21	Clay
1/9/20	RPW90		693257	9718100	50	20	40	0	60	10	30	0	2.5	2	3	3	2	Clay
1/9/20	RPW89	SG	697500	9726497	45	20	60	0	40	20	40	0	9	5	4	4	5	Clay
1/9/2	RPW80	LG	697863	9733530	10	30	60	0	10	30	60	0	4	10	25	11	7	Loam
28/8/20	RPN4v1	NW	724710	9787276	40	20	50	0	40	10	50	0	3	1.5	2.5	2	2	Loam
26/8/20	RPN23v1	NM	700446	9817443	0	15	90	0	0	10	90	0	40	20	35	17	35	Clay
27/8/20	RPN17	NW	691513	9820649	0	30	80	0	0	30	70	0	21	11	28	21	31	Loam
27/8/20	RPN5v1	NW	693506	9825487									4	25	6	5	10	Loam
27/8/20	RPN17	NW	696360	9824293	40	10	40	0	50	10	40	0	4	5	3	3.5	3	Loam
27/8/20	RPN19	NW	712919	9824171	5	40	50	0	5	40	55	0	12	25	7	7	8	Loam

27/8/20	RPN2	LG	720114	9824557	0	40	60	0	0	40	60	0	9	9	7	9	4	Loam
28/8/20	RPN15	NW	719377	9810385	0	20	80	0	0	20	80	0	6	4	6	7	6	Clay
28/8/20	RPN3v1	NW	723827	9811635	5	40	50	0	5	35	60	0	4	5.5	7	6	4	
28/8/20	RPN12v1	SG	746151	9816018	40	10	60	0	40	10	50	0	4	5	4	3	6	Clay
28/8/20	RPN1v1	NM	747092	9800549	0	10	70	0	0	20	80	0	6	6	6.5	8	7	Loam
4/9/20	RPC39	CW	725522	9742291	50	10	50	0	40	10	50	0	3	5	4	5	3	Clay
4/9/20	RPC48		731966	9743395	0	0	0	0	0	0	0	0	4	5	7	6	5	Loam
4/9/20	RPC28v1	CW	733435	9752122	40	10	40	0	40	10	50	0	8	8	4	6	6	Clay
4/9/20	RPC27v1	NC	735119	9752776	20	30	50	0	30	10	60	0	3	3	4	4.5	5	Clay
4/9/20	RPC44v1	CW	732198	9750058	40	10	60	0	30	10	60	0	2	2	3	3	2	Loam
4/9/20	RPC42v1	CW	731685	9747150	40	10	60	0	30	20	50	0	3	3	5	6.5	6	Loam
4/9/20	RPC31v1		731237	9745513	50	10	40	0	50	10	40	0	6	18	2	10	4	Loam
4/9/20	RPC33v1		728509	9744028	0	0	0	0	0	0	0	0	1		1	1	1	Loam
3/9/20	RPC30	WCW	700982	9757838	30	5	70	0	30	5	65	0	3	5	6	5	5	Clay
3/9/20	RPC46v1	Open wood land	726837	9730595	30	10	70	0	25	5	70	0	10	5	3.5	5.5	4	Loam
3/9/20	RPC34	Open wood land	727339	9733654	100	0	0	0	100	0	0	0	Burnt	Burnt	Burnt	Burnt	Burnt	Loam
03/9/20	RPC32v1	Open woodland	721907	9737454	20	20	65	0	20	20	60	0	7	6.5	3	8	7	Loam
03/9/20	RPC37v1	Open woodland	719979	9738226	30	10	80	0	20	10	70	0	8	3.5	3.5	10	6	Loam
03/9/20	RPC47	Open woodland	710029	9730955	30	0	70	0	30	0	70	0	21	35	24	38	16	Loam
03/9/20	RPC35v1	Woodl	708221	9746531	30	0	60	0	30	0	70	0	5	3	4	4	6	Loam

		and																
02/9/20	RPC38	LG	716773	9719686	0	20	80	0	0	20	80	0	32	36	34	36	25	Loam
02/9/20	RPC40	LG	724608	9713107	5	30	70	0	5	25	70	0	16	29	18	19	15	Loam
02/9/20	RPC 26	LG	717366	9709972	10	10	80	0	10	10	80	0	23	16	9	11	12	Loam
02/9/20	RPC41	SG	735886	9691473	30	10	70	0	20	10	70	0	11	7	11	3	10	Loam
02/9/20	RPC45	LG	716246	9678410	5	20	80	0	5	20	75	0	14	20	9.5	13	10.5	Clay
02/9/20	RPC49	LG	715419	9687198	10	30	70	0	5	30	65	0	15	12	15	24	13.5	Loam
02/9/20	RPC43	LG	722025	9690391	50	30	70	0	5	25	70	0	23	8	14	16	10	Loam
02/9/20	RPC29	LG	710588	9701786	0	10	90	0	0	10	90	0	22	14	19	14	28	Clay
29/8/20	RPN10	NW	741597	9776288	50	10	30	0	60	10	30	0	4	4	7	4	4	Loam
5/9/20	RPM 74v1		684654	9698209	20	20	60	0	20	20	60	0	11	14	9	15	10	Clay
5/9/20	RPM 69v1	SW	683230	9700732	40	20	50	0	30	10	60	0	4	4	5	6	7	Clay
5/9/20	RPM 68v1	SW	682755	9702764	10	40	60	0	10	30	60	0	5	4	3.5	6.5	14	Clay
5/9/20	RPM 73v1	SW	687244	9696524	0	20	80	0	0	30	70	0	12	24	8	16	14	Clay
5/9/20	RPM 50v1		680646	9703546	30	10	60	0	20	10	70	0	6	7	2	3	6	Clay
5/9/20	RPM 54v1	SW	678331	9703559	40	10	50	0	40	10	50	0	4	5	7	2	5	Clay
5/9/20	RPM 58v1	SW	676371	9704587	90	5	0	0	95	5	0	0	0	0	0	0	0	Clay
05/9/20	RPN57v1	SW	681438	9708533	5	50	60	0	5	35	60	0	6	24	11	8	5	Clay
05/9/20	RPM72		684008	9711929	0	50	70	0	0	30	70	0	13	10	8	9	11	Clay
08/9/20	RP8v1	NW	700886	9832239	10	50	70	0	10	20	70	0	6	23	14	17	15	Clay
08/9/20	RPN22v1	NW	700291	9828672	50	20	60	0	40	10	50	0	3	4	4.5	3	3	Clay
08/9/20	RPN24v1	NW	692938	9827944	50	20	60	0	40	10	50	0	3	4	3.5	3.5	4.5	Loam

(b)Map Used and Available Opuntia location

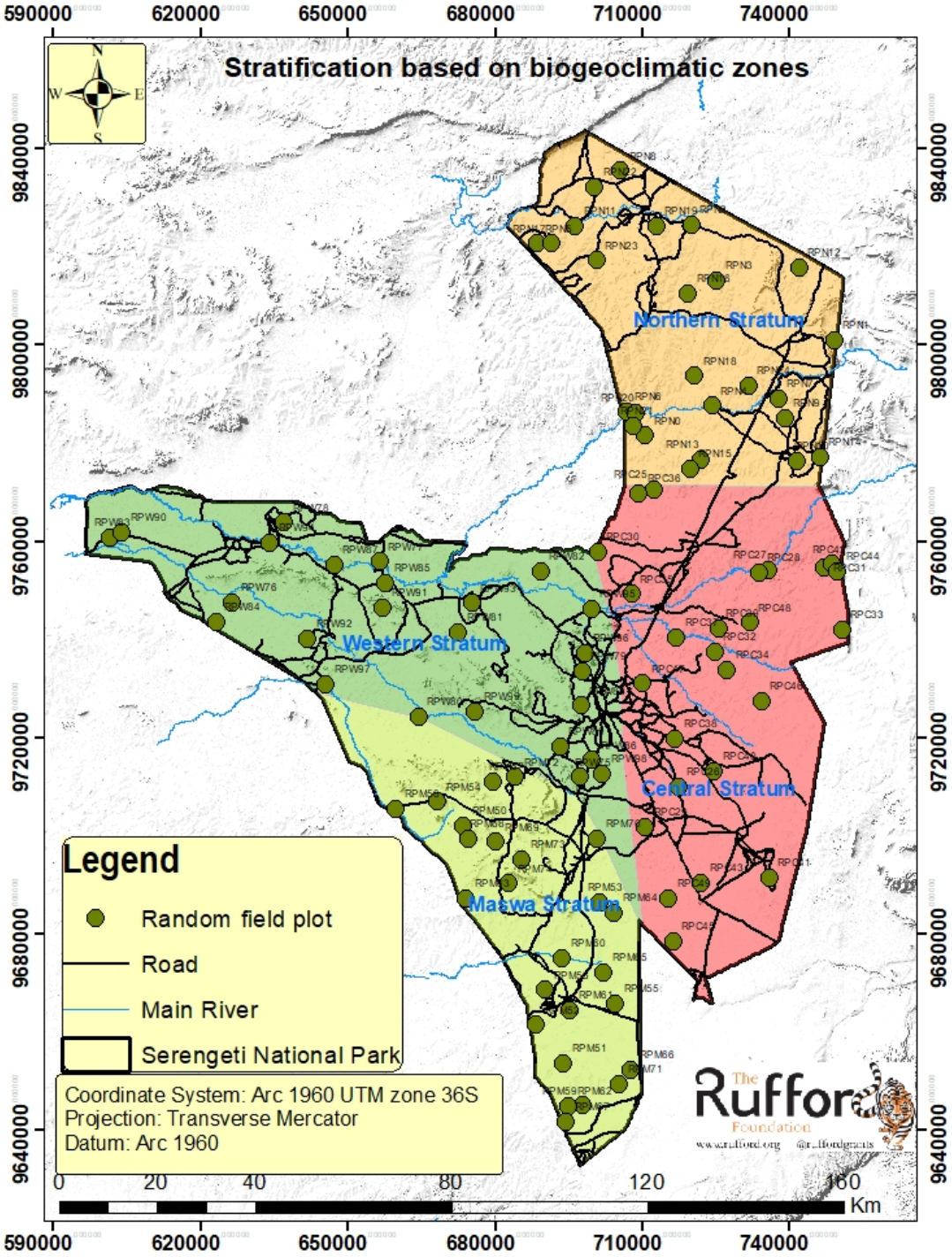


(c)Data collection protocol

Sampling design
The stratification of Serengeti National Park (Project site) was done by dividing the ecosystem based on bio geoclimatic zones (low rain volcanic shallow soils (south), black cotton wooded savanna (Maswa), alluvial flood plain with ironstone soils with mixed acacia woodlands (west), granitic leached soils with clay swales with Combretum and Acacia woodlands (north), sandy soils (Terminalia woodland), riverine closed canopy forests). Therefore, these proposed strata were used in order to improve data collection and bring systematic representation throughout the ecosystem figure 8.

Sampling unit/Field plot:
Randomly field plots were established within each of these strata data were collected. At each "used" and "available" point I sat up a sample design such as a 4x4m plot in which was used to collect covaries variables. Field covariates which were collect at each sampling point were: relative cover of five most prevalent plant species, percentage bare ground, classification of grazing (1-5; high to low), number and species of dung piles, soil classification (estimated percentage of clay,

silt, sand). Grass biomass (estimated with disc pasture meter), number of termite mounds within 100m, catena placement (i.e., low, mid, high in the hill slope).



(d) Field work materials and equipment

- Field vehicle
- GPS
- Prepared field form
- Pencils
- Board
- My clear bag
- Writing board
- Camera
- GPS batteries

Other equipment:

- Disc pasture meter and measuring stick
- Field tape measure
- Rope (for plot making

(e) Vegetation data collection sheet

Date: _____

Sample ID: _____

Coordinates:
X: _____
Y: _____

Broad scale habitat:
SG LG WCW WCM NM NW MG T

1* Vegetation

	Cover: Scratch	Cover: Good
Bare soil		
Litter		
G1 _____		
G2 _____		
G3 _____		
Rest		
Legumes		
Forbs		

2 Biomass (disc pasture height)
1. _____
2. _____
3. _____
4. _____
5. _____

3 Clipping fresh leaves
Themeda triandra ☐
Eragrostis tenafolia ☐
Penesetum mezianum ☐
Digitaria macroblephra ☐
Sporobolus fimbriatus ☐
Sporobolus iclodos ☐
Dom:_____ ☐

Catena
Top
Middle
Bottom

4 Wet Clippings (25 x 25 cm) x 5

	Bag	Grass	Bag	Forbs
1.				
2.				
3.				
4.				
5.				

	Bag	Legume	Soil
1.			☐
2.			☐
3.			☐
4.			☐
5.			☐

5 Grazed → Ungrazed
1 2 3 4 5

6

Species	Heaps dung number

500 m radius

Herbivores species	Number

50 m radius
Termite mounds

Active	Dead

8 Fire
1
2
2 +

500 m radius

Dominant tree species	Visual density
1 _____	No trees
2 _____	>500m
3 _____	300-500m
	150-300m
	<150m

Notes on reverse:

Digital pictures ☐

* The data in boxes with numbers (1 → 7) need to be collected in the 4 x 4 m plot

(f) Field Photos